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The Stock Market, Consumption, and Inflation: Empirical Evidence of Iran

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Abstract

The Iranian stock market has recently fluctuated sharply; at constant prices, it increased 7.3 times from March 2019 to August 2020 but decreased to less than half the following year. The inflation rate also increased sharply. So, the question arose as to whether the stock market value, as a wealth, through an indirect channel of consumption (wealth), is one of the factors increasing inflation. This study used a structural equation model to investigate this issue using monthly data from 2016 to 2021 by studying two equations of consumption and inflation. Results show that although the stock market value is not one factor that affects consumption, GDP growth and housing, as well as wealth, are significant factors in consumption. Therefore, the stock market value through the indirect channel does not lead to inflation. In addition, the stock market value does not affect inflation directly. But Money growth and Exchange rate are the most crucial factors affecting inflation, and GDP growth has slowed inflation in Iran.

Keywords: Exchange Rate, Inflation, Money, Stock Market, Wealth.

JEL Classification: E21, E31, E51.

1. Introduction

There is a divergence of opinion about the relationship between inflation and the stock market. Some believe there is a negative relationship between inflation and the stock market (Fama, 1981). Some theories argue that the stock market protects against inflation well (Fisher, 1930). Although the inflation effect on the stock market has been analyzed in several studies, less attention has been paid to the impact of increasing stock market value on macroeconomic variables like inflation.

In recent years, inflation has become a significant problem in Iran. There are different views on the causes of inflation in Iran's liquidity, exchange rate, government budget deficit, expectations, and imported inflation (Sadeghi et al., 2010; Azimi et al., 2013; Pourkazemi et al., 2016). Given Iran's rising inflation and stock market fluctuations, finding a relationship between these variables has received much attention. Moreover, in recent years, the share of stock assets in the income of Iranian households has increased. In addition, the number of shareholders has increased in recent years, so 60% of the population of Iran in 2020 received a stock exchange code (Securities & Exchange Organization).

On the other hand, many vital stocks (such as petrochemicals, automobiles, and metals) that play an essential role in the stock market index are state-owned. The growth of stock wealth in the income of Iranian households and the intervention of the Iranian government in the price of large corporation stocks are very noticeable. So, one of the debates is whether the increase in the stock market's value has a role in intensifying Iran's inflation. On the one hand, it has been raised that the growth of the stock market value from the wealth channel can be one of the reasons for inflation because, with the increase in wealth, consumption increases, which increases the demand, leading to inflation. On the other hand, Iran's stock market grows under political decisions, not real ones. Therefore, decisions affecting the growth of the stock market may cause inflation. Nevertheless, any country's stock market is one of that country's development factors. Therefore, this study seeks to answer whether the increase in the value of the stock market is involved in the occurrence of inflation or not.

The stock market has many ways of influencing inflation. Because of Pigou's wealth effect, rising household income and purchasing power increase the consumption level. This study focuses on the impact of the stock market on inflation through the consumption channel, although it is also examined for further analysis of the liquidity channel. Also, this study contributes to the Literature in several ways: I) Despite the central importance of the above issues, a comprehensive survey of the effect of changes in stock market value on inflation through consumption has not been conducted. Therefore, to our knowledge, this study examines for the first time the effect of increased stock market value on inflation through the wealth (consumption) channel; II) Since no comprehensive research has been conducted, there is no clear theoretical basis for this relationship. As such, this study collects and extracts the theoretical framework of this study of theories and parallel studies; III) Applying the structural equation model to examine the effect of the stock market on inflation

through consumption provides exciting results. Therefore, this study uses the structural equation model to investigate the impact of stock market value on inflation from the consumption channel in Iran.

In the next section of the article, the Literature is reviewed. In the third section, data and methodology will be introduced. The empirical results are shown in the fourth section, the fifth section reports further analysis, and finally, conclusions and policy recommendations are presented in the sixth section.

2. Literature review

We first look at theories about the impact of stock values on consumption. As there are no studies to consider the direct effect of stock value on inflation, we relied on the theories on the relationship between stock market value and consumption and the relationship between consumption and inflation. So, we extracted a channel of stock market impact on inflation via the consumption channel.

2.1 Stock Value and Consumption

The consumption function indicates the relation between consumption and various factors affecting it. There are several theories about consumption. In 1936, Keynes argued that multiple factors affect consumption, but income is the most significant factor influencing consumption. Keynes's ideas contradicted the classical theories, which argued that rising interest rates would reduce consumption. Duesenberry (1949) claimed that people resist the reduction of consumption after getting used to a level of consumption and that current consumption depends on past income in addition to current income. Ando & Modigliani (1963) proposed a lifecycle model. They divided an individual's life into youth, middle age, and old age. Under the life cycle model, real consumption depends on income from work, household net wealth. So, if wealth rises unexpectedly, households will save less and consume more over their lifetime. Friedman (1957) proposed the theory of permanent income.

According to Friedman's theory, consumption is obtained by optimization between individual utility periods. Friedman believed consumption was dependent on permanent income. He divided income into two groups: permanent and temporary income, and implicitly included wealth in the consumption function. Therefore, in life cycle theories explicitly and in permanent income theory, wealth is also included as one factor determining the consumption level. However, wealth as a factor influencing consumption was first proposed by

Pigou in 1943. Pigou argued that falling prices increase real wealth (people's purchasing power), increasing consumption. The effect of increased consumption due to increased purchasing power is called the Wealth or Pigou Effect. Some empirical studies have also studied the impact of wealth on the consumption function (Jensen and Johannesen, 2017; Zhang et al., 2021; Aiello et al., 2023). Peltonen et al. (2012) analyzed housing prices (as financial wealth) and stock prices (as liquidity wealth) to examine the effect of wealth on consumption. Ciarlone (2011) examined the impact of income changes, real wealth, and financial wealth on private consumption. He considered housing prices for real wealth and stock market prices for financial wealth.

Given that today, the share of stock assets in the wealth of Iranian households has increased, stock wealth as one of the sources of income can affect household consumption expenditures. In addition, as the share of stock assets in household income has increased, household consumption is sensitive to changes in the stock market (Azizi, 2009; Mankiw and Zeldes, 1991). The stock market affects consumption through both direct and indirect channels. Some studies have examined the direct effect of the stock market on consumption (Poterba, 2000; Jensen and Johannesen, 2017; Di-Maggio et al., 2018; Zhang et al., 2021). Rising the stock market's value means increasing shareholders' wealth, which increases the wealth directly and leads to increased consumer spending (Dynan and Maki, 2001). Some studies have also considered the indirect effect of the stock market on consumer sentiment (Ludwig and Slok, 2002). Increasing the stock market's value improves the future income of shareholders (households), which in the future and with delays increases the consumption expenditures through the indirect channel. Rising stock prices increase the value of collateral, which helps financially constrained households obtain easy consumer loans. So, household consumption increases (Simo-Kengne et al., 2015). Stock market fluctuations through indirect channels change long-run consumption by about 76%, affecting the household's psychology, expectations, ability, and financial budget (Ampudia and Ehrmann, 2017). However, some studies also argue that the indirect effects of wealth are not fundamental determinants of consumption expenditure (Dynan and Maki, 2001). Zhang et al. (2021) showed that a drop in the stock market index reduces household consumption by around 3%, from the direct channel of the effect of wealth and the indirect channel of pessimistic expectations and limited ability to finance. Cieslak and Vissing-Jørgensen (2021) indicated that stock market fluctuations cause fluctuations in household wealth and income. Cooper and Dynan (2016) also demonstrated that stock market fluctuations

change aggregate demand from the investment channel. Chodorow-Reich et al. (2021) stated that a dollar increase in stock market wealth would increase consumer spending by 3.2 cents. Some studies have found a higher percentage (Di-Maggio et al., 2020), claiming that a dollar increase in stock market value increases consumption by 5 to 15 cents per year. In different countries, the effect of wealth on consumption shows different percentages. A dollar increase in wealth in Japan increases consumption by about one percent (Mutoh et al., 1993). In Italy, a dollar increase in revenue changes consumption by about 3 to 3.5 percent (Rossi and Visco, 1995). Some studies have argued that increases in consumption occur gradually and over time as wealth increases (Brayton and Tinsley, 1996). Some surveys have also found no significant relationship between stock market wealth and consumption (Zhou and Carroll, 2012). Some researchers have also discussed the two-way relationship between household consumption and the stock market (Liu and Shu, 2004; Hui et al., 2012). Di-Maggio et al. (2018) investigated the effect of stock wealth on the consumption of Swedish households and discovered the heterogeneous behavior of stock wealth on consumption in different income deciles. Liu and Li (2023) investigated how habits are formed on the consumption of households in youth and old age and found that reducing current consumption by reducing the habit stock will increase future wealth. They argued that the consumption function in habit formation changes over time. Arellano (2023) investigated the effect of income shocks on US household consumption using a nonlinear quantile approach with annual data from 2005 to 2017 and found significant heterogeneity in consumer responses to income shocks. Aiello et al. (2023) investigated the effect of digital currency wealth on households' consumption and found that the MPC digital currency profits are twice the MPC stock dividends. In addition, they found that digital currency wealth affects the real economy through the consumption channel. According to the various theories and studies mentioned above, the consumption function in this study in the benchmark model is as follows:

$$C = f(VM, GDP, PH) \quad (1)$$

In Equation 1, C is real private consumption, VM is the real stock market value (financial wealth), GDP is real GDP, and PH is housing price (real wealth).

2.2 Stock Value and Inflation

The relationship between consumption and inflation to the theory of inflation due to demand pressure, can be explained among the various theories of inflation.

Keynes's theory of inflation from the point of demand pressure considers the emergence of inflation as the reason for the increase in aggregate demand. The rise in demand may be due to the increase in the real and monetary sectors of the economy. In the real sector, factors such as an increase in consumer spending, investment spending, and exports, and a decline in imports can increase aggregate demand or, in other words, push the aggregate demand curve upward. However, the increase in demand may be due to monetary factors. Increasing the money supply due to expansionary monetary policy increases aggregate demand and the general level of prices (Pourkazemi et al., 2016). Keynes argues that an increase in effective demand leads to an increase in real output as long as there are unemployed factors of production. Still, when labor and capital equipment are relatively fully employed, a further increase in demand can lead to higher prices. Keynes calls this net inflation (Pourkazemi et al., 2016; Azimi et al., 2013). In addition, as a society's inflation expectations increase, consumption and aggregate demand increase, leading to higher inflation (Coibion et al., 2023). According to the various theories, the factors affecting inflation in the benchmark model of this study are as follows:

$$P = f(C, E, M2, IR) \quad (2)$$

In Equation 2, P is inflation, C represents real private consumption, E indicates the exchange rate, $M2$ shows liquidity, and IR is the interbank interest rate.

Inflation is one of the most important economic problems that some researchers believe is affected by stock prices (Gupta and Inglesi-Lotz, 2012). In addition, the real stock price through the wealth (consumption) channel can affect aggregate demand and inflation (Antonakakis et al., 2017).

This research examines the effect of stock market value on inflation through the consumption channel and answers whether the increase in the value of the Iranian stock market has contributed to the intensification of inflation. There is a possibility that household wealth and income changes will directly lead to changes in household consumption, affecting the consumer price index. Wealth directly and rapidly affects consumption; consumption increases in the coming periods as wealth increases. (Dynan and Maki, 2001). The dramatic rise in inflation in Iran in recent years has sparked much debate as to whether an increase in the value of the stock market index through the "Wealth Effects" channel could lead to inflation with a boom in consumer spending. In addition to the wealth effect, some researchers discuss another channel for the stock market

to influence inflation. For this purpose, approaches with mediator variables are used. The SEM approach can properly show the direct and indirect effects of the independent variable (stock market value) through the mediating variable (consumption) on the dependent variable (inflation) and answer the question of whether the stock market can lead directly or indirectly through the consumption channel. Some researchers argue that sometimes, the stock market can play a role in liquidity and thus raise inflation. So, in this study, the effect of stock market value on inflation is also investigated through the liquidity channel for further analysis. According to the existing study gap, this study examines the direct and indirect effects of the stock market on inflation. In addition, despite the severe and stable inflation in Iran, the fluctuations of stock returns and the rapid increase in the number of shareholders in recent years, the results of this study can help policymakers in order to control inflation and developing the stock market for economic growth. Despite this importance, there is relatively little empirical evidence on the effects of the stock market on inflation. Therefore, this study is one of the first attempts to test the impact of increasing stock market value on inflation from the consumption channel.

3. Data and Method

3.1 Trends

This subsection discusses trends in the Iranian stock market and inflation from September 2016 to September 2021. The value of the Iranian stock market has been increasing in recent years. The value of the Iranian stock market (the total value of the stock exchanges in the Tehran Stock Exchange and OTC) at the current price has increased from about 4259240 billion Rials in 2016 to about 67593993 billion Rials in 2021. In addition, the Iranian economy has constantly been exposed to high inflation rates in recent years. It has been rising since 2017, and annual inflation in 2020 has reached about 48.7% (Securities & Exchange Organization; Central Bank of Iran).

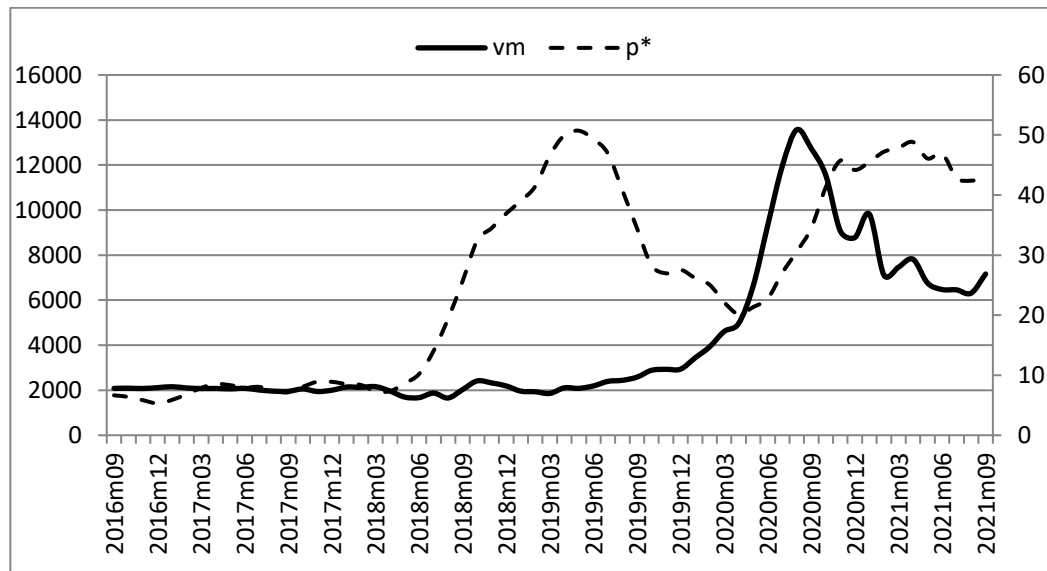


Figure 1. The Trends of the Iranian Stock Market Value at a Fixed Price in Thousand Billion Rial (Solid Line on the Left) and Annual Inflation in Percent (Dashed Line on the Right)

Source: Research finding.

Figure 1 shows that the real value of the Iran Stock Exchange had an upward trend during the study period. The slope of this value has been mild from 2016m9 to 2019m12, and from 2019m12 had an upward trend to 2020m8. It experienced a sharp fall from 2020m8 to 2020m12 and fluctuated greatly until 2021m9. In addition, annual inflation had an upward trend. The chart indicates that inflation has been growing steadily from 2018m3 to 2019m4. From 2019m4 to 2020m4 has taken a downward trend. Inflation has risen again from 2020m4 to 2020m11. After a slight decrease, it increased again to 2021m4 and has seen many fluctuations since 2021m4. Generally, the two variables show the same pattern in some periods. Nevertheless, it is noteworthy that inflation has continued to rise since 2020m8, when the value of the Iranian stock market fell sharply.

3.2 Data

This study's period is considered monthly from September 2016 to September 2021. The variables used in this study and their source are presented in Table 1. Consumption and GDP data are available quarterly. Monthly data for these two variables were obtained from the Denton method. Denton's method interpolates a

time series (such as a season) and applies the constraints that the interpolated series follows (Bloem et al., 2001).

Table 1. Variable Acronyms, Definitions, and Sources

Abbreviation	Variables	Sources
VM	The market value of the stock market (Sum of stock and OTC values) (constant with GDP deflator)), Billion Rial	Securities & Exchange Organization (SEO)
GDP	Gross domestic product (constant= 2012), Billion Rial	Statistical Center of Iran
HP	The average purchase and sale price of one square meter of residential infrastructure, Rial	Statistical Center of Iran
C	Consumption (Private sector final consumption costs) (constant=2012)	Statistical Center of Iran
M2	Liquidity	Central Bank of Iran (CBI)
E	exchange rate (unofficial)	Central Bank of Iran (CBI)
IR	Interbank interest rates (%)	Central Bank of Iran (CBI)
CPI	Consumer price index (the base year 2016)	Statistical Center of Iran
P	Inflation	calculated based on CPI

Source: Research finding.

3.3 Method

Mediation is a causal relationship between several variables so that the first variable (X) affects the second variable (M), and the second variable affects the third variable (Y). The variable that depends on all or part of the effect of the independent variable on the dependent variable is called the mediating variable(M) (Baron and Kenny, 1986).

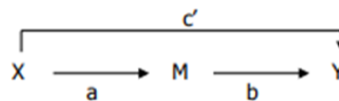


Figure 2. Relationships between the First and Third Variables and the Mediator Variable

Source: Baron and Kenny (1986).

Figure 2 shows path a, the effect of the first variable (stock market value) on the second variable (consumption), and path b, the effect of the second variable (consumption) on the third variable (inflation). These two paths are

called direct effects. The path c' where the relationship between the first variable (stock market value) and the third variable (inflation) is shown by the second variable (consumption or mediation), is called the indirect effect (Kenny et al., 2020).

Several approaches have been proposed to calculate the indirect effect. Most of these new approaches achieve the same values for the indirect effect. Statistical tests should be analyzed for significance and standard error to estimate the extent of the indirect effect. Structural Equation Modeling (SEM) is one of the most potent analysis methods in models with mediator variables. This model is a mathematical and statistical combination of several regressions that came together in a system to analyze complex phenomena. Therefore, this approach is very suitable for testing complex relationships between variables and has been used in various studies of different sciences (Teo, 2011; Adelson, 2012).

The SEM approach has several advantages. In addition to examining the paths defined in the model, the SEM approach makes it possible to estimate more complex models. Another advantage of the SEM approach is that it provides helpful information about model compatibility with data. In addition, unlike linear multiple regression models, SEM can calculate measurement error (Hoyle, 2012).

In the SEM approach, first, based on the hypotheses and study questions, a general outline of the relationships between the variables is drawn (Adelson, 2012). This study uses the approach (SEM) to estimate the effect of stock market value on inflation with the consumption mediating variable.

There are several methods to evaluate the fitting of the model (Hoyle, 2012). Model fitness tests are called fitness indices. These indicators are constantly developing and evolving (Alavi, 2013). Different studies evaluate different indicators. Normalized fitness index (NFI) and Tucker-Louise index (TLI) or non-normalized fitness index (NNFI) are among the model fitness indices in which values above 0.9 to 0.95 mean a good fit (Iacobucci, 2010). The fit index (GFI) with a coefficient less than 0.9 indicates poor fit. In addition, the Root Mean Square Error of Approximation index (RMSEA) is also one of the fitness indices of the model, and values less than 0.08 are acceptable. However, some studies have reported values less than 0.1 as acceptable. Values below the 0.08 index (SRMR) also indicate a good fit (Dion, 2008; Alavi, 2013).

4. Empirical Results

Recently, the increase in stock market value and the upward inflation growth in Iran have raised several questions about the relationship between these two variables. Therefore, this study with monthly data has studied the relationship between these two variables of the consumption channel with the SEM approach. The SEM approach has several estimation methods. One of the methods for estimating the sem approach is the Maximum Likelihood (ML) method, which has been used in several studies (Kline, 2011). This method shows the extent to which the observed variances and covariances between the variables can be reconstructed with the specified model, also known as a good fit evaluation (Brown, 2006). In this study, the maximum likelihood method has been used. Since the technique is based on assumptions, such as the normal distribution of variables, some pre-tests should be considered before estimating the model (Harrington, 2009). Thus, the normality of the variables is checked first. The Shapiro-Wilk and the Shapiro-France tests are used to check the normality of the data (Royston, 1992). The result shows that the probability values of the Shapiro-Wilk and Shapiro-France tests for all variables are higher than 0.05. Therefore, the normality of the distribution of the variables is accepted.

After examining the normality test of variables, the unit root test checks the variables' significance. For this purpose, the generalized Dickey-Fuller (1979) test is used. The results of the Augmented Dickey-Fuller test are shown in Table 2. The results show that the variables are nonstationary at the level, but with the first-order difference, the variables remain the same. The unit root test results when variables are in the natural logarithms indicate that all variables are stationary.

Table 2. Augmented Dickey-Fuller Test of Unit Root

Variables	Dickey-Fuller test	Variables	Dickey-Fuller test
VM	-0.946	LVM	-3.612
GDP	-2.097	LGDP	-4.107
HP	-0.504	LHP	-3.112
C	-2.540	LC	-4.589
M2	0.720	LM2	-2.990
E	-2.407	LE	-3.045
IR	-2.295	LIR	-3.501
CPI	1.125	LCPI	-2.611

Source: Research finding.

Note: Critical values (-3.566, -2.922, -2.596) at the level (1%, 5%, 10%), respectively. "L" variables in the natural logarithms.

The Breush-Pagan heteroscedasticity test is performed in the next step to check the heterogeneity. In this test, the null hypothesis indicates equal variances in the model. The results of this test showed that there is no variance heterogeneity problem in the estimated model.

The Breusch-Godfrey LM test examined the variables' autocorrelation. In this test, the null hypothesis is that there is no autocorrelation. The results of the autocorrelation test show that the null hypothesis is not accepted. Then, Toda and Yamamoto's (1995) causality tests are analyzed to examine the direction of causality. It is necessary to examine the long-run relationship and cointegration test between the variables to perform a conventional Granger causality test; in contrast, in the Toda-Yamamoto causality test, information about the cointegration properties of the system is not necessary. The Toda and Yamamoto Causality test results are presented in Table 3. The results indicate that there is a one-way relationship from VM to C. In addition, the results in this table show that VM is not the cause of CPI.

Table 3. Toda and Yamamoto No-Causality Test VAR Model Results

Excluded	Chi-sq	Prob.	Direction of causality
Dependent variable: LVM LC	1.612	0.446	$C \neq VM$
Dependent variable: LC LVM	11.89	0.0001	$VM \longrightarrow C$
Dependent variable: LCPI LVM	6.181	0.045	$VM \neq CPI$
Dependent variable: LVM LCPI	2.783	0.248	$CPI \neq VM$

Source: Research finding.

Table 4. Results of Model Estimation by ML Method with Total Sample Data

Structural	Variables	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
LC	LVM	-0.0407***	-0.0407***	-0.0407***	-0.0407***	-0.0407***	-0.0407***	-0.037***
	LGDP	0.972***	0.972***	0.972***	0.972***	0.972***	0.972***	0.836***
	LHP	0.073***	0.073***	0.073***	0.073***	0.073***	0.073***	-0.086*
	LM2	--	--	--	--	--	--	0.300***
	CONS	-0.528	-0.528	-0.528	-0.528	-0.528	-0.528	0.089
LCPI	LC	-0.570***	-0.331**	-0.297**	-0.376***	2.554***	0.365	-0.570***
	LM2	1.117***	1.112***	1.092***	1.050***			1.117***
	LE	-0.207***	-0.291***	-0.273***	--	1.47***	2.59***	-0.207***
	LIR	0.170***	0.183***	0.197***	0.173***	0.109	-0.200	0.170***
	LVM	--	-0.009	--	--	--	--	--
	LGDP	--	-0.456**	-0.480**	-0.238	-0.417***	--	--
	CONS	3.531**	7.90***	7.60***	2.792	14.521	-26.74***	3.531**
	N	61	61	61	61	61	61	61
	CD	0.996	0.997	0.997	0.996	0.861	0.823	0.997

Source: Research finding.

Note: ***, **, * denote statistically significant at the 1%, 5%, 10%, level, respectively; “L” denotes variables in natural logarithms.

Table 5. Results of the Goodness of Fit Tests

Fit Statistic	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Optimal values
RMSEA	0.077	0.080	0.079	0.080	0.81	0.085	0.079	0.08>
GFI	0.989	0.998	0.996	0.994	0.992	0.990	0.996	0.9<
CFI	0.990	0.999	0.997	0.995	0.994	0.992	0.999	0.9<
TLI (NNFI)	0.933	0.922	0.900	0.939	0.993	0.889	0.899	0.9<
SRMR	0.035	0.035	0.035	0.040	0.06	0.07	0.024	0.08>
CD	0.996	0.997	0.997	0.996	0.861	0.823	0.997	R ²
N	61	61	61	61	61	61	61	-

Source: Research finding.

After reviewing the pre-tests, the relationships drawn in Equations 1 and 2, and Figure 2 are estimated using the SEM approach. These relationships are first estimated in the form of the benchmark model (1),¹ and then, for further analysis of the results, models (2)², (3)³, (4)⁴, (5)⁵, and (6)⁶ are also estimated. Model (7)⁷ is presented by changing the variables of the first part.

According to Table 4, it is observed that the coefficients of the first part of models 1 to 6 are similar because the variables of the first part of these models (i.e., the variables affecting consumption) are considered the same in all six models, so the coefficients are the same. In model 7, the variables of the first part (factors affecting consumption) are different from the six previous models, so the coefficients are different.

The empirical results of models 1 to 6 are similar in terms of factors affecting consumption and show that the real value of the stock market (VM) has a negative and significant effect on consumption. Then, by increasing the VM by one percent, 0.0407 percent of real consumption decreases. The impact of VM on household consumption in model 7 is also negative and statistically significant. Household income is the sum of savings and consumption; rising stock market value has led to a redistribution of the household income mix. As stock market value increases, households save more and consume less to take advantage of stock market speculation conditions. In addition, the more pessimistic consumers are, the more pessimistic they are about the future state of the economy (Zaremba et al., 2020). Therefore, due to the poor economic situation in Iran, due to international sanctions, despite the increase in the value of the stock market, Iranian households, due to a pessimistic view of the economic situation, refrain from increasing consumption and save to increase financial wealth so that they can deal with financial problems if bad economic conditions continue. Therefore, increasing market value through indirect consumption channels can not exacerbate inflation in Iran. Some studies have found that stock market fluctuations change aggregate demand from the investment channel (Copper and Dynan, 2016). Some studies, such as Zhang et al. (2021), have also found that the stock market directly correlates with consumption during a downturn.

¹. Model (1): $C = f(VM, GDP, HP)$, $CPI = f(C, M2, E, IR)$

². Model (2): $C = f(VM, GDP, HP)$, $CPI = f(C, M2, E, IR, VM, GDP)$

³. Model (3): $C = f(VM, GDP, HP)$, $CPI = f(C, M2, E, IR, GDP)$

⁴. Model (4): $C = f(VM, GDP, HP)$, $CPI = f(C, M2, IR, GDP)$

⁵. Model (5): $C = f(VM, GDP, HP)$, $CPI = f(C, E, IR, GDP)$

⁶. Model (6): $C = f(VM, GDP, HP)$, $CPI = f(C, E, IR)$

⁷. Model (7): $C = f(VM, GDP, HP, M2)$, $CPI = f(C, M2, E, IR)$

Real GDP has a positive and statistically significant effect on consumption in models 1 to 7. In fact, with a one percent increase in GDP, real consumption increases by about 0.972 percent. Batrancea (2021) studied the effect of GDP on household consumption with monthly data from 28 countries of the European Union from December 2019 to October 2020 and found that economic growth has a positive and significant effect on household consumption.

Housing price (HP) has a positive and significant effect on private sector consumption in models 1 to 6. In model 7, the impact of HP on C is significant at 10%. Housing in Iran is the main component of the wealth of the household. Therefore, with the increase in housing prices, household consumption increases through the wealth channel. Xu et al. (2018) also found a positive relationship between housing prices and consumption. However, some studies have also found that housing prices rise, household savings increase, and consumption decreases (Waxman et al., 2020).

In models 1 to 6, variables affecting consumption are considered constant, and the coefficients of the six models in the consumption function are the same. However, in model 7, the effect of liquidity on consumption is also analyzed. The results show that the impact of M2 on C is positive and statistically significant. It can be said that with a one percent increase in liquidity, consumption increases about 0.30 percent. In a study for Saudi Arabia, Algaeed (2016) found that household consumption increased as liquidity increased as wealth increased. Orphanides and Solow (1990) also argued that different rates of liquidity growth occur with varying inflation rates.

Real private sector consumption (C) reduces CPI on all models except Model 5. Because consumption is part of GDP, CPI decreases as consumption increases as a component of income. In addition, the effect of consumption on CPI in this period in Iran is more than the total income channel (total income, which is the sum of savings and consumption) than the total demand channel. In addition, by introducing real GDP into the model, the impact of consumption on inflation is diminished (see Model 2, Model 3, and Model 5 in Table 8).

Liquidity (M2) increases CPI in all models. Therefore, Friedman's theory of inflation in Iran is correct, and liquidity growth is the most critical factor in causing inflation in Iran. With a one percent increase in liquidity growth, inflation increases by about 1.117 percent. Therefore, the findings of this study show that although inflation in Iran is not just a monetary phenomenon and other factors have had a positive effect on its formation, the growth of liquidity has had the highest share in the formation of inflation (Model Results 1). The results of

other models show that inflation increases by more than one percent with a one percent increase in liquidity growth. Some studies support our results (Sadeghi et al., 2010; Shah et al., 2014).

An exchange rate (E) increase significantly and negatively affects the CPI in the presence of liquidity. By removing liquidity from the model, the impact of exchange rates on CPI becomes positive and significant (see results in Models 5 and 6). Models 5 and 6 show that with an increase of one percent in the exchange rate, inflation increases by more than one percent. In fact, with the rise in the exchange rate, imported raw materials become more expensive, which leads to an increase in the cost of items whose raw materials are imported, and causes prices to rise.

In most models, the Interbank interest rate (IR) positively and significantly impacts CPI. In model (1), with an increase of one percent interest rate, inflation increases by about 0.170 percent. Deviations in monetary policy lead to higher interest rates, which lead to lower investment and higher inflation (Lawal et al., 2018).

An increase in stock market value (VM) does not directly affect the CPI (Model 2 results in Table 8).

An increase in real GDP reduces the CPI (see the results of models 2, 3, and 5 in Table 8). Empirical results are consistent with some studies (Valdovinos, 2003; Talha et al., 2021; Dua and Goel, 2021). In this study, after estimating the models, goodness-of-fit tests are evaluated. The results of goodness-of-fit tests are presented in Table 5.

RMSEA in this study in different models shows a value equal to or less than 0.08. The value indicates the desired fit. Table 5 shows that all models' GFI and CFI values are higher than 0.9. This study examined the Tucker-Louise (TLI) or abnormal fitness index (NNFI). The results of this index show that models 1 to 4 reported values above 0.9, and model 5 showed values close to 0.9. SRMR values in all models are reported below 0.08. The CD also plays the role of R^2 in the model, which shows high values. Good fit tests indicate that all the studied models have a good fit.

5. Further Analysis

Given that from 2016m9 to 2019m3, the stock market value has not grown much, but after this date, the Iranian stock market value has experienced unprecedented growth. Therefore, the study period to better understand the results and further analysis is divided into two sub-samples, the first period (2016m9 - 2019m3) and

the second (2019m4 - 2021m9). The average growth of all variables in the two sub-samples is shown in Table 6. In the first period, the real monthly growth of the stock market value was about 0.334%, while in the second period was more than 5%. Therefore, considering whether this stock market growth has caused inflation in recent years has intensified inflation.

Table 6. Average Monthly Growth of Variables in Two Sub-Samples

Variables	VM	GDP	HP	C	M2	E	CPI
The first period	0.334	-0.125	2.714	0.315	1.740	1.00	1.667
The second period	5.083	0.323	4.199	0.717	2.654	0.009	2.523

Source: Research finding.

Table 7. Estimation Results by ML Method, First Sub-Sample (2016m9 - 2019m3)

Structural	Variables	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
LC	LVM	-0.089	-0.089	-0.089	-0.089	-0.089	-0.089	-0.072
	LGDP	0.915***	0.915***	0.915***	0.915***	0.915***	0.915***	0.599**
	LHP	0.095***	0.095***	0.095***	0.095***	0.095***	0.095***	-0.091
	LM	--	--	--	--	--	--	0.286**
	CONS	0.795	0.795	0.795	0.795	0.795	0.795	4.207
LCPI	LC	-1.126***	-0.702***	-0.849***	-0.725***	0.206	-0.563	-1.126***
	LM2	1.280***	1.116***	1.187***	0.916***	--	--	1.281***
	LE	-0.384**	-0.252*	-0.339**		0.847***	1.039***	-0.384**
	LIR	0.223	0.185	0.139	0.084	0.114	0.441	0.223
	LVM	--	0.146*	--	--	--	--	--
	LGDP	--	-0.459*	-0.421*	-0.526**	-1.376***	--	--
	CONS	11.266	10.283	14.249***	13.279***	12.603**	0.242	11.266***
	N	31	31	31	31	31	31	31
	CD	0.978	0.978	0.980	0.976	0.924	0.898	0.980

Source: Research finding.

Note: ***, **, * denote statistically significant at the 1%, 5%, 10%, level, respectively; “L” denotes variables in natural logarithms.

Table 8. Estimation Results by ML Method, Second Sub-Sample (2019m4-2021m9)

Structural	Variables	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
LC	LVM	-0.033	-0.033	-0.033	-0.033	-0.033	-0.033	-0.038**
	LGDP	0.886***	0.886***	0.886***	0.886***	0.886***	0.886***	0.745***
	LHP	0.081***	0.081***	0.081***	0.081***	0.081***	0.081***	-0.120
	LM2	--	--	--	--	--	--	0.407***
	CONS	0.491	0.491	0.491	0.491	0.491	0.491	0.690
LCPI	LC	-0.050	-0.238**	-0.180**	-0.1807**	1.84*	2.257***	-0.051
	LM2	0.999***	1.014***	0.986***	0.986***	--	--	0.999***
	LE	-1.47	-3.48	-3.64		1.01	4.15	2.58
	LIR	0.138***	0.085***	0.106***	0.1061***	-0.12	0.0618	0.138***
	LVM	--	-0.012	--	--	--	--	--
	LGDP	--	0.483***	0.437**	0.4378***	2.54*	--	--
	CONS	-4.47	-8.68	-8.76	-8.76***	-4.88	-26.74***	-4.47
	N	30	30	30	30	30	30	30
	CD	0.995	0.996	0.996	0.995	0.689	0.625	0.996

Source: Research finding.

Note: ***, **, * denote statistically significant at the 1%, 5%, 10%, level, respectively; “L” denotes variables in natural logarithms.

Therefore, the seven models in the two sub-samples are estimated for further analysis with the SEM approach. The results of these estimates are presented in Tables 7 and 8.

The results of Table 7 show the estimation of models 1 to 7 in the first period. The results indicate that the value of the Iranian stock market in the first period does not significantly affect consumption. Given that the real growth of the effect of the Iranian stock market in this period has been minimal, the slight growth of the stock market could not affect the real consumption of households during the first period. However, GDP growth and housing prices positively and significantly affect consumption. In addition, liquidity has a positive and statistically significant impact on real consumption.

In the first period, as in the whole period, the CPI decreases with increasing consumption. In addition, as expected, liquidity was an essential factor in increasing the CPI, so with a one percent increase in liquidity, the CPI has grown by about 1.281 percent (model 7). Given that the exchange in the first period was very high (Table 7), the CPI increases as the exchange rate increases in the absence of liquidity. This effect is so significant that in Model 6, with a one percent increase in the exchange rate, the CPI increases by about 1.039 percent. In the first period, interbank interest rates did not grow much, so there is no significant relationship between interbank interest rates and CPI.

The results of Table 8 show no significant relationship between stock market value and consumption in the second period. There is no indirect channel of stock market impact on inflation in Iran in this period, and severe inflation in this period has other reasons than the growth of the stock market. Rising real GDP, housing prices, and liquidity have increased household consumption through the wealth channel.

Empirical results show no significant relationship between consumption and CPI in models 1 and 7. Consumption and CPI have a negative and significant relationship in models 2, 3, and 4. In models 5 and 6, the relationship between consumption and CPI becomes positive and significant by eliminating liquidity. Increased liquidity in all models has a positive and significant effect on CPI. Since the exchange rate has grown slightly in the second period, the increase in the exchange rate has not significantly affected the CPI. There is no significant relationship between the exchange rate and CPI in the second period. While in the first period, when the exchange rate experienced high growth, it significantly affected CPI. Interbank interest rates have a positive and statistically significant relationship with CPI in models 1, 2, 3, 4, and 7. Stock market value does not

directly affect CPI (Model 2). Real GDP and CPI also have a positive and significant relationship in this period.

6. Conclusion

From 2018 onwards, the inflation rate in Iran has been about 29% on average. Iran's stock market has also experienced sharp fluctuations. Therefore, the question arises, can the growth of the stock market cause inflation with the increase in consumption? To answer this question, this study aims to investigate the effect of stock market value on inflation from the consumption channel using the monthly data of Iran during the period 2016m9 to 2021m9.

The results showed that the increase in stock market value could not increase consumption and indirectly increase inflation. The Pigou wealth channel is not established through Iran's stock market. Also, the rise in stock market value did not statistically affect inflation in Iran. The results of the estimates in different sub-samples also reported similar results. Although in the second sub-sample, from 2019m4 to 2021m9, the Iranian stock market has experienced monthly growth of over 5%, even this unprecedented stock market growth has not led to an increase in real consumption. The reason can be that the stock growth in Iran has not occurred with real factors and is not sustainable. So, this unstable growth cannot increase the real wealth of households and increase demand. Therefore, this study reported that the growth of the stock market in the period under study was not a factor in inflation in Iran through the consumption channel. Abbate et al. (2021), by examining the effect of the financial shock on inflation in the United States, argued that since the financial shock affects the supply side and causes changes in production and inflation in the opposite direction, its effects on inflation are uncertain. Some studies in other countries found that stock wealth has a heterogeneous effect on household consumption (Di-Maggio et al., 2018).

Empirical results showed that liquidity, real GDP, and housing prices increased real consumption in all the studied periods. Numerous studies have supported these results (Algaeed, 2016; Xu et al., 2018; Batrancea, 2021). Deniz and Thanasis (2023) found that income is an important factor in the consumption function of different countries. Aiello et al. (2023) observed that stock wealth affects the US economy through the consumption channel. Coskun et al. (2022) also discovered that the effects of housing wealth are greater than financial wealth on consumption in 25 OECD countries. Empirical results also showed that consumption had a negative and statistically significant effect on CPI. In

addition, the results showed that the most critical factors of inflation in Iran in the studied periods were liquidity and exchange rates, and real economic growth has helped to reduce inflation. Therefore, this study suggests that monetary policymakers should pay more attention to liquidity and its inflationary effects in Iran in implementing monetary policy. In addition, another critical step in reducing inflation is to stabilize the exchange rate.

The results of this study show that the stock market's growth has not been an essential factor in inflation in the period under investigation. Still, analyzing other variables affecting inflation helps to provide solutions to reduce inflation.

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The Environmental Costs of Sanctions: Global Evidence

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Abstract

Depending on the amount and scope of the sanctions, the application of international sanctions to various countries can have a variety of environmental effects. Sanctions exert pressure on the environment for a variety of reasons, including making it difficult to access technology, destabilizing investment conditions in the field of enhancing productivity and advancing technology, and limiting the government's ability to protect the environment. In this article, we investigate the impact of sanctions on the environment of sanctioned countries. We use the ecological footprint index as a comprehensive index to measure the amount of pressure on the environment and its destruction, and we seek an answer to the question of whether unilateral, multilateral, American, European, United Nations, economic, and non-economic international sanctions increase the intensity of the ecological footprint. In order to assess the research's hypothesis, data from twenty countries subject to sanctions between 1992 and 2018 are utilized. The findings of this study indicate that various intensities of international sanctions have a direct correlation with the ecological footprint index.

Keywords: Dynamic Panel Data, Ecological Footprint, Environment, Sanctions.

JEL Classification: F51, Q01, Q5.

1. Introduction

Globalization is swiftly becoming a condition characterized by the interconnectedness of the economies of all nations. This globalization is based on "interdependence." The globalization of the international monetary and financial system, coupled with mutual dependence, entails dynamic and ever-changing economic, political, cultural, and social developments at the national, regional, and global levels. In such a scenario, all nations are affected by the actions of the others proportionally to their commercial, financial, and economic connections. The imposition of various sanctions against certain nations is one of the measures and policies that have a significant impact on different nations. International sanctions are typically punitive actions taken by a nation, a group of nations, or international organizations against nations that do not adhere to international commitments and

agreements (Doxey, 1996; Lacy and Niou, 2010). These sanctions are frequently imposed by countries with greater economic strength as a means of combating and weakening the political, economic, and military power of the target nation (Pape, 1997). As coercive diplomacy, sanctions are essentially a combination of diplomacy and intimidation. However, all sanctions have punishment as a primary objective. The rationale and logic behind applying economic sanctions can be summed up in three instances: 1) the desire to influence the policies of a government or even alter its regime, 2) the punishment of a government for its policies, and 3) a symbolic display of protest against the target government's policies (Carter, 1987). Regarding the effect of applying economic sanctions on various aspects of the economies of the target countries and their effectiveness in achieving the desired goals, numerous studies have been conducted, including the following: Afesorgbor et al. (2016) examined the effects of economic sanctions on income inequality. Korotin et al. (2018) analyzed the crisis in Ukraine and economic sanctions and their effect on the exchange rate. Mirkina (2018) examined the short- and long-term effects of sanctions on foreign direct investment. Chen et al. (2019) showed the effect of international sanctions on energy efficiency. Early and Peksen (2020) investigated the shadow economy and the effectiveness of economic sanctions in order to explain why democratic nations are more susceptible to sanctions. Nguyen and Do (2021) studied the impact of economic sanctions on Russia's and its 49 trading partners' trade. Wang and Du (2022) investigate the welfare effects of economic sanctions against Russia using general equilibrium model. Gutmann et al. (2022) evaluate the various economic consequences of international sanctions. Pintor et al. (2023) examined the impact of economic sanctions on health and health systems in low-income and middle-income countries. Chen et al. (2023) investigated the effect of assessment of energy sanctions in geo-conflict in the war between Russia and Ukraine. Moteng et al. (2023) explained the mechanisms by which international sanctions affect energy poverty.

While the above-mentioned studies have examined the impact of sanctions on various factors, very few studies have studied the effects of sanctions on the environment. This is despite the fact that imposing economic sanctions and isolating a nation can have direct and indirect effects on that nation's environment as a platform for achieving development. Among the environmental effects of sanctions are restrictions on the import of environmentally friendly technologies, the violation of citizens' right to a healthy environment, the violation of international environmental obligations regarding financial, technical, and scientific aid to the sanctioned country, and the sanctioned nation's inability to improve its environmental quality standards. In fact, economic sanctions, by exerting pressure on national economies, cause environmental concerns to take a

back seat to other concerns (Carussi, 2000). The increase in types of pollution and the country's inability to optimally utilize international capacities have slowed the process of responding appropriately to environmental problems, resulting in a decline in the quality of life and health of the sanctioned nations' citizens.

Madani (2020) and Fu (2020) are the only two studies that focused on the effect of sanctions on the environment. Maddani (2020) designed a casual model for the environmental implications of sanctions. Fu (2020) examined the impact of sanctions on countries' environment using the environmental performance index (EPI). The purpose of this study is to explore the hypothesis that environmental destruction is a result of international sanctions. The main contribution of the present study is to provide an empirical quantitative analysis by using the ecological footprint index as a comprehensive index of environmental issues and ecological efficiency (the ability to regenerate the land and respond to the needs of organisms while preserving resources) and using dynamic panel data regression to investigate the role of the sanctions on the environment. We will also see if this effect varies depending on the seriousness and kind of sanctions. We use information from 20 countries that were subject to sanctions between 1992 and 2018 for this purpose. The ecological footprint index is used to determine how much the environment has been damaged. The ecological footprint index highlights the difficulties that humans face in coexisting with nature and the continuity of life with it. It also demonstrates the impact that each society's way of life has on the environment (Wilson and Anielski, 2005).

The remainder of this paper is organized as follows. Section 2 provides the literature on the subject matter (theoretical foundations and empirical background). Section 3 describes the data and the variables. Section 4 presents the empirical results, and Section 5 closes the paper with concluding remarks.

2. Theoretical Foundations

In order to change a country's policies, a country or group of countries may use sanctions, which are actually coercive measures (Carter, 1992). According to Hufbauer et al. (2012), sanctioning nations frequently have multiple objectives, and sanctions can serve as a warning shot for potential future transgressions by the target nation and other nations. Sanctions affect many economic sectors, including trade, investment, employment, and economic growth, whether or not the ultimate goal is accomplished. The negative consequences of sanctions throughout history for various aspects of the target nation, particularly its economy and way of life are undeniable; the most notable examples are the embargoes on Iraq and Cuba. International sanctions may have an impact on politics in the areas of corruption, democracy, and human rights. According to Peksen's 2009 research, economic sanctions, particularly multilateral sanctions, erode the respect for human rights even more. Additionally, government corruption is correlated with democracy, the

history of the legal system, and the proportion of protesters in the population, and the severity of corruption in sanctioned countries is more intense than in non-sanctioned countries. Sanctions also can harm the labor market by restricting international trade, reducing global energy supply through supply chain effects, reducing investment in the sanctioned country, and limiting the structure and preferences of consumption and production. (Chen et al., 2023).

2.1 Sanctions and the Environment

Changes in trade, production, and other factors connected to these sectors, such as investment and employment, are the most significant ways that sanctions have an effect on a nation's economy. As a result, in a straightforward classification, the three major effects of economic sanctions—export, import, and capital inflow and outflow—can be separated.

It is anticipated that the foreign exchange resources from exports will be disrupted and the merchants will incur significant costs as a result of the imposition of economic sanctions against the financial and export channels of the countries. A low level of export diversification in the target nation, such as in oil-producing nations, makes an export embargo very risky because it increases oil output and hastens the depletion of oil reserves.

On the other hand, the high reliance of production on the import of diverse raw materials, intermediate products, and capital goods is one of the channels that are vulnerable to potential threats posed by sanctions imposed on a country's economy. Even if the sanctions procedures do not result in the cessation of imports, the increase in import costs will increase the cost of domestic production, which will increase domestic prices and reduce the competitiveness of manufactured commodities on international markets. Sanctioning imports can lead to a decrease in the quantity of imports on the one hand, and an increase in the price of imports per unit of that quantity on the other. Reducing imports will decrease the government's revenue from tariffs. Yet, the increase in costs, coupled with the rise in inflation by affecting the production sector, consumption, and government budget, has far greater effects on the domestic economy of the target country, especially when the amount of import cannot be reduced due to the existing structures. By severing or restricting a country's trade relations with the international community, the possibility of achieving a higher level of consumption than domestic production will be lost, and the sanctioned country will move toward importing capital goods, thereby increasing smuggling and currency and capital market instability.

The structure of exports and imports has a decisive effect on the level and condition of a country's environment, so that in developed nations, many safeguard themselves from the entry of any polluting activity. With this work, they alter the negative correlation between income and pollution. Obviously, sanctions on the

export and import obscure the connection between the environment and income because it distorts the connection between production and consumption—for instance, when the production structure of developed countries gradually incorporates clean technology, but their consumption structure remains environmentally destructive. In this way, international sanctions significantly increase energy poverty. Sanctions can increase the price of clean and modern energy through different channels and reduce purchasing power. Because of this, low-income people may not be able to afford modern energy prices, which hinders the reduction of energy poverty and could push most countries to use more conventional energy than clean energy (Moteng et al., 2023).

Moreover, by imposing export and import restrictions, economic sanctions impede the provision of food, safe drinking water, medicine and medical equipment, fuel, etc. in the target country, thereby violating the right to health one of the manifestations of which is the optimal use of environment (Petrescu, 2010; Madani, 2020). The imposition of UN sanctions on Iraq under the moniker “oil for food” is an illustration of the negative effects of sanctions on the right to a healthy environment, which jeopardized the Iraqi people’s lives by creating unfavorable food supply, medical care, water purification, and health services (Al-Sammarrai, 1995).

The inflow and outflow of capital is another path that is significantly impacted by sanctions. Studies indicate that foreign direct investment can affect environmental quality due to its impact on economic growth. Foreign direct investment in developing nations causes an increase in environmental degradation and pollution. This is performed in the form of foreign direct investment, and the result of this type of investment for a country with low environmental standards and low income is an increase in pollution (Amri, 2016; Copland and Taylor (1994).

Figure 1 depicts the influence channels of sanctions on the environment.

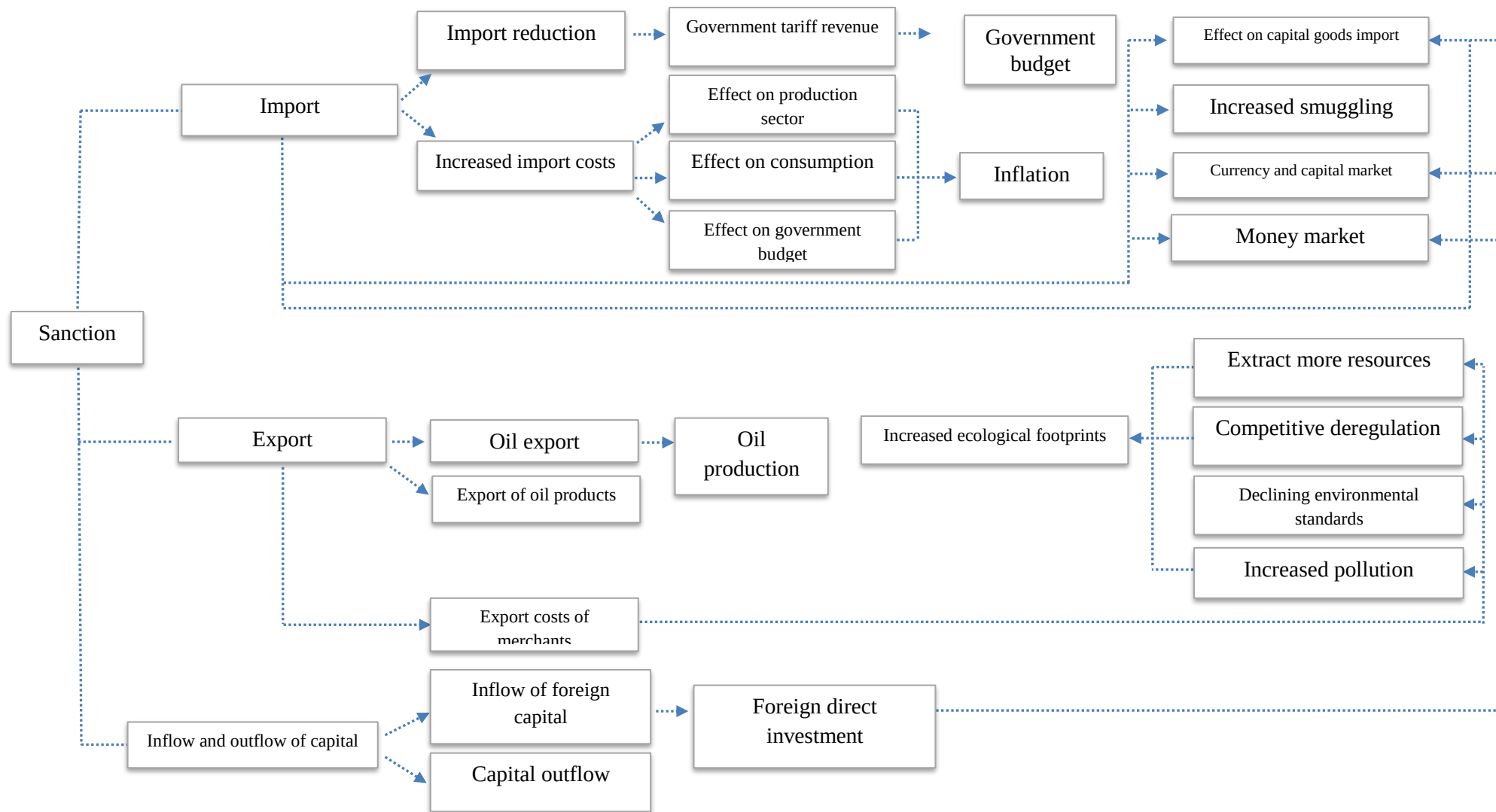


Figure 1. The Impact of Economic Sanctions on Environment
Source: Research finding.

3. Data and Variables

Based on the list of sanctioned countries in the Foreign Assets Control Office and the United Nations Security Council, this paper investigates the effect of sanctions on the ecological footprint of 18 sanctioned countries¹ by studying their data during the years 1992 to 2018. By overcoming the distortions of a small sample, the use of panel data as opposed to a time series approach can prevent a misleading relationship between variables (Granger and Newbold, 1974). In large observations also, taking into account heterogeneity and correlation, it is favored rather than cross-sectional techniques (Wooldridge, 2012). Due to the dynamic nature of the research model, the dependent variable interval is placed as an explanatory variable on the right side of the model. Consequently, based on the research of Yin et al. (2019), the research model is as follows:

$$EF_{it} = \alpha_i + \theta EF_{it-1} + \beta_i \text{Sanction}_{it} + \gamma X_i + \varepsilon_{it} \quad (1)$$

where EF_{it} represents the ecological footprint index of sanctioned nations during period t . Sanction_{it} is considered an international sanctions index (including unilateral, multilateral, American, European, United Nations, economic, non-economic and severity of sanctions). X_{it} represents additional variables that influence the ecological footprint (gross domestic product, consumption, trade liberalization, foreign direct investment, industry, technology, population, and urbanization). ε_{it} is random error terms.

Sanction data was obtained from the databases of the German Institute for Global and Area Studies², Deep Packet Inspection³, and the International Energy Agency⁴, and data related to the ecological footprint index was obtained from the Global Footprint Network website. The World Bank provided information on additional control variables.

The ecological footprint shows information about the pressure and impact of human activity on environmental resources and provides us with the possibility of comparing the demand for resources and the capacity of the earth to respond to this demand. Wackernagel and Rees's (1996) ecological footprint index (EFI) has been taken whose enhanced version is as follows:

$$EF = \frac{P}{Y_n} \quad (2)$$

¹. Belarus, Cameroon, China, Colombia, Guatemala, Haiti, Indonesia, Iran Islamic Rep, Niger, Nigeria, Pakistan, Peru, Russian Federation, Sri Lanka, Thailand, Togo, Turkey, and Vietnam.

². GIGA

³. DPI

⁴. IEA

In order to achieve acceptable results a fixed global unit called the global hectare (gha) is used to compare consumption structures, ecological footprint, and biological capacity. The global hectare is a standard unit for calculating the productivity and efficiency of diverse types of land. Therefore, the aforementioned relationship must be multiplied by the efficiency factor and the equilibrium factor of the land areas to compute the ecological footprint in global hectares[\] (Global Footprint Network Report, 2016).

$$EF = \frac{P}{Y_n} YF.EQF \quad (3)$$

where P represents the amount of product obtained or waste (equal to the annual demand of a type of product). Y_n represents the national return average for P . YF is the yield factor (the ratio of the national average yield per hectare of land to the global average yield for that type of land) for the country and land area type. EQF is the equilibrium factor (representing the relative productivity between land and water types) for the country and the category of land area. According to the type of land use and year, the equilibrium factor is the demand for a specific type of land in the average units of biologically productive areas of the world, which is a constant value in a year for each country. According to the 2018 Global Footprint Network reports, the equilibrium and yield factors per global hectare are provided as an example in the table below.

Table 1. Equilibrium Factor and Efficiency of Different Land Areas

Land type	Equilibrium factor	Efficiency factor
Agriculture	2.52	0.14
Jungle	1.28	1.28
Pasture	0.43	6.19
High seas (seas and oceans)	0.35	-
Built-up land	2.52	7.13
Other water resources (lake, etc.)	0.35	8.13

Source: Global Footprint Network (2016).

Ecological footprint is compared with biological capacity (BC) (the amount of available land, both dry and wet, to provide the required resources and absorb people's waste, expressed in global hectares). It is calculated as follows:

$$BC = AYF.EQF \quad (4)$$

In Equation 4, BC represents the biocapacity (global hectare) and A represents the areas available for a particular land use type in hectares.

In accordance with Portela & Soest (2012), Fu and et al. (2020), our classification of international sanctions includes unilateral, multilateral, United States, European

[\]. Global Footprint Network, Ecological Footprint Atlas (2016)

Union, and economic sanctions. Unilateral sanctions indicate that only the United States or the European Union apply international sanctions. Multilateral sanctions represent sanctions imposed by the United States and the European Union. We also adjust the economic sanctions variable to demonstrate the effect of sanctions on the economy of the target country.

Taylor and Copland (1994) and Kretschmer et al. (2011) utilized the variable of foreign investment (one of the variables conveying development) to analyze the degree of efficiency and environmental degradation. This study measures the impact of foreign direct investment as a control variable on the ecological footprint index. The ratio of net foreign direct investment to GDP is used for this purpose.

The use of the GDP index as a fundamental variable in calculating the rate of economic growth and measuring a country's level of development can have negative environmental effects. In pursuit of economic growth, various nations will make greater use of their environment; consequently, the pressure they exert on the environment will increase. Following Yang et al. (2010), Zhang et al. (2015), Yu and Liu (2016), who utilized the GDP index as a measure affecting the relationship between environmental degradation and efficiency, in this paper we employ GDP per capita (constant 2015 US dollars) in sanctioned nations. Population is a significant contributor to environmental pollution, particularly the rise in the emission of air pollutants like CO₂ (Zhao et al., 2005). Continuous population growth are a worsening of ecological conditions and a worsening of environmental pollution. Consequently, we use the total population as a control variable that influences the ecological footprint. As a result of rising consumption and GDP, trade liberalization will increase exports and imports, which may increase the ecological footprint. Therefore, it will have a negative impact on the environment (Chang et al., 2015). As a trade liberalization variable, we use exports plus imports as a percentage of GDP in this study. Consumption is one of the fundamental factors in calculating the ecological footprint of societies, so it follows that people will need to consume more resources to provide consumer products, services, and infrastructure (in the form of companies). As a result, the quantity of ecological footprint will increase as consumer spending rises. In fact, final consumption expenditures are expenditures made on consumer products that generate benefits in the present. In this study, final consumption expenditures are expressed as a percentage of gross domestic product. Urbanization is a significant contributor to environmental pollution, particularly the increase in emissions of air pollutants such as carbon dioxide (CO₂) (Poumanyvong and Kaneko, 2010; Zhao et al., 2006). The deterioration of ecological conditions and the worsening of environmental pollution are the results of the continuous growth of the urban population and the expansion of the urban scale. Therefore, we use the urbanization variable, which is measured by the ratio of urban population to total population, as a control variable. All the knowledge, processes, tools, products, methods, and

systems used in the production of goods or services constitute technology. Improving the quality of the environment in various countries requires a focus on environmentally friendly technologies. In the meantime, the imposition of sanctions can restrict the sanctioned country's access to these technologies, which contribute to the destruction of the environment. In fact, the quality of the sanctioned country's environment will deteriorate as a result of a variety of economic sanctions that reduce the level of sustainable development and damage environment, as well as the target country's decreased concern for the environment and its lack of access to green technologies and assistance from developed nations. Environmental impact of the industrialization structure is controversial. According to Wang et al. (2010), Yang et al. (2010), Yu and Liu (2016), an increase in industrialization leads to a decline in environmental performance and, thus, environmental degradation. While Meng and Dai (2016), Hu and Li (2012), noted that the proportion of industrial value added to GDP has a positive effect on environmental efficiency because it contributes to the growth of GDP. Hence, the industry may result in a larger ecological footprint. Therefore, we use the industry variable (the percentage of industrial value added to GDP) in this study.

According to Table 2, the average number of unilateral and multilateral sanctions is 0.18 and 0.16, respectively, indicating that there are slightly more unilateral sanctions than multilateral sanctions. The United States imposes more sanctions on average (0.30%) than the European Union (0.16%) and the United Nations (0.04%) which is in line with Neuenkirch and Neumeier (2015). The average economic and non-economic sanctions are 0.34 and 0.008 respectively, indicating that the majority of sanctions are economic. The average intensity of international sanctions is 1.18, indicating that the majority of sanctions are moderate. The standard deviation of GDP is 1.45, with a minimum of 9.83 and a maximum of 1.39, indicating that the level of economic development among the target countries varies significantly. Comparing the upper limit and lower limit of the variables of foreign direct investment, population and urbanization, consumption, trade liberalization, technology and industry leads to the conclusion that the target countries differ greatly in terms of the value of foreign direct investment, population and urbanization, the balance between consumption and production, the level of technology and industry, and trade liberalization.

Table 2. Descriptive Statistics

Variable	Mean	Median	Max	Min	Std.Dev	Skewness	Kurtosis	Jarque-Bera	Prob
Efi	-0.596864	-0.53446	0.669397	-3.63978	0.874264	-1.07135	4.511061	139.2087	0.0000
Consumption	285000000000	68300000000	7650000000000	871000000	805000000000	6.156203	45.42772	37245.08	0.0000
Fdii	2.17206	1.692558	18.81778	-5.0882	2.226709	1.762876	11.37892	1669.962	0.0000
Gdp	444000000000	82400000000	13900000000000	983000000	1450000000000	6.479433	48.46721	45169.66	0.0000
Industry	30.29682	28.88444	49.63725	14.59647	8.348895	0.371794	2.395571	17.56166	0.0000
Population	134000000	52705001	1400000000	3945902	290000000	3.604404	14.77572	3860.348	0.0000
Technology	25.94695	24.91915	50.52867	1.819031	11.92967	-0.12326	2.000126	20.28236	0.0000
Trade	56.44011	47.26435	157.9743	20.72252	28.7527	1.638287	4.94192	277.4461	0.0000
Urban	48.14395	45.9735	80.778	15.529	19.478898	0.060263	1.78752	30.06384	0.0000
Unilateral	0.18107	0.0000	1.0000	0.0000	0.385473	1.656452	3.743833	233.4545	0.0000
Plurilateral	0.168724	0.0000	1.0000	0.0000	0.374894	1.769124	4.1298	279.3618	0.0000
Us	0.304527	0.0000	1.0000	0.0000	0.460681	0.849502	1.721654	91.54587	0.0000
Eu	0.166667	0.0000	1.0000	0.0000	0.373062	1.788854	4.2	288.36	0.0000
Un	0.043321	0.0000	1.0000	0.0000	0.203539	4.493108	21.18802	8334.011	0.0000
Economic	0.341564	0.0000	1.0000	0.0000	0.474723	0.668177	1.446461	85.03638	0.0000
Intensity	1.183128	0.0000	5.0000	0.0000	1.766061	1.092248	2.650778	99.10308	0.0000
Non-Economic	0.00823	0.0000	1.0000	0.0000	0.090441	10.88615	119.5083	284476.4	0.0000

Source: Research finding.

Table 3. Panel Unit Root Test

Variable	ADF			PP			LLC			IPS		
	statistic	prob	Situation	statistic	prob	Situation	statistic	prob	situation	statistic	Prob	situation
Lefi	74.0675	0.0002	I (0)	101.715	0.0000	I (0)	-5.65897	0.0000	I (0)	-8.01931	0.0000	I (0)
Lconsumption	213.93	0.0000	I (1)	217.95	0.0000	I (1)	-14.6096	0.0000	I (1)	-13.2822	0.0000	I (1)
Lfdii	94.1707	0.0000	I (0)	82.5546	0.0000	I (0)	-4.68286	0.0000	I (0)	-5.47486	0.0000	I (0)
Lgdp	221.552	0.0000	I (1)	231.73	0.0000	I (1)	-14.2096	0.0000	I (1)	-13.3864	0.0000	I (1)
Lindustry	252.176	0.0000	I (1)	49.2156	0.0000	I (0)	-16.216	0.0000	I (1)	-1.66324	0.0000	I (0)
Lpopulation	215.695	0.0000	I (0)	158.481	0.0000	I (0)	-9.01759	0.0000	I (0)	-20.5358	0.0000	I (0)
Ltechnology	76.6419	0.0000	I (0)	126.374	0.0000	I (0)	-4.14094	0.0000	I (0)	-4.25122	0.0000	I (0)
Ltrade	75.9119	0.0000	I (0)	76.8159	0.0000	I (0)	-3.74063	0.0000	I (0)	-3.92009	0.0000	I (0)
Lurban	216.842	0.0000	I (0)	156.829	0.0000	I (0)	-67.805	0.0000	I (0)	-72.1023	0.0000	I (0)

Source: Research finding.

4. Empirical Results

4.1 Panel Unit Root Tests

To conduct a unit root test, we use the statistics of Fisher-ADF, Fisher-PP (Maddala and Wu, 1999), LLC and IPS (Levin et al., 2002; Im et al., 2003) for the research variables except for international sanctions that is virtually inserted into the model. According to the data in Table 3, the variables for ecological footprint, foreign direct investment, technology, trade liberalization, and urbanization are at stationary level, while the variables for GDP and consumption have been stationary by one time differentiation. The industry variable is stationary at level with the PP and IPS statistics, but it has a common unit root with the ADF and LLC statistics, so it will be stationary with one time differentiation.

4.2 Estimation Results

In this research, we employ the generalized method of moments developed by Arellano and Bond (1991) to estimate the dynamic panel model. Since the dependent variable in the dynamic panel model is dependent on the error term, we use the second lag of the dependent variable and the lags of other variables in the form of a recursive form as a tool for the dependent variable lag based on the generalized method of moments. Therefore, it is regarded as the most appropriate instrument variable in circumstances where: the error term lacks serial correlation, follows a moving average process of a specific order, and the future value of the dependent variable has no impact on the explanatory variables' present values. The reliability of the employed tools determines the consistency of dynamic panel estimators. This is assessed using the Sargan Test.

The model estimation findings are shown in Table 4. American, European, United Nations, unilateral, multilateral, economic, and non-economic sanctions all have positive, statistically significant coefficients. In this manner, the research's hypothesis regarding the influence of global sanctions and the severity of different types of sanctions on the ecological footprint index is confirmed. The results of this study are consistent with Fu et al. (2020) and Madani (2020) show that international sanction harms the environment of targeted countries.

Based on additional findings, the coefficients of GDP, population, trade liberalization, and foreign direct investment of consumption and industry all have positive and significant correlations with the ecological footprint index, which is to be anticipated. Additionally, there is a negative and significant correlation between the two variables of urbanization and technology.

Table 4. Model Estimation Results

variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
LCONSUMPTION	1.787581* (0.018771) [0.0000]	1.733542* (0.019485) [0.0000]	1.924756* (0.017565) [0.0000]	1.543822* (0.012392) [0.0000]	1.704724* (0.010654) [0.0000]	1.828014* (0.070573) [0.0000]	1.741778* (0.038258) [0.0000]	1.722258* (0.011032) [0.0000]
LFDII	0.150766* (0.000617) [0.0000]	0.159177* (0.000482) [0.0000]	0.151886* (0.000579) [0.0000]	0.145521* (0.000393) [0.0000]	0.148436* (0.000378) [0.0000]	0.157866* (0.001146) [0.0000]	0.157539* (0.001017) [0.0000]	0.135983* (0.000645) [0.0000]
LGDP	1.559252* (0.021281) [0.0000]	1.52626* (0.020987) [0.0000]	1.763939* (0.019270) [0.0000]	1.315159* (0.013434) [0.0000]	1.482891* (0.011697) [0.0000]	1.599084* (0.074988) [0.0000]	1.520137* (0.042996) [0.0000]	1.496855* (0.014260) [0.0000]
LINDUSTRY	0.735064* (0.006630) [0.0000]	0.869338* (0.006369) [0.0000]	0.923145* (0.006310) [0.0000]	0.81927* (0.005779) [0.0000]	0.681399* (0.007683) [0.0000]	0.87126* (0.016130) [0.0000]	0.942627* (0.007051) [0.0000]	0.263418* (0.006759) [0.0000]
LPOPULATION	1.539265* (0.034352) [0.0000]	1.872081* (0.029680) [0.0000]	2.023811* (0.016388) [0.0000]	1.916491* (0.036324) [0.0000]	1.46361* (0.038001) [0.0000]	1.864127* (0.055301) [0.0000]	1.988236* (0.050653) [0.0000]	0.938749* (0.031327) [0.0000]
LTECHNOLOGY	-0.18828* (0.004752) [0.0000]	-0.2509* (0.002836) [0.0000]	-0.13866* (0.005702) [0.0000]	-0.06434* (0.003624) [0.0000]	0.211926* (0.003697) [0.0000]	-0.06894* (0.007397) [0.0000]	-0.1106* (0.006821) [0.0000]	-0.43008* (0.009314) [0.0000]
LTRADE	.0152502* (0.006903) [0.0000]	0.368859* (0.003124) [0.0000]	0.387574* (0.003955) [0.0000]	0.224751* (0.003880) [0.0000]	-0.10105* (0.007612) [0.0000]	0.36379* (0.013134) [0.0000]	.0399532* (0.006062) [0.0000]	0.265293* (0.265293) [0.0000]
LURBAN	-1.80851* (0.052420) [0.0000]	-1.99628* (0.056570) [0.0000]	-1.60648* (0.038492) [0.0000]	-2.01021* (0.070355) [0.0000]	1.773119* (0.029690) [0.0000]	-1.78192* (0.048540) [0.0000]	-1.62476* (0.080834) [0.0000]	1.640408* (0.049952) [0.0000]
UNILATERAL	0.151158* (0.002032) [0.0000]							
PLURILATERAL		0.500657* (0.003466) [0.0000]						
US			0.487463* (0.002221) [0.0000]					
EU				0.5284* (0.004069) [0.0000]				
UN					0.195546* (0.012921) [0.0000]			
ECONOMIC						0.458287* (0.458287) [0.0000]		
INTENSITY							0.137096* (0.000744) [0.0000]	
NON-ECONOMIC								18.77682* (2.225057) [0.0000]
J-STATISTIC	216.3587	215.7184	213.8993	217.6692	208.2136	212.0049	217.9005	210.6978
PROB(J-STATISTIC)	0.648455	0.65989	0.708206	0.624713	0.782383	0.723481	0.620481	0.744554

Source: Research finding.

Note: Standard error is written in parenthesis, prob. value is written in brackets, and * shows 1% level of significance.

According to the Sargan test, PROB (J-STATISTIC) is 0.64 for unilateral sanctions, 0.65 for multilateral sanction, 0.7 for American, 0.62 for European, 0.78 for UN, 0.72 for economic, and 0.62 for noneconomic sanctions, and 0.74 for sanction severity that are higher than 0.05, indicating the significance of the total regression.

5. Conclusion

In the economic literature and according to the Pollution Haven Hypothesis, countries with capital (primarily developed countries) tend to transfer their capital in polluting industries to countries with a lower commitment to environmental protection. It is accomplished through direct foreign investment and trade liberalization. In the estimation of the model, foreign direct investment and the trade liberalization variable have a positive and significant effect on the ecological footprint in embargoed nations. Embargoed countries, due to factors such as lack of active presence in the economy and global competition, lack of security and political stability, legal and political obstacles, inefficiency of the banking and monetary system, and pervasive corruption, are compelled to seek foreign direct investment from unsuitable business partners. It turns out that there is a high risk that the efforts of the target countries to achieve economic development will result in environmental degradation. In addition, when countries deregulate competition to reduce the costs of environmental regulations, unrestricted trade may lead to a general decline in international environmental standards. As the majority of sanctioned countries are exporters of raw materials and importers of processed goods, which is the transfer of dirty (polluting) industries, less stringent environmental regulations in a country disrupts the relative cost of production among other trading partners in this instance. The pollution haven hypothesis suggests that environmental regulations may have dynamic effects on capital flows and encourage the relocation of polluting industries to nations with less stringent environmental regulations. In this approach, export-driven economic growth resulting from free trade agreements and foreign direct investment encourages the exploitation of natural resources at an unsustainable rate. Therefore, trade liberalization and foreign direct investment result in the growth of more polluting industries in embargoed nations and increase the pressure on resources, thereby increasing the ecological footprint. The majority of sanctioned nations are developing or underdeveloped nations with a large population, taking into account that the use of natural products and services to meet the requirements of life and ensure the continuation of life will have an effect on the planet. As a result, as the population of a region increases, the ecological footprint of that region will increase and fewer resources will be available; consequently, the population variable coefficient has a positive significant effect on the increase of the ecological footprint, as determined by the model estimation. Similarly, given that the activities and efforts of countries to increase their GDP take place in the context

of the environment; in order to achieve more economic development in a variety of ways under the conditions of sanctions, the aforementioned nations must use more resources. As a consequence, the impact on the environment will increase, as will the ecological footprint. Thus, there will be a positive relationship between the GDP index and the increase in the ecological footprint. Moreover, one of the fundamental factors in calculating the ecological footprint of societies is their consumption, so it can be concluded that governments and individuals need to increase their consumption in order to provide consumer products, infrastructure, and services. Hence, the ecological footprint will increase as consumption rises.

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Examining the Relationship between “Knowledge-Based Capital” and “Output per worker” in Iran’s Manufacturing Sector

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Abstract

Researches show that knowledge-based capital (KBC) plays a significant role in modern economies, with this non-tangible type of capital being the greatest form of business investment and a major contributor to economic growth in advanced economies. Despite its importance as an important driver of economic growth, there are not enough researches that focus on the role of KBC in developing countries, so this paper aims to examine the relationship between KBC and Output per worker in Iran’s manufacturing sector. To achieve this, we utilized a two-step estimation method; in the first step, we estimated KBC as a latent variable in the Iranian manufacturing sector using exploratory factor analysis. In the second step, we examined the relationship between KBC and Output per worker in Iran’s manufacturing sector using a panel data regression analysis. Our findings indicate that KBC plays no significant role in Iran’s manufacturing sector. A probable explanation of lower level of complexity in manufacturing sector of Iran is that the sector is not enough developed to need such factors to produce innovative and knowledge-based products, so, the knowledge-based capital has not a significant role in that. In another words, the manufacturing sector in Iran is yet equipment based and more relies on primary materials rather than high level knowledge-based factors.

Keywords: Exploratory Factor Analysis, Knowledge-Based Capital (KBC), Manufacturing Industries, Output.

JEL Classification: E22, O34.

1. Introduction

Recent economic literature is replete with words such as intangible capital, intellectual capital, knowledge-based capital (KBC), etc. In fact, these words have the same meaning and refer to a certain type of capital with two distinguishing

qualities (see for example, Ewens et al., 2025; OECD, 2013; Chahal and Bakhshi, 2016). As implied by the phrases intellectual and intangible, this type of capital is non-physical. Second, it is knowledge-based; therefore, KBC is a form of capital that is both intangible and unphysical and, as its name suggests, is based on knowledge that is gaining increasing relevance in modern, developed economies. In recent decades, KBC investment in developed economies has outpaced physical capital investment (machinery, equipment, and building). As seen in Figure 1, the aging population and natural resource restrictions in these countries have pushed them toward production enhancement methods and expanding economies, both of which are dependent on expanding innovations. These are referred to as endogenous growths in the growth literature, with investments in knowledge and innovation being the primary factors.

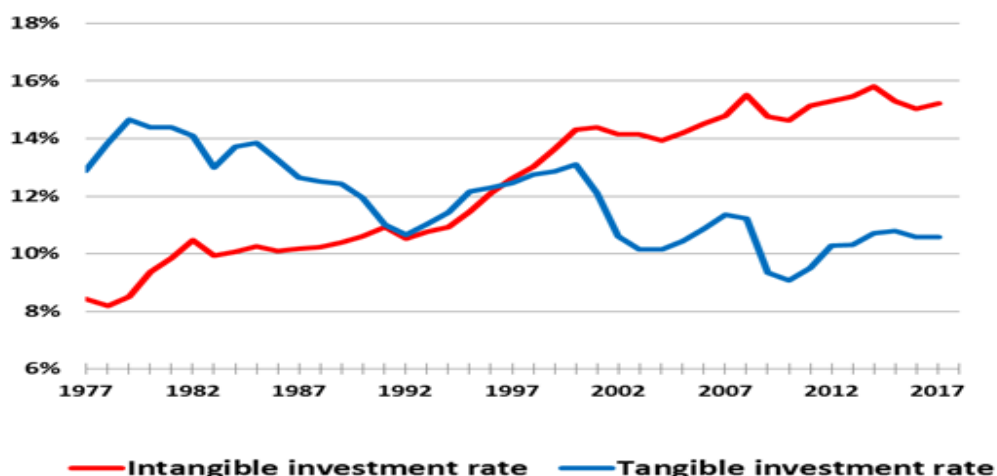


Figure 1. U.S. Investment, 1977 - 2017 (Nonresidential Business Investment Relative to Business Sector Gross Value Added)

Source: INTAN-Invest.

As stated previously, one of the primary characteristics of KBC is its intangibility, which makes its measurement problematic. In recent years, a great deal of research has been conducted to overcome this obstacle. In general, numerous scholars examine the subject of quantifying KBC at the country, industry and firm levels (Corrado et al., 2005), the pioneering study on the measurement of KBC, contributes to the solution by providing a stable framework for measuring KBC at the country level. Unlike efforts to assess KBC in developed countries, nothing is done in developing countries such as Iran. In the majority of developing

countries, there is no definition of KBC in national accounts, making data collection nearly impossible.

Even though a great deal of study has been conducted at the micro level, it would be nearly impossible for a researcher to investigate KBC at this level due to data collection difficulties. Examining corporate balance sheets is a crucial aspect in measuring KBC at the firm level, as demonstrated by Ewens et al. (2025), who use the corporate incorporation method, based on balance sheet information, to estimate intangible capital at market prices. See also Marrocu et al. (2011), in which the authors evaluate the effect of intangible capital on firm-level productivity in six European countries using balance sheet data of firms for the period 2002 to 2006 and capitalizing intangible assets as intangible capital.

In developing countries such as Iran, however, we do not have access to reliable balance sheet information that may be utilized for KBC estimate. Furthermore, when it comes to intangible assets, Iran has poor accounting standards. Due to difficulties in collecting data at both the micro and macro levels in Iran, we examine KBC at the industry level in this work.

Moreover, the most influential, fundamental, and prominent works KBC have focused on developed countries while a few, do this for developing economies. This might have roots in weak databases in developing countries. In this research, we are going to study KBC in Iran as a developing country to fill the existing gap.

This paper investigates the relationship between KBC and Output per worker in Iran's manufacturing. As there is no information about KBC regardless of the level of analysis, we must first estimate KBC in the manufacturing sector before examining its relationship with Output per worker. Consequently, this is a two-step estimation process in which we will first estimate KBC in manufacturing using exploratory factor analysis. In the second step of estimation, we use the estimated KBC as an explanatory variable to investigate the link between KBC and per capita production using a fixed-effect cross-section weighted panel data regression technique.

2. Knowledge-based Capital (KBC)

The last decades have witnessed dramatic growth in the economic (and social) importance of knowledge and learning (OECD, 2013; Stiglitz and Greenwald, 2014; Thelen, 2019). Knowledge-based or intangible capital like skills, patents, know-how, software or databases have become essential for surviving and thriving in today's economies (Haskel and Westlake, 2017).

KBC is a collection of assets that provide future benefits for firms. In contrast to machines, equipment, vehicles, and structures, however, these assets are not physical. This non-tangible form of capital is, increasingly, the largest form of business investment and a key contributor to growth in advanced economies (OECD, 2013).

According to a widely accepted classification, we can group KBC into three types:

- **Computerized information** (software and databases);
- **Innovative property** (patents, copyrights, designs, trademarks);
- **Economic competencies** (including brand equity, firm-specific human capital, networks of people and institutions, and organizational know-how that increases enterprise efficiency).

Table 1 sets out knowledge-based capital in three different classes.

Table 1. Classification of the Forms of KBC

Type of KBC asset	Type of knowledge-based capital
Computerized information	Knowledge embedded in, computer programs and computerized databases
Software	
Databases	
Innovative property	Knowledge acquired through scientific R&D and nonscientific inventive and creative activities
Research & Development	
Mineral explorations	
Copyright and creative assets	
New architectural and engineering designs	Knowledge embedded in firm-specific human and structural resources, including brand names
Economic competencies	
Brand-building advertisement	
Market research	
Worker training	
Management consulting	
Own organizational investment	

Source: OECD (2013); Corrado et al. (2005).

Table 1 offers a widely accepted definition of KBC; however, one can choose other classifications depending on a particular case study. For example, Chahal and Bakshi (2016) categorized intellectual capital into human capital, structural capital, and relational capital. In another case (Ewens et al., 2025) split intangible assets into knowledge and organizational capital.

In addition, Romer (2012) defines learning-by-doing as a factor of knowledge accumulation in his book and says: “The central idea is that, as individuals produce goods, they inevitably think of ways of improving the production process. For example, Arrow (1962) cites the empirical regularity that after a new airplane design is introduced, the time required to build the frame of the marginal aircraft is inversely proportional to the cube root of the number of aircraft of that model that has already been produced; this improvement in productivity occurs without any evident innovations in the production process. Thus, the accumulation of knowledge occurs in part not as a result of deliberate efforts, but as a side effect of conventional economic activity. This type of knowledge accumulation is known as *learning-by-doing*”.

3. Literature Review

KBC measurement is a novel and complex issue that has recently appeared in the literature with Corrado et al. (2005) as one of the pioneer publications in the issue. Corrado et al. (2005) measured KBC according to the USA growth accounting framework where they added a time dimension to Solow’s growth accounting framework and defined capital as any use of resources in a way that increases the future consumption at the expense of today’s consumption. Hence, they take expenditures on intangible assets including R&D, copyright, movies, databases, and improved organizational structures, brand equity, and so on as investment items. To measure KBC, they collected data on expenditures on intangible assets according to the USA national accounting definitions. The results indicate that while investment in intangibles in the business is equal to that on tangibles, a large portion of this type of investment is not reflected in the USA’s national accounts. The findings also show that including intangible investment in national accounts could raise the average growth rate of real product and labor productivity in the late 1990s. Corrado et al. (2009), in line with the former literature, incorporated intangible capitals in the standard growth resources model (which has been used by BLS) and found that this adaption meaningfully changes the growth pattern in the united states, so that the rate of labor production change increases quickly and capital deepening becomes the dominant force in the labor productivity growth.

Therefore, the role of multifactor productivity has decreased proportionally whereas labor share of income has noticeably increased in the recent half a century. Corrado et al. (2017), following the preceding research, while reviewing the literature on measuring KBC, estimated it across the Europe union and the united states based on their own expanded model in his 2005 paper. They also provided a

summary of recent empirical evidence about the role of intangible capital as a stimulus for the growth of sectors and industries for all Europe Union countries and the United States to come up with examples of intangible assets` data applications. Van Ark et al. (2009) studied measurement methods of intangible capital and its share in economic growth using a comparison of investment in intangibles internationally and the degree to which this investment is embedded in 11 developed countries. They found that intangible assets have a comparatively large impact on economic growth in a way that, according to the study, they roughly account for one-fourth of productivity growth in the United States and big countries of Europe.

However, research on KBC is not limited to the macro level and there are several studies on the micro level. For example, Chahal and Bakshi (2016) measured KBC in the banking system of India as a developing country to stress the importance of KBC. They distributed questionnaires in 144 branches of 21 commercial private and public banks where due to the high level of experience and knowledge among the branch managers. The questionnaires were given to 3 executives and one senior manager of each branch. They used the confirmatory factor analysis method and also took human capital, relational capital, and structural capital as three dimensions of KBC. The results confirm that the whole dimensions of KBC have significant effects on it though relational capital has the most impact comparatively and human capital stands next to it.

Besides KBC measurement, much research has been done on the impact of KBC on economic growth and productivity at the macro, micro, industry, and firm level. At the macroeconomic level, Phale et al. (2021) examined the effects of pillars of a knowledge-based economy on economic growth in South Africa from 1998 to 2018 using a Cobb-Douglas production function and World Bank knowledge-based economy framework. Using a multivariate panel data model, they estimated both dynamic and static long-run relations which show government effectiveness, saving adjusted on education expenditures, tertiary enrollment, technical and scientific journals, and mobile cellular subscriptions positively impact economic growth. The findings indicate that the innovation pillar is the most influential element that affects economic growth and next to it are education, skill, and information and communication infrastructures. In addition, Abdih et al. (2006) empirically investigated the knowledge production function by looking for cointegration relations. They found two long-run cointegration relations where the first depicts long-run production function and the second points to a long-term, positive relationship between total factor productivity and knowledge stock.

Following the importance of intangible investment on productivity growth in developed economies, Corrado et al. (2014) set out intangibles investment data by industry for 14 EU countries in 1995-2010 and industry growth accounting incorporating these data for 8 countries. The results show that though intangible investment has increased in the service and manufacturing sectors, the increase has been more intense in the service. According to the other findings, intangible assets have the same share in labor productivity growth in both sectors, service, and manufacturing, and in developed countries, this share exceeds the effect of improved labor quality. Corrado et al. (2014) also showed that, in countries with high economic growth, those with good performance in both manufacturing and service have in general experienced higher productivity growth. Finally, they observed that countries with very low TFP (which stands for total factor productivity) growth have low labor productivity growth. One of the papers examining intangible assets' impact on productivity growth is Crass, Peters (2014). They simultaneously compare the effects of innovative capital, human capital, branding capital, and organizational capital on productivity and looked for complementarity or substitutability between these types of capital. The results indicate that human capital and branding capital have a noticeable, positive impact on productivity whereas licenses and patents have a slight influence on raising productivity; likewise, the same is true for organizational capital. The authors also found several complementarities between different kinds of intangible assets. Another study by Siedschilage (2019) looks into the representativeness of firm productivity to investment in knowledge-based capital including a range of intangible assets such as R&D, intellectual property assets, computer software, organizational, and branding capital in Ireland, a small open economy. This study gets rid of the representative firm assumption and takes into account the heterogeneous behavior of firms that differ with respect to size, export participation, and type of sector they are active in. Based on the findings, simultaneous investment in any type of KBC, has complementary and substitutionary effects on a firm's productivity and these patterns of correlation are different among different kinds of firms and sectors.

Felix (2019) reviewed the literature on the effect of investment in intangible assets on labor productivity growth at the country, industry, and firm levels. They concluded that investment in intangible assets has gained increasing importance in explaining the dynamics of labor productivity.

To end our discussion in this section, we look into mechanisms through which KBC impacts economic growth. There exists much research on this topic,

especially OECD (2013), a comprehensive study that focused on the relationship between KBC, reallocation, and productivity growth. The report vividly shows that how providing basis and factors (competition, trade specialization, institutional capacities, production factors stock, and knowledge infrastructure) affects investment in KBC and leads to productivity growth in an economy. According to this report, firms' investment in KBC would result in efficient allocation and productivity growth. With respect to technology, firms are either on the frontiers of technology or far from it, hence competition pressures would end up in the continuation of firms' innovative activities keeping them on the boundaries of technology. Aghion and Howitt (1992) believe that when exposed to competitive pressures, firms continue their innovative activities to stay on the frontiers of expanding new and innovative technologies. On the other hand, for firms far from the frontiers, investing in KBC is crucial since those who have done a poor job in this area might be forced to descale or exit the market which in turn frees up resources for the firms producing with the most efficient technologies. Eventually, through this mechanism, firms with the highest productivity would gain the largest market shares; a fact that ends in efficient resource allocation (Olley and Pakes, 1996). Riley and Robinson (2011) examined the relationship between intangible assets and economic growth from different angles and illustrate that intangible assets affect, both directly and indirectly, the production process through innovation. According to this study, taking intangible assets as a production factor first enhances productivity at the firm level and then, by improving firms' performance due to incorporating intangible assets into the production process, increases the economy's performance at both sectoral and regional levels which finally results in a raise in productivity in national accounts and economic growth.

Note that Research on the KBC is not restricted to the areas described above. For example, Seidl (2023) concentrated on the role of public investments and the organization of societies on the formation of KBC. He found that corporatist countries invest a lot more in knowledge-based capital, and corporatism also affects how countries react to deindustrialization. This is an important finding given the key role of long-term policy making in areas like climate change politics, pandemic preparedness or responding to the digital transformation. Also, Lasinio et al. (2019) investigated the role of knowledge-based capital for participation and value appropriation in global value chains (GVC) for a sample of European countries over 1995–2011. They find that knowledge-based capital is positively correlated with participation and value appropriation along the value chain.

4. Model Specification

Our empirical model is based on the production function of the firm, as technical possibility of the firm. According to the literature, we conjecture that, KBC as a form of capital will affect firms' technology from the production function channel. To analyze the role of KBC in the industry, our approach is to investigate its role in industrial production function as a factor. So, following Di Ubaldo and Siedschlag (2021) as well as Crass and Peters (2014), the Cobb-Douglas production function is as follows:

$$Q_{it} = A_{it} L_{it}^{\alpha_l} M_{it}^{\alpha_m} C_{it}^{\alpha_c} K_{it}^{\alpha_k} e^{\varepsilon_{it}} \quad (1)$$

Q_{it} : is output (real value added) in industry i at time t ;

A_{it} : are exogenous factors (other than factors of production) that affect output in industry i at time t ;

L_{it} : is number of labors in industry i at time t ;

M_{it} : is raw material in industry i at time t ;

C_{it} : is physical capital accumulated in industry i at time t ;

K_{it} : is KBC accumulated in industry i at time t ;

e_{it} : is stochastic shock to output in industry i at time t ;

$\alpha_l, \alpha_m, \alpha_c$ and α_k : the output elasticities of inputs.

To model we assume that A_{it} can be decomposed as follow:

$$A_{it} = \theta_i u_t \quad (2)$$

where u_t is exogenous factors that affect production function at levels above the industry, such as macroeconomic conditions (invariant to i but variable at the time dimension t), and θ_i and industry-specific factors other than inputs.

Put A_{it} in Equation 1 and take the logarithm to obtain the following equation:

$$q_{it} = \theta_i + u_t + \alpha_l l_{it} + \alpha_m m_{it} + \alpha_c c_{it} + \alpha_k k_{it} + \varepsilon_{it} \quad (3)$$

Within which small letters denote the respective log values of output and inputs in industry i at time t , ε_{it} is the error term which accounts for unobserved shocks and measurement errors.

Output per worker is obtained from equation 3 as follows:

$$q_{it} - l_{it} = \theta_i + u_t + (\alpha_l - 1) l_{it} + \alpha_m m_{it} + \alpha_c c_{it} + \alpha_k k_{it} + \varepsilon_{it} \quad (4)$$

Equation 4 can be further written as follows:

$$q_{it} - l_{it} = \theta_i + u_t + (\alpha_l + \alpha_m + \alpha_c + \alpha_k - 1)l_{it} + \alpha_m(m_{it} - l_{it}) + \alpha_c(c_{it} - l_{it}) + \alpha_k(k_{it} - l_{it}) + \varepsilon_{it} \quad (5)$$

Assuming constant returns to scale assumption, $\alpha_l + \alpha_m + \alpha_k + \alpha_c = 1$, Equation 4 becomes:

$$q_{it} - l_{it} = \theta_i + u_t + \alpha_m(m_{it} - l_{it}) + \alpha_c(c_{it} - l_{it}) + \alpha_k(k_{it} - l_{it}) + \varepsilon_{it} \quad (6)$$

$q_{it} - l_{it}$: Output per worker of industry i at time t ,

$m_{it} - l_{it}$: material per worker in industry i at time t .

$c_{it} - l_{it}$: physical capital per worker in industry i at time t ;

$k_{it} - l_{it}$: knowledge-based capital per worker in industry i at time t ;

To complete Equation 6, u_t , and θ_i must be specified. For u_t , we can employ variables GDP growth and economic openness as macro-level exogenous industry-determining factors denoted by GDP and Openness¹, respectively. θ_i , represents industry-specific variables that do not change over time but differ by industry. The empirical regression equation can be expressed as follows:

$$q_{it} - l_{it} = \theta_i + \alpha_m(m_{it} - l_{it}) + \alpha_c(c_{it} - l_{it}) + \alpha_k(k_{it} - l_{it}) + \alpha_1 openness + \alpha_2 Gdp + \varepsilon_{it} \quad (7)$$

5. Empirical Strategy

5.1 Dataset

Our econometric framework has a two-stage structure in which we estimate KBC in the first stage and use this estimation as a variable in the second. In the majority of developing countries, including Iran, there is no complete and reliable database about science and technology, but we can estimate knowledge-based capital using other databases. The Iranian statistical center publishes a comprehensive database for Iranian manufacturing firms which covers International Standard of Industrial Classification (ISIC) codes up to 4-digit, covering firms that have 10 and more employees. Due to changes in ISIC version over time, 4-digit codes have deficiencies, including changes in code definitions; so, we choose to use 2-digit ISIC codes (containing ISIC codes 10 to 33) to estimate our regression equation and the KBC for each 2-digit manufacturing code. Our dataset covers the years 2002 to 2018. In the second stage, following the estimation of KBC, we evaluate the influence of KBC on Output per worker at the industrial level. To accomplish this, we specify the production function with precision and estimate the final model. We chose the manufacturing sector because, unlike other sectors, not only

¹. See for example, Wong (2009); Umoh and Effiong (2013).

is there sufficient information available, but it also contains the necessary level of detail for this analysis.

5.2 Estimation of KBC

To estimate KBC, we have adopted the exploratory factor analysis (EFA) method. As to why we took EFA approach, it suffices to say that KBC is intangible so we can treat it as a latent factor in the factor analysis method. EFA method aims to discover some details about the nature of independent variables influencing the dependent variable, which is unobservable directly but can be traced out by observable variables. The main idea in the exploratory factor analysis is that, although KBC is not observable directly, its footprint can be traced out in variables correlated with it. There exist similar papers using factor analysis to measure KBC, for example, Chahal and Bakshi (2016) estimated KBC in India's banking sector using the confirmatory factor analysis method.

In the exploratory factor analysis, it is necessary to choose variables that are related to KBC, such that every variable denotes one aspect of the latent variable, KBC. It is like painting an object, by looking at its shadow. In the factor analysis, the linkage between the latent variable, the KBC, and observable variables is constructed by "factor loadings". Factor loadings should be estimated by an appropriate method, here we have used the Maximum Likelihood method, to estimate the factor loadings. After choosing variables and estimating the factor loadings for every observable variable in the first stage, we can compute the estimated KBC.

The factor analysis regression used in the first stage is comprised of two types of variables, dependent and independent (latent) variables where the last one is called the factor. Table (2) indicates independent variables in the factor analysis model. According to the literature, we can divide the variables into 5 major groups including learning-by-doing¹, computer knowledge, innovative asset, economic competence, and human capital. In fact, we conjecture that variables in each group would explain one aspect of the latent knowledge-based capital, including the groups classified in Table 2.

¹. Inclusion of simple workers and workers with low levels of education is because of two different purposes. First, through learning by doing channel, as noted by Arrow (1962) and emphasized by Romer (2012), knowledge accumulation is not necessarily through purposeful efforts, but it can be caused by repetition of a simple work in the production process, done even by simple workers. Second, our purpose to inclusion of that variables is also to estimate and compare the roles of different levels of education on the KBC accumulation.

Table 2. Exploratory Factor Analysis of the Dependent Variables for KBC Estimation by 2-Digite ISIC Codes

Group	Row	Variable symbol	Definition
Learning-by-doing	1	WSIMPLE	Share of simple workers in total workers in the production lines
	2	WSKILLED	Share of skilled workers in total workers in the production lines
Computer knowledge	3	SSOFTWARE	Ratio of expenditures on computer software to the sale
Innovative asset	4	SRESEARCH	Ratio of expenditures on R&D to the sale
Economic competence	5	SEXPORT	Ratio of exports to the sale
	6	SEDUC	Ratio of expenditures on training to the sale
	7	SCOMISION	Ratio of expenditures on sale commission to the sale
	8	SADVERTISING	Ratio of expenditures on advertising, banners and press to the sale
Human capital	9	WTECH	Share of technicians in total workers in the production lines
	10	WENG	Share of engineers in total workers in the production lines
	11	PHDRATIO	Share of workers with PhD grade in total literate employees
	12	MASTERRATIO	Share of workers with Master's degree in total literate employees
	13	LICANSERATIO	Share of workers with bachelor degree in total literate employees
	14	COLLEGERATIO	Share of workers with college degree in total literate employees
	15	DIPLOMARATIO	Share of workers with diploma degree in total literate employees
	16	SCHOOLRATIO	Share of workers with workers less than diploma degree in total literate employees

Source: Research finding.

5.3 The Estimation of Labor Productivity Equation

After the estimation of KBC using the factor analysis, we can estimate Equation (7) to analyze effects of KBC on Output per worker in the manufacturing sector of the Iranian economy. To do that, it is necessary to quantify the variables in Equation (7). Based on the Iranian Statistical Center's database of manufacturing firms, we have the following data for the variables of the Equation (7):

VA_{it} = Real¹ value added in industry i at time t ;

L_{it} = Number of employees in industry i at time t ;

M_{it} = value of raw materials consumed in industry i at time t ;

$Equipment_{it}$ = as a proxy for C_{it} , fixed capital investment in industry i at time t ; which is included investments in equipment, computer software and hardware. In other words, we included any fixed investment other than land and buildings in every ISIC code;

L_{it} = Total number of employees in each ISIC code in every year;

KBC_{it} = Knowledge-Based Capital in industry i at time t (estimated by factor analysis);

GDP_t = Real GDP growth of the Economy² at time t ;

$Openness_t$ = the index of economic openness at time t ;

The openness is measured in macro-level as follow: $openness = \frac{Export + Import}{Gdp}$

where *Export* and *Import* are respectively value of non-oil export and total import of the Iran economy.

Ultimately, we have θ_i , the industry-specific effect, which may be fixed or random; we will select between the two based on the Hausman test for fixed or random effects.

6. Empirical Result

According to Table (3), as to factor analysis model, we estimated one factor which we can take as KBC; in other words, there is a latent factor which its influence on dependent variables is observable. As it is obvious in Table (3), the Bartlett chi-square is significant at 5 percent type I error, rejecting the null hypothesis that the correlation matrix of the variables is diagonal. In other words, the hypothesis that there are no correlation and covariance between variables of interest is rejected at 5 percent level, indicating that there is a significant relationship between the variables, and we can think that, the KBC is the linkage between the variables.

¹. Data for value added in each ISIC code are expressed in nominal values (Iranian Rial). To convert them to real values, we used the deflator index used by the Iranian Statistical Centre to deflate each ISIC codes. This is also true for other nominal data that we used in Equation 7.

². The macro data such as GDP and export and import values are obtained from Iranian Central Bank Database.

Table 3. Results of the Factor Analysis (First Estimation)

	Loadings F1	Communality	Uniqueness
WTECH	0.606890	0.368315	0.631685
WSKILLED	-0.550891	0.303481	0.696519
WSIMPLE	-0.457630	0.209426	0.790574
WENG	0.901950	0.813514	0.186486
SSOFTWARE	0.006302	3.97E-05	0.999960
SRESEARCH	0.291097	0.084737	0.915263
SEXPORT	0.001954	3.82E-06	0.999996
SEDUC	0.270344	0.073086	0.926914
SCOMISION	0.185389	0.034369	0.965631
SCHOOLRATIO	-0.828722	0.686780	0.313220
SADVERTISING	0.088443	0.007822	0.992178
PHDRATIO	0.275550	0.075928	0.924072
MASTERRATIO	0.838383	0.702886	0.297114
LICENSERATIO	0.978772	0.957995	0.042005
DIPLOMARATIO	0.016236	0.000264	0.999736
COLLEGERATIO	0.735612	0.541125	0.458875

Factor method: Maximum likelihood

Number of factors: Minimum average partial

Source: Research finding.**Table 4.** Model Analysis

Chi-square statistic	12916.93
Chi-square prob.	0.0000
Bartlett chi-square	12700.06
Bartlett probability	0.0000
Parameters	32
Degree-of-freedom	104

Source: Research finding.

The results in Table 3 show that all the variables but simple workers, skilled workers, and literate workers without a diploma have a positive and direct correlation with KBC¹. Looking at wskilled and wsimple factor loadings indicates that the more investment in KBC by the firms, the less will be important to the learning-by-doing in a firm and the more will be the role of academic education for the firms. This notion makes a positive relation between KBC and the level of academic education of workers of the firms. As it is obvious when looking at the

¹. In the factor analysis approach, variables having a higher correlation with a factor, which is measured by the factor loading, fall into that factor's group. The larger the factor loadings, the greater influence of the variable in explaining the factor.

coefficients of variables capturing workers' education (variables 11 to 16 in Table2), the conclusion will be confirmed.

SSOFTWARE coefficient indicates that investment in computer software has a small though positive impact in developing KBC in the Iranian manufacturing sector. In other words, KBC in the sector has not yet had enough embodiments in the form of software knowledge. Besides, export and advertising have the lowest coefficients in the economic competence group. Overall, it can be said that KBC (the latent factor in question) is mostly influenced by the education level of the labor force.

Table 4 displays the results of the second step estimation, estimation Equation7, in terms of the 2-digit ISIC codes of Iranian manufacturing firms. Before executing Equation 7, we conducted two specification tests: the Redundant Fixed Effects Test (see Appendix) and the Correlated Random Effects-Hausman Test. These tests were used to determine the nature of the θ_i in Equation 7. As described above, θ_i is unobserved heterogeneity within each ISIC code (the industry-specific effects). First, it is crucial to determine whether or not there are significant industry-specific differences between the data. To do this, we conducted Redundant Fixed Effects using the F-statistics and the chi-squared statistics to examine the hypothesis that there is no significant industry-specific heterogeneity in the data. The null hypothesis cannot be accepted based on the statistics and 5% type I error; therefore, we must specify θ_i as industry-specific heterogeneity. Then, using the Hausman Test, it must be established whether the effects are random or fixed. To perform the Hausman test, we must model random effects using generalized least squares and estimate Equation 7. The estimation results (given in the appendix) show that all variances of the random part of the equation are due to the idiosyncratic stochastic part and the individual effects have zero variances. This shows that the random effects are not appropriate for estimation of the equation. Because of the zero variances of the random effects, the standard errors of the Hausman test are not consistent with the assumptions of the test (see the results of the Hausman test in the appendix) and then, the results of the test are not reliable. The crucial assumption of random effects estimates is that there is not any correlation between θ_i and the explanatory variables, which is also the null hypothesis of the Hausman test. Since the Hausman test's assumptions and random effects are unreliable, it is preferable to utilize the fixed effects estimating approach, which is robust to the correlation between individual effects (θ_i s) and explanatory variables of the Equation 7. Therefore, the robustness of the

fixed effects model in the presence of a probable correlation between $\theta_{i,s}$ and the explanatory variables leads us to select it.

Based on the results of the specification tests, we should specify $\theta_{i,s}$ as fixed effects. Table 5 displays the results of the fixed effects estimation of Equation 7. As is clear, the adjusted R-squared is approximately 96%, showing that the explanatory variables in Equation 7 are capable of explaining 96 percent of the variations of the Output per worker in terms of 2-digit ISIC codes of the Iranian manufacturing sector. Because of possible autocorrelation problem in the regression residuals, we have adjusted the standard errors to be robust against autocorrelation. As there are no lagged dependent variables on the right side of Equation 7, the Durbin-Watson test is valid. Also, for robust standard errors in the case of probable heteroscedasticity, we selected White diagonal standard errors & covariance for the parameter standard errors.

Table 5. Estimation Results of Equation 7, the Dependent Variable Is the Logarithm of the Value Added per Worker in ISIC Codes

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.767829	0.300958	-15.84220	0.0000
LOG(EQUIPMENT/L)	0.070618	0.017546	4.024674	0.0005
LOG(M/L)	0.652133	0.050526	12.90701	0.0000
LOG(KBC/L)	0.038121	0.025765	1.479568	0.1526
LOG(OPENNESS)	0.092503	0.044337	2.086340	0.0482
GDP	0.003160	0.001225	2.580324	0.0167
Effects Specification				
Cross-section fixed (dummy variables)				
Weighted Statistics				
Root MSE	0.223568	R-squared	0.963148	
Mean dependent var	-1.512925	Adjusted R-squared	0.960425	
S.D. dependent var	1.481071	S.E. of regression	0.231963	
Sum squared resid	20.39287	F-statistic	353.7626	
Durbin-Watson stat	0.929103	Prob(F-statistic)	0.000000	
Unweighted Statistics				
R-squared	0.906278	Mean dependent var	-0.624076	
Sum squared resid	26.46975	Durbin-Watson stat	0.418829	

Source: Research finding.

As demonstrated, all explanatory variables, except KBC are significant at a type I error level of 5% and each has a positive effect on output per worker. For our purposes, it is obvious that the coefficient of KBC is not significant even at

10% type I error, although it has a positive sign. The economic openness coefficient is significant and positive indicating that the more open an economy is to the world economy, the greater the labor productivity gains for Iran's manufacturing firms.

Comparing coefficient values, it is obvious that material has greatest positive impact on output per worker in each Iranian manufacturing codes, which shows that among other things, the output in Iranian manufacturing sector is dependent more on the availability of materials. Equipment has also positive and significant coefficient which shows that in Iran's manufacturing sector, physical capital has a significant and important role in production processes. The coefficient of KBC is not significant, which we can interpret it as follow. Because manufacturing sector in Iran is not enough knowledge based, so its demand for knowledge-based capital is also insignificant. Principally, knowledge-based capital is of such intangible assets that applicable in high level processes of productions. For example, activities of research and development, data gathering and analysis and so on. According to our dataset, average ratio of research costs to total sales was 0.083 percent, which is less than 0.1 of 1 percent. As another example, in our dataset, average ratio of expenditures in computer software to total sales was 0.031 of percent. The figures show that investment in intangible knowledge-based items in manufacturing sector of Iran is very low. Our interpretation is that the sector is not enough developed to need such factors to produce innovative and knowledge-based products. In another words, the manufacturing sector in Iran is yet equipment based and more relies on primary materials rather than high level knowledge-based factors.

The significant coefficient of economic openness shows that economic policies in the form of a more closed economy and greater limitations on foreign commerce will have a negative impact on labor productivity in the Iranian manufacturing sector. Another aspect of this coefficient is that, in a more open economy there is more facilitate to provide material and equipment that should be imported.

Finally, GDP has also a positive significant coefficient which can be interpreted as positive impacts of better macroeconomic conditions on economic performance of manufacturing industry in Iran.

7. Conclusion

KBC plays a significant role in modern economies, with this non-tangible type of capital being the greatest form of business investment and a major contributor to

economic growth in advanced economies. Despite its importance as an important driver of economic growth, there are not enough researches that focus on the role of KBC in developing countries, so the aim of this paper was to examine the relation between KBC with Output per worker in Iran's manufacturing sector. To do that, we have adopted a two-step estimation method; in the first step using the exploratory factor analysis method, we have estimated KBC, as a latent variable, in the Iranian manufacturing sector.

In the second step, we have estimated a per worker production function to analyze the effects of factors of production in Iranian manufacturing industry. Our results show that material has greatest positive impact on output per worker in each Iranian manufacturing codes, which show that among other things, the output in Iranian manufacturing sector is dependent more on the availability of materials. Equipment has also positive and significant coefficient which show that in manufacturing sector in Iran physical capital has a significant and important role in production processes.

The coefficient of KBC is not significant at 5 percent type I error, which we can interpret it as follow. Because manufacturing sector in Iran is not enough knowledge based, so its demand for knowledge-based capital is also insignificant. Principally, knowledge-based capital is of such intangible assets that applicable in high level processes of productions. Our interpretation is that the sector is not enough developed to need such factors to produce innovative and knowledge-based products. In another words, the manufacturing sector in Iran is yet equipment based and more relies on primary materials rather than high level knowledge-based factors.

The results show that economic policies in the form of a more closed economy and greater limitations on foreign commerce will have a negative impact on labor productivity in the Iranian manufacturing sector. Another aspect of this coefficient is that, in a more open economy there is more facilitate to provide material and equipment that should be imported. And finally, our results show that there is a positive relationship between better macroeconomic conditions and Output per worker of the manufacturing industry in Iran.

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Appendix

Eviews Outputs

1. Redundant Fixed Effects Tests

Redundant Fixed Effects Tests

Equation: EQ1

Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	101.643371	(23,379)	0.0000
Cross-section Chi-square	803.626538	23	0.0000

Cross-section fixed effects test equation:

Dependent Variable: LOG(Q/L)

Method: Panel Least Squares

Date: 12/09/22 Time: 18:44

Sample: 1381 1397

Periods included: 17

Cross-sections included: 24

Total panel (balanced) observations: 408

White period (cross-section cluster) standard errors & covariance (d.f. corrected)

Standard error and t-statistic probabilities adjusted for clustering

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.573766	0.971450	-2.649405	0.0143
LOG(EQUIPMENT/L)	0.086614	0.082258	1.052961	0.3033
LOG(M/L)	0.425559	0.055671	7.644230	0.0000
LOG(KBC/L)	0.137982	0.083521	1.652060	0.1121
LOG(OPENNESS)	0.131650	0.138224	0.952438	0.3508
GDP	0.009496	0.004884	1.944239	0.0642
Root MSE	0.659622	R-squared		0.371445
Mean dependent var	-0.624076	Adjusted R-squared		0.363628
S.D. dependent var	0.833022	S.E. of regression		0.664527
Akaike info criterion	2.035113	Sum squared resid		177.5214
Schwarz criterion	2.094102	Log likelihood		-409.1630
Hannan-Quinn criter.	2.058455	F-statistic		47.51252
Durbin-Watson stat	0.061471	Prob(F-statistic)		0.000000

2. Random Effects Estimation

Dependent Variable: LOG(Q/L)

Method: Panel EGLS (Cross-section random effects)

Date: 12/09/22 Time: 18:47

Sample: 1381 1397

Periods included: 17

Cross-sections included: 24

Total panel (balanced) observations: 408

Swamy and Arora estimator of component variances

White period (cross-section cluster) standard errors & covariance (d.f. corrected)

Standard error and t-statistic probabilities adjusted for clustering

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.697202	0.897371	-4.120037	0.0004
LOG(EQUIPMENT/L)	0.116856	0.089270	1.309015	0.2035
LOG(M/L)	0.513351	0.123640	4.151965	0.0004
LOG(KBC/L)	0.105177	0.061665	1.705616	0.1016
LOG(OPENNESS)	0.184192	0.113811	1.618397	0.1192
GDP	0.009421	0.004037	2.333540	0.0287
Effects Specification				
			S.D.	Rho
Cross-section random			0.659676	0.8694
Idiosyncratic random			0.255621	0.1306
Weighted Statistics				
Root MSE	0.253264	R-squared		0.537072
Mean dependent var	-0.058394	Adjusted R-squared		0.531314
S.D. dependent var	0.372691	S.E. of regression		0.255147
Sum squared resid	26.17017	F-statistic		93.27695
Durbin-Watson stat	0.489962	Prob(F-statistic)		0.000000
Unweighted Statistics				
R-squared	0.346285	Mean dependent var		-0.624076
Sum squared resid	184.6273	Durbin-Watson stat		0.069450

3. Hausman Test

Correlated Random Effects - Hausman Test

Equation: EQ1

Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.

Cross-section random	0.000000	5	1.0000

* Cross-section test variance is invalid. Hausman statistic set to zero.

** WARNING: robust standard errors may not be consistent with assumptions of Hausman test variance calculation.

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
LOG(EQUIPMENT/L)	0.116616	0.116856	0.000665	0.9926
LOG(M/L)	0.520431	0.513351	0.003225	0.9008
LOG(KBC/L)	0.096407	0.105177	0.001332	0.8101
LOG(OPENNESS)	0.187252	0.184192	0.000500	0.8912
GDP	0.009328	0.009421	0.000001	0.9368

Cross-section random effects test equation:

Dependent Variable: LOG(Q/L)

Method: Panel Least Squares

Date: 12/09/22 Time: 18:47

Sample: 1381 1397

Periods included: 17

Cross-sections included: 24

Total panel (balanced) observations: 408

White period (cross-section cluster) standard errors & covariance (d.f. corrected)

Standard error and t-statistic probabilities adjusted for clustering

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.836455	1.066619	-3.596836	0.0015
LOG(EQUIPMENT/L)	0.116616	0.092919	1.255028	0.2221
LOG(M/L)	0.520431	0.136060	3.825012	0.0009
LOG(KBC/L)	0.096407	0.071655	1.345443	0.1916
LOG(OPENNESS)	0.187252	0.115988	1.614412	0.1201
GDP	0.009328	0.004204	2.218952	0.0366

Effects Specification

Cross-section fixed (dummy variables)

Root MSE	0.246369	R-squared	0.912315
Mean dependent var	-0.624076	Adjusted R-squared	0.905837
S.D. dependent var	0.833022	S.E. of regression	0.255621
Akaike info criterion	0.178185	Sum squared resid	24.76468
Schwarz criterion	0.463300	Log likelihood	-7.349752
Hannan-Quinn criter.	0.291006	F-statistic	140.8319
Durbin-Watson stat	0.518534	Prob(F-statistic)	0.000000

4. Results of Equation 7:

Dependent Variable: LOG(Q/L)

Method: Panel EGLS (Cross-section weights)

Date: 12/09/22 Time: 18:48

Sample: 1381 1397

Periods included: 17

Cross-sections included: 24

Total panel (balanced) observations: 408

Linear estimation after one-step weighting matrix

White period (cross-section cluster) standard errors & covariance (d.f. corrected)

Standard error and t-statistic probabilities adjusted for clustering

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.767829	0.300958	-15.84220	0.0000
LOG(EQUIPMENT/L)	0.070618	0.017546	4.024674	0.0005
LOG(M/L)	0.652133	0.050526	12.90701	0.0000
LOG(KBC/L)	0.038121	0.025765	1.479568	0.1526
LOG(OPENNESS)	0.092503	0.044337	2.086340	0.0482
GDP	0.003160	0.001225	2.580324	0.0167
Effects Specification				
Cross-section fixed (dummy variables)				
Weighted Statistics				
Root MSE	0.223568	R-squared	0.963148	
Mean dependent var	-1.512925	Adjusted R-squared	0.960425	
S.D. dependent var	1.481071	S.E. of regression	0.231963	
Sum squared resid	20.39287	F-statistic	353.7626	
Durbin-Watson stat	0.929103	Prob(F-statistic)	0.000000	
Unweighted Statistics				
R-squared	0.906278	Mean dependent var	-0.624076	
Sum squared resid	26.46975	Durbin-Watson stat	0.418829	



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Examining the Determinants, Efficiency, and Potential Export of Indonesia's Plantation Commodities to G-20 Countries

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Abstract

Consisting of 70.50% of the world's GDP and 58.37% of the world's population, countries participating in the G-20 have the potential to be a very profitable export market for Indonesia's plantation commodities. However, the value of Indonesia's plantation commodity exports to countries in the G-20 tends to fluctuate and has even declined during certain periods. So, this paper aims to analyze the determinants, efficiency, and potential of Indonesia's plantation commodity exports to G-20 countries for the 2005-2020 period. The Stochastic Frontier Gravity Model (SFGM) and Random Effect (RE) models are estimated simultaneously to ensure the robustness of the results. Model estimates show that the GDP of exporters, GDP of importers, GDP per capita of importers, and population of importers have a positive effect on the flow of trade in Indonesian plantation commodities to countries in the G-20. Conversely, trade costs have a negative impact on Indonesia's plantation commodity exports. Another finding is that Indonesia's plantation commodity exports to countries in the G-20 have not been efficient with an average efficiency value of 52.45%. The implication is that there are still untapped opportunities to increase exports. Based on the calculation of export potential, the trading partner countries with the largest export potential are the United States (US\$ 1,020.586 million), China (US\$ 462.557 million), Japan (US\$ 219.557 million), and Brazil (US\$ 111.339 million). Based on the results, efforts to maximize Indonesia's plantation commodity export potential should be focused on countries with large economies and populations, and low trade costs.

Keywords: Export Efficiency, Export Potential, G20, Panel Data, Stochastic Frontier Gravity Model.

JEL Classification: F1, F4, Q1.

1. Introduction

The agricultural sector plays an important role in the economic and social development of Southeast Asian countries like Indonesia (Liu et al., 2020).

Indonesia's geographical conditions contribute to its comparative advantage and specialization in the production and export of agricultural commodities, especially plantations (Rum and Rijoly, 2020; Tety et al., 2022). The total export value of Indonesian plantation commodities such as cocoa, coffee, tea, mate, and spices (HS 09 and 18) will reach US\$ 2.912 million in 2021. The export value of Indonesian plantation commodities has fluctuated in the last 10 years, with a decreasing trend of 0.6% per year (Trademap, 2022). This shows that even though geographically Indonesia has advantages, in the era of trade globalization, this comparative advantage must be maintained by increasing productivity through innovation and strengthening institutions involved in exporting agricultural commodities in Indonesia (Sulaiman et al., 2020).

Other efforts that can be made to increase exports of plantation commodities are through optimizing traditional markets and diversifying potential markets (Wahyudi and Maipita, 2019). This can be done through involvement in global cooperation in order to develop exports of Indonesian plantation commodities. One of the global collaborations that Indonesia participates in is the G-20 forum. The G-20 forum is an association of several countries with the largest GDP and population in the world, controlling 70.50 percent of the world's total GDP and 58.37 percent of the world's population (Astuti et al., 2022). Countries that are part of the G-20 forum which have a large GDP and population, can be optimized as trading partners because they will affect the amount of demand for exports from Indonesian plantation commodities (Noviyani et al., 2019; Syachbudy, Firdaus and Daryanto, 2018). Trade relations between Indonesia and G-20 countries have been established for a long time through export-import activities. In fact, G-20 countries have become some of Indonesia's traditional export destination markets (Sabaruddin, 2017). Several countries participating in the G20 forum have already become export destinations for Indonesian plantation commodities, such as the United States, China and India, as well as European countries like the Netherlands, Germany and France, which are very dependent on spices from Indonesia (Sulaiman et al., 2020).

Indonesia's export of plantation commodities (HS 09 and 18) to G-20 countries in the 2005-2020 period fluctuated quite a bit, with a tendency to increase (Figure 1). Even as it increased, in certain periods there were negative fluctuations in Indonesia's plantation commodity exports to G-20 countries. The biggest negative fluctuations occurred in 2013 and 2018 with a decrease of 13.75% and 10.33%, respectively. In addition, since 2018 the increase in Indonesia's exports has not been as large as the previous year as shown by a graph which tends to slope. This should be a concern for Indonesia whose economy is affected by international trade in agricultural commodities, including plantations. In general, a country's export activities are determined by a combination of several factors, both in terms of supply, demand, and other external factors (Effendi, 2014; Ganbaatar et al., 2021; Malau, Ulya, et al., 2022; Nasrullah et al., 2020).

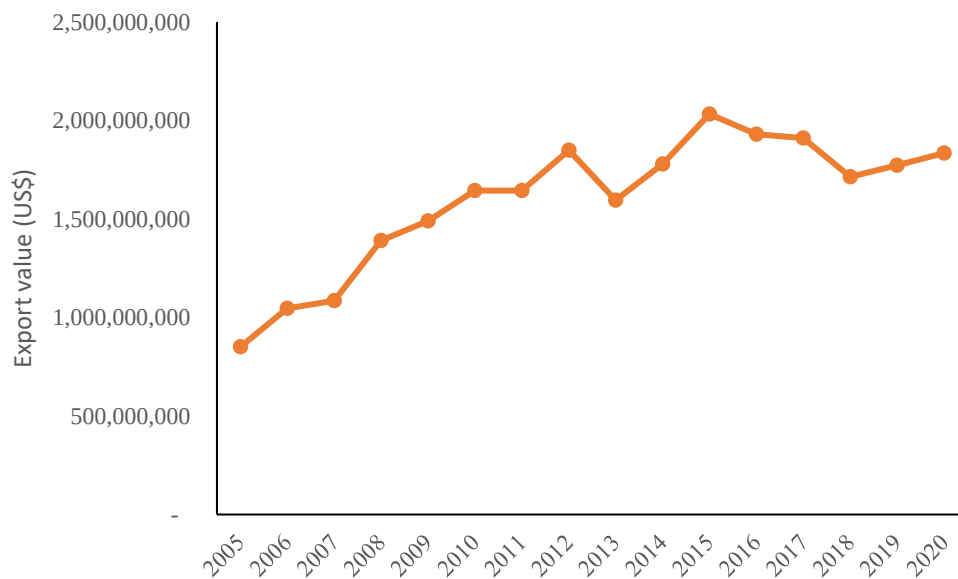


Figure 1. The Value of Indonesia's Plantation Commodity Exports to the G-20 Countries
Source: UN Comtrade (2022).

The exportation of plantation commodities plays an important role in the economic development of Indonesia. Given the importance of plantation commodity exports to the Indonesian economy and the trend of increasing exports of Indonesian plantation commodities to the G-20 countries which tends to slow down, it is important to analyze the factors affecting Indonesia's exports of plantation commodities to the G-20 countries. Analyzing the determinants of Indonesia's plantation commodity exports to the G-20 countries is also important because of Indonesia's involvement in global trade cooperation such as the G20 forum. Not only is this an important opportunity to increase exports, but it can also increase imports as a form of market openness between countries (Putri et al., 2021; Sugiharti et al., 2020).

Previous studies have attempted to analyze the determinants of Indonesia's plantation commodity exports to the G-20 countries, but the output is still partial in the context of commodities and countries. In addition, the effect of the variables on exports is debatable (see (Riyani et al., 2018; Rosyidi et al., 2021; Sanny and Natallya, 2020; Sumiyati, 2020). Analyzing the factors affecting exports is considered still relevant in identifying countries that need special attention to increase exports and countries that still have the potential to expand exports (Abdullahi et al., 2022), so that exports of plantation commodities can continue to grow. Identifying new opportunities in the export of plantation commodities can elevate the contribution of the plantation sector to the national economy. In a broader scope, the first objective of the research was to analyze the factors

influencing Indonesia's plantation commodity exports to G-20 countries, leading to conclusions about the important factors that determined these exports.

On the other hand, previous studies have focused more on analyzing the factors influencing exports, where the basic theory is used as a gravity model (see (Malau et al., 2022; Morland et al., 2020; Nasrullah et al., 2020; Rambe and Malau, 2023; Supriana et al., 2022)). Several studies have also developed a gravity model analyzing the influence of other factors such as trade sanctions (see (Rasoulinezhad, 2019; Rasoulinezhad and Popova, 2017)). In addition to analyzing the determinants of exports, this research further analyzed the efficiency and potential of Indonesia's plantation commodity exports to the G-20 countries. Through an analysis of export efficiency, it was found that much of Indonesia's actual exports were able to reach their export potential or the level of gap between actual and potential exports (Abdullahi et al., 2022).

Export efficiency can be measured using the Stochastic Frontier Gravity Model (SFGM) approach (Abdullahi et al., 2021; Atif et al., 2019). The use of SFGM was intended to overcome the limitations of the gravity model with OLS estimates (Kalirajan, 2008), which tended to be biased in estimating potential export values (Noviyani et al., 2019). Based on this investigation, the measurement of export efficiency in the Indonesian context was still very limited, especially for exports of plantation commodities. In fact, there is still relatively little application of SFGM in the international trade literature (Atif et al., 2019). The use of SFGM carried out for the scope of Indonesia measured the efficiency of Indonesia's total exports to 62 trading partner countries (Noviyani et al., 2019) and tested the impact of AFTA on Indonesia's exports to 25 trading partner countries (Effendi, 2014).

Despite the importance of plantation commodity exports to the Indonesian economy, only a few studies have comprehensively addressed plantation exports. As a comprehensive analysis, this study aimed to analyze the factors influencing Indonesia's plantation commodity exports to G-20 countries. Furthermore, the efficiency of Indonesia's plantation commodity exports to G-20 countries for each country and the potential value of Indonesia's plantation commodities exports to the G-20 countries as a whole was analyzed. This research contributes to filling a gap in the literature regarding the study of export efficiency, especially exports of plantation commodities which are still very limited for the scope of Indonesia.

2. Literature Review

The theory of international trade has been developed with several approaches, but in general there are 4 basic reasons for the occurrence of international trade, namely: 1) differences in natural and geographical conditions among countries, 2) differences in production costs, 3) "relative advantages" that a country has; and 4) the effect of production scale (Jerzy and Oleksandr, 2022). Although international trade theory continues to develop, changes in theory in many cases are preceded by changes in international trade practices which have recently become

increasingly complex (Chen, 2022). Many economists have tried to understand the practice of international trade, such as Tinbergen who tried to understand the occurrence of international trade with the approach of Newton's theory of gravity. This approach describes the occurrence of bilateral trade based on the size of the economy represented by GDP and the distance between countries (Atif et al., 2019; Masood et al., 2022). This approach is then known as the gravity model which is widely used to analyze international trade and is carried out by completing the parameters of economic size, distance, and various other parameters that are considered to affect trade.

Various other studies use the gravity model to show that trade among countries is positively influenced by the GDP of the exporting countries, colonial links (Renjini et al., 2017), the GDP of the importing countries (Ganbaatar et al., 2021; Masood et al., 2022; Renjini et al., 2017), continuous countries (Morland et al., 2020), population (Sugiharti et al., 2020) and the presence of FTA (Masood et al., 2022). On the other hand, there are several factors which are considered to have a negative effect on international trade, including distance, including distance (Effendi, 2014; Ganbaatar et al., 2021), landlocked (Masood et al., 2022), and exchange rate (Abidin et al., 2013; Effendi, 2014). The gravity model continues to be developed in research by adding new variables which are adjusted to developments in international trade practices, such as adding the variable sanctions on exports (see Rasoulinezhad, 2019; Rasoulinezhad and Popova, 2017).

In addition to the expansion of analysis variables, the use of the gravity model in international trade analysis has begun to see some criticism by economists. The gravity model fails to estimate the effect of Multilateral Trade Resistance (MTR) such as tariff rates, colonial connections, and common languages in bilateral trade (Abdullahi et al., 2022). In addition, the gravity model is considered to be only suitable for calculating trade data among countries that have normal trade relations and cannot be used to estimate the maximum trade value between countries (Atif et al., 2019). Several studies have calculated the potential export value using errors from the processed gravity model, but in fact the estimated error value is considered to be inaccurate in describing export potential (Noviyani et al., 2019).

To overcome the weakness of this gravity model, (Kalirajan, 2008) offers the concept of a gravity model which combines it with the Stochastic Frontier Analysis (SFA) approach and is known as the Stochastic Frontier Gravity Model (SFGM). SFA is an analytical technique that is widely used in production economics to evaluate the efficiency of a company. In international trade, the SFA approach can be used to estimate efficiency and maximum export potential in bilateral trade (Abdullahi et al., 2021). Besides being able to measure export efficiency, the use of SFGM can also correct economic distance bias which can cause heteroscedasticity problems, so that SFGM will provide results with strong theoretical implications for trade policy (Nguyen, 2022).

The SFGM analysis method is still relatively new, so its use in international trade studies is still limited (Atif et al., 2019). SFGM applications can be found in several international trade studies with different country commodities and objects. From the commodity side, SFGM has been used to analyze agri-food commodities (Abdullahi et al., 2021; Barma, 2017; Xu et al., 2023), rice, and coffee (Nguyen, 2022), downstream palm oil products (Tandra & Suroso, 2023), and chemical products (Atif et al., 2019). For Indonesia, SFGM has been used to measure the efficiency of Indonesia's exports to 62 trading partner countries (Noviyani et al., 2019) and to analyze the impact of AFTA on Indonesia's exports to 25 trading partner countries (Effendi, 2014).

Although there have been studies on international trade using SFGM with Indonesian objects, there have been no studies that focus on analyzing plantation commodities, because other studies (Noviyani et al., 2019) and (Effendi, 2014) typically analyze all aspects of Indonesian export commodities. Studies that use SFGM for the sectoral commodity scope with certain markets such as the G-20 need to be carried out to formulate Indonesia's export development strategy. Apart from being able to find the determinants of exports, the use of SFGM will also show the level of efficiency and potential for the export of Indonesian plantation commodities to G-20 countries. Measurements of efficiency and export potential will fill in the gaps in previous international trade studies, which generally focused on partially analyzing the determinants of exports, both of commodities and certain country objects (see Akbar and Widyastutik, 2022; Asliyana and Setyowati, 2022; Rambe and Malau, 2023; Riyani et al., 2018; Sugiharti et al., 2020; Wardhany and Adzim, 2018). In the end, this research is designed to fill a gap in the literature on the use of SFGM for analysis of Indonesia's trade with G-20 countries, especially the scope of plantation commodities that have not been analyzed in previous studies.

3. Material and Methods

3.1 Model Specification

A gravity model is most commonly used in the context of international trade analysis in order to utilize the basic assumption that trading transactions between two countries is positively influenced by the economic size of the two countries, but negatively affected by the distance between these countries (Abdullahi et al., 2022; Nguyen, 2022). The gravity model is the most popular quantitative method for analyzing trade flows among countries (Baier et al., 2014; Nguyen, 2022). The fundamental formula of the gravity model is:

$$Trade_{ij} = \alpha (GDP_i \times GDP_j) / DIS_{ij} \quad (1)$$

where, $Trade_{ij}$ is the trade value between the two countries, namely country i and country j ; GDP_i and GDP_j are the economic sizes of country i and country j ; and DIS_{ij} is the distance between the two countries, namely country i and country j .

This basic model is transformed into a linear form using logarithms, so that the basic model for Indonesia's plantation exports to the G20 countries is as follows:

$$\ln EXP_{ij} = \beta_0 + \beta_1 \ln GDP_i + \beta_2 \ln GDP_j + \beta_3 \ln DIS_{ij} + \varepsilon_{ijt} \quad (2)$$

The gravity model used in international trade research has developed very rapidly and has undergone many modifications. The development of gravity models in the last few decades has become more mature, then forming general linear equations that are easy to use for empirical testing (Li et al., 2020). The basic theory of the gravity model uses distance as a proxy for trading costs. However, trading cost is made up of many components, not just transportation costs which are represented by distance. Trading cost is also affected by product quantity, port waiting time, and quarantine costs. Therefore, this study used the trading cost variable (COT) because it is more representative than distance.

The gravity model has the advantage of being able to include other additional variables that are thought to affect trade relations between exporters and importers (Bensassi et al., 2015). Based on previous studies, there are several variables that must be considered as determining factors for exports of Indonesian plantation commodities to G-20 countries (Atif et al., 2019; Effendi, 2014; Noviyani et al., 2019). In addition to GDP and trading costs, this study used the importer's GDP per capita, population of the importing country, and exchange rates. GDP per capita of importers was used as a proxy for the purchasing power of the people of trading partner countries, implying that a higher GDP per capita of importers will increase Indonesia's exports of plantation commodities. The importer population also influences the export flow of Indonesian plantation commodities, because a larger importing country population will increase trade flows. The use of exchange rate variables plays an important role in international transactions. The use of these variables causes Indonesia's plantation commodity export model to G-20 countries to undergo adjustments in the form of the following equation:

$$\begin{aligned} \ln EXP_{ijt} = & \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln GDPCAPIM_{jt} \\ & + \beta_4 \ln POP_{jt} + \beta_5 \ln RER_{jt} + \beta_6 \ln COT_j + \varepsilon_{ijt} \end{aligned} \quad (3)$$

where, EXP_{ijt} is Indonesia's export value of plantation commodities (i) to the destined country (j) in year (t), GDP_{it} is Gross Domestic Product (GDP) of Indonesia in year (t), GDP_{jt} is the Gross Domestic Product (GDP) of importer (j) in year (t), $GDPCAPIM_{jt}$ is GDP per capita of importer (j) in year (t), POP_{jt} is population of importer (j) in year (t), RER_{jt} is Rupiah exchange rate against currency of destination country (j) in year (t), COT_j is cost incurred by importer in conducting trade (j), and ε_{ijt} is the error term.

Although the gravity model is commonly used in international trade analysis, its estimates are not based on the maximum possible limit on trade among countries (Atif et al., 2019). Several studies calculate the value of potential exports using errors from the estimation results of the gravity model, but the results are not precise in describing potential exports (Noviyani et al., 2019). Furthermore, the

estimation of the gravity model using OLS tends to be biased because the OLS estimation results represent a centralized value or the middle value of the data set used, not an upper limit value. A study by Kalirajan, (2008) proposed a SFGM model that combines Stochastic Frontier Analysis (SFA) production analysis and the gravity model. This model allows for estimation of efficiency and export potential in bilateral trade (Abdullahi et al., 2021). SFGM is different from the conventional gravity model because SFGM has two error terms, where one error term indicates the value of trading inefficiency and the other error term is an error caused by other factors that are not expected in the model (Noviyani et al., 2019). The basic model of the frontier approach is (Effendi, 2014):

$$X_{ij} = f(Z_i; \beta) \exp(v_i - u_i) \quad (4)$$

where X_{ij} is the export value of country i to country j , $f(Z_i; \beta)$ function consists of factors influencing bilateral trade potential (Z_i) and β is the estimated parameter, v_i is the error term, which is implicitly outside the trade boundary, and u_i is an error term including an economic distance bias as a trading constraint.

Thus, the econometric model used in this study is:

$$\ln EXP_{ijt} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln GDPCAPIM_{jt} + \beta_4 \ln POP_{jt} + \beta_5 \ln RER_{jt} + \beta_6 \ln COT_j + (v_i - u_i) \quad (5)$$

Equation is equal to equation (4) but the error term component is divided into u_i and v_i . v_i is a two-sided error indicating statistical interference based on an estimation error which follows normally distributed assumptions. u_i is a one-sided error that includes economic distance bias as a trade barrier, and it results in differences in actual and potential exports in trade between two countries. Therefore, Indonesia's export efficiency to each G-20 country can be calculated on the following equation (Xu et al., 2023):

$$\begin{aligned} \text{Export efficiency}_{ij,t} &= \frac{\text{Actual export}_{ij,t}}{\text{Potential export}_{ij,t}} = \frac{\exp(X_{ij,t}\beta + v_{ij,t} - u_{ij,t})}{\exp(X_{ij,t}\beta + v_{ij,t})} \\ &= \exp(-u_{ij,t}) \end{aligned} \quad (6)$$

The export efficiency value varies from 0 to 1, where a value of 1 means that actual export has reached their potential export value (Atif et al., 2019; Noviyani et al., 2019). Therefore, Indonesia's potential export can be calculated by following equation:

$$\text{Potential export}_{ij,t} = \frac{\text{Actual export}_{ij,t}}{\text{Export Efficiency}_{ij,t}} \quad (7)$$

To verify the gravity model's result, panel data regression with a Random Effect (RE) approach is frequently used to obtain gravity estimates because this approach calculates for unobservable heterogeneity and controls Multilateral Trade Resistance (MTR) phenomenon (Abdullahi et al., 2022; Atif et al., 2019). Apart from the Random Effect (RE), there are other approaches to panel data regression analysis, namely Pooled Least Squared (PLS), and Fixed Effect (RE). Therefore,

this study tried to compare the gravity model coefficients with the result of panel data regression from the following equation:

$$\ln EXP_{ijt} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln POP_{jt} + \beta_4 \ln TO_{jt} + \beta_5 \ln RER_{jt} + \varepsilon_{ijt} \quad (8)$$

3.2 Data Description

To find out the determinants and efficiency levels of Indonesia's plantation commodities exports to the G-20 countries, an econometric model was used. This consisted of several variables, including Indonesia's plantation export value (USD), GDP of Indonesia (USD), real GDP of importer (USD), GDP per capita of importer (USD), population (people), real exchange rate (IDR/LCU), and trade cost (US\$) (Table 1). This study used panel data from trade in Indonesian plantation commodities with 18 trading partners of the G-20 countries in the 2005-2021 period. However, this study limited plantation commodities to only HS 09 (tea, coffee, spices, and cashew) and HS 18 (cocoa and its derivatives) which Indonesia exported to trading partner countries, namely the United States, South Africa, Saudi Arabia, Australia, Brazil, Argentina, China, the United Kingdom, Italy, India, Germany, Japan, South Korea, Canada, French, Mexico, Russia, and Turkey. Data was obtained from various sources, namely UN Comtrade, Center d'Etudes Prospectives et d'Information (CEPII), World Bank, United Nations Conference on Trade and Development (UNCTAD), and The Economic and Social Commission for Asia and the Pacific (UNESCAP).

Table 1. The Variables and Data Sources

Data	Data Description	Unit	Data Source
The value of plantation commodities exports	The sum of Indonesia's HS 09 and HS 18 export value	USD	UN Comtrade
GDP exporter/importer countries	Gross Domestic Product of exporter/importer at market price	USD	World Bank
GDP per capita importer countries	Gross Domestic Product per capita of importing countries	USD	World Bank
Population	The number of populations in each country	People	World Bank
Real exchange rate	The ratio of Indonesian Rupiah to importing country's currency	IDR/LCU	UNCTAD
Trade cost	The cost that must be paid by the importing countries to carry out trade activities between countries	US\$	UNESCAP

4. Results and Discussion

4.1 Factors Affecting Plantation Commodity Export of Indonesia towards G-20 Countries

The descriptive statistics of the variables used in this study are presented in Table 2 with several important points. First, the data used was balanced, namely 288 observations for all variables. Second, there was no large variations in all variables. This can be seen from the relatively small standard deviation value. Third, all the variables used had good minimum and maximum observation ranges.

Table 2. Descriptive Statistic

Variable	Obs	Mean	Std.Dev	Min	Max
Export Value	288	17.4170	1.4811	12.4103	20.4426
GDP Exporter	288	27.3386	0.2390	26.933	27.3576
GDP Importer	288	28.1875	0.9606	26.3126	30.6230
GDP per capita Importer	288	9.7877	1.0073	6.5720	11.1295
Population	288	18.4174	1.1197	16.8308	21.0676
Real Exchange Rate	288	7.617	2.0234	2.0619	9.9260
Trade cost	288	5.1813	0.2743	4.5386	5.9567

Source: Research finding.

To identify the factors influencing Indonesia's plantation commodity exports to the G-20, the SFGM maximum likelihood estimator was utilized, as well as Random Effect (RE). Both models were used to guarantee the robustness of the estimation results. The feasibility of SFGM was shown by the value of the gamma coefficient (γ) which was close to 1 (0.9346). The high value of γ also confirmed that SFGM was an appropriate choice to explain variations in Indonesia's plantation commodities exports to G-20 countries (Vinh and Phuong, 2022). Gamma (γ) measures the ratio of export variations caused by export inefficiencies to the total variation in exports (Atif et al., 2019; Abdullahi et al., 2022). Based on the Hausman test, RE (Random Effect) was more suitable than FE (Fixed Effect), so the test was continued to the LM test. The LM test was used to select RE or Common Effect. The test results showed the probability value of the LM test was 0.0000 or significant at the 1% significance level, so it can be concluded that RE was better than Common Effect. Therefore, the RE model was used to guarantee the robustness of the estimation results together with the SFGM.

The analysis in this study presented the results of SFGM and RE simultaneously because the signs, values and significance of the coefficients were relatively the same. This supported the robustness of the research results. However, this study focused more on SFGM because it was supported by a large γ (0.9346) so it was better at explaining variations in Indonesia's plantation commodities exports to G-20 countries, while RE was only supported by an R-Square value of 0.4196.

Table 3. The Result of SFGM and RE Estimation

Variable	SFGM		RE	
	Coefficient	Std. Error	Coefficient	Std. Error
GDP Exporter	0.3810	0.1757**	0.5052	0.1266***
GDP Importer	0.5699	0.2242**	0.9319	0.2697***
GDP per capita				
Importer	0.3406	0.1784**	0.3623	0.1807**
Real Exchange Rate	-0.0054	0.0728	-0.0413	0.0654
Population	0.3673	0.2117**	0.3113	0.2615
Trade Cost	-0.615	0.2889**	-0.7035	0.2815**
Cons	-14.9868	5.4093***	-27.9869	4.5209***
Mu	-1.4777	5.0283*		
Eta	0.0164	0.0008		
Sigma-squared	2.6087	4.1615		
Gamma	0.9346	0.1042		
Log Likelihood	-187.5523			
Hausman test			0.1341	
LM test			0.0000***	
R-Square			0.4196	

Source: Research finding.

Note: *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.

Based on Table 3, the GDP of exporters had a positive and significant effect. These results indicated that an increase in Indonesia's GDP would increase Indonesia's exports of plantation commodities to G-20 countries, *ceteris paribus*. These results are consistent with the basic theory of the gravity model and previous studies which concluded that exporter GDP has a positive effect on export values (Abdullahi et al., 2022; Atif et al., 2017; Ganbaatar et al., 2021; Nguyen, 2022; Supriana et al., 2022). Importers' GDP also had a positive and significant effect, so that an increase in importers' GDP would increase exports of Indonesian plantation commodities to G-20 countries, *ceteris paribus*. This result is in line with economic theory and several previous studies which reported that importers' GDP has a positive effect on exports (Abdullahi et al., 2021; Assoua et al., 2022; Nasrullah et al., 2020; Renjini et al., 2017; Zainuddin et al., 2020).

In the literature on gravity models, GDP was used as a proxy for economic size. However, in this study, the economic size of Indonesia and its trading partner countries as members of the G-20 served as a gravity model. The GDP of exporters showed the export capacity of Indonesia's plantation commodities, while the GDP of importers revealed the amount of demand for exports of plantation commodities by G-20 countries. The GDP of exporters and importers, which had a positive and significant effect, showed that the income of the two countries, both exporters and importers, supported the demand and supply conditions for Indonesia's plantation

commodity exports. The sign of a positive and significant coefficient on the GDP of exporters and importers demonstrated that the larger size of the economy encouraged the flow of Indonesia's plantation commodity exports to G-20 countries. Based on these results, Indonesia could focus its efforts on increasing exports of plantation commodities to countries with large economies.

Another interesting result from this study was the importer's GDP coefficient which was greater than the exporter's GDP, both SFGM and RE. Based on these results, the supply response to changes in Indonesia's GDP was smaller than the demand response due to changes in the importing country's GDP. The implication was that importers had greater power to make supply adjustments in response to changes in demand. This was because G-20 countries, as Indonesia's export destinations, were developed countries with very strict export requirements, especially with the existence of Non-Tariff Measures (NTMs). NTMs are more widely enforced by developed countries such as the USA, Japan, and Canada, which have proven to have a negative impact on exports of plantation commodities from developing countries, such as Indonesia (Crivelli and Groeschl, 2016; Darhyati et al., 2017).

In addition to GDP, trading cost was the basic variable of the gravity model whose effect was tested on Indonesia's plantation commodity exports. Trading cost had a negative and significant effect on both SFGM and RE. In the SFGM model, the coefficient obtained was -0.615, while the RE model produced a coefficient value of -0.703. The value of the SFGM coefficient meant that a 1% increase in trading cost would lead to a decrease in the amount of Indonesia's plantation commodity exports to G-20 countries by 0.615%, *ceteris paribus*. These results are in line with the research of (Eum et al., 2021), which concluded that trading cost had a negative effect on exports of agricultural companies. Research by (Ayuda et al., 2022) also reported that trading cost, as a measure of distance between trading partners, had a negative effect on Latin American Agri-food exports. (Xu et al., 2017) also reported that transportation cost affects the value of Chinese exports. In addition, (Xu and Liang, 2017) also added that trading cost is a determining factor in the share of exports of Chinese manufactured products.

The implication of the coefficient of trading cost being negative was that Indonesia could maximize the export of plantation commodities to G-20 countries with closer distances, so that trading costs could be minimized. Australia, China, India, South Korea, and Japan are several trading partner countries that can be considered because geographically these countries are closer to Indonesia. This implication is supported by research carried out by (Nurdin et al., 2019), which stated that transportation cost significantly affects Indonesian exports. To support international trade, Indonesia also needs to improve the quality of the services and logistics infrastructure. In line with this, (Ahsan et al., 2021), confirmed the importance of increasing the trade facility index to increase exports in Pakistan.

Based on Table 3, this study confirmed the existence of the gravity model indicated by the sign and significance of exporters' GDP, importers' GDP, and trading cost. The gravity model postulates that the GDP of exporting and importing countries has a positive impact on exports, whereas geographical distance or trading cost has a negative impact (Liu et al., 2020; Shobande, 2019). The implication of this finding was that countries with larger economic sizes traded more. The farther the exporter was from the trading partner country, the less goods were traded due to higher transportation costs.

In addition to using the basic variable gravity model, this study also examined the effect of importers' GDP per capita. Several studies used the variables GDP and GDP per capita simultaneously in international trading analysis (see Abdullahi et al., 2021; 2022; Tandra and Suroso, 2023). GDP was a proxy for economic size, while GDP per capita described purchasing power. GDP per capita of importers had a positive and significant effect on SFGM and RE. The results of this study are in line with previous studies which reported a positive effect of importers' GDP per capita on exports (Darhyati et al., 2017; Malau, Ulya, et al., 2022). The implication was that an increase in GDP per capita of importers would increase exports of Indonesian plantation commodities to G-20 countries, *ceteris paribus*. An increase in per capita GDP encouraged increased purchasing power and consumption, so that to meet this increase importing countries would carry out larger exports. The G-20 forum consists of countries with relatively large GDP per capita, so they become potential markets for the development of Indonesia's plantation commodity exports.

Based on SFGM, the importer population also had a positive and significant effect. As an implication, the increase in the importer population would increase exports of Indonesian plantation commodities. These results are in line with Barma, (2017) who studied exports of Indian agricultural products and Abdullahi et al., (2021) who examined exports of Nigerian agri-food products to 70 of its trading partner countries. The population of importing countries can be a proxy for the market size of trading partner countries (Noviyani et al., 2019), so the results of the analysis showed that the positive effect of population on Indonesia's plantation commodity exports to G-20 countries were logical. Apart from being the combined countries with the largest GDP in the world, the population of the G-20 countries is also quite large, reaching 58.37 percent of the world's population (Astuti et al., 2022). Even countries with the largest populations in the world, namely China, India, and the United States, are also G-20 countries. This condition shows the large market size of G-20 countries, which has a positive correlation with the high number of requests to meet the needs of each country. Therefore, Indonesia's involvement in the G-20 forum should be maximized to increase exports of plantation commodities. The Indonesian government can maximize the existence of trading cooperation to increase trade volume with countries with the

largest populations, such as the ASEAN-China Free Trade Area (ACFTA) and the ASEAN-India Free Trade Area (AIFTA).

4.2 Efficiency of Indonesia's Plantation Commodity Export to G-20 Countries

Based on the SFGM results, it was known that the trading partners with the highest export efficiency values for Indonesian plantation commodities were Germany (92.95%), South Africa (90.65%), and Russia (86.45%). Meanwhile, trading partner countries with the least technical efficiency were Argentina (6.26%), Turkey (15.25), and China (20.65%) (Table 4). This condition indicates that Indonesia's exports of plantation commodities to the G-20 countries were not yet optimal, as indicated by the average technical efficiency value of 52.45%. As an implication, Indonesia still has the potential to increase exports of plantation commodities (HS 09 and HS 18) to G-20 countries.

Optimizing the potential for increasing Indonesia's exports to G-20 countries can be done through establishing better trade relations, reducing political disputes, and trade agreements (Atif et al., 2019). In addition, Indonesia must also have a commitment to improving the quality of plantation products that meet quality standards in export destination countries. Commitment to improving the quality of plantation commodities is necessary because most of G-20 countries are developed countries with high levels of consumer awareness. For example, Indonesia's coffee export market share in the European Union was only 4.17%, even though Indonesia is one of the largest coffee producers in the world. The low share of the Indonesian coffee market in the European Union can be caused by the non-fulfillment of sustainability certification which indicates good production standards (Salam & Putri, 2019; Wahyudi et al., 2020).

Table 4. Export Efficiency Level of Indonesia's Plantation Commodities to G-20 Countries

No	Destination Country	Efficiency (%)	No	Destination Country	Efficiency (%)
1	South Africa	90.65	10	Italy	69.32
2	USA	59.85	11	Japan	64.64
3	Saudi Arabia	34.53	12	Germany	92.95
4	Argentina	6.26	13	Canada	43.14
5	Australia	84.76	14	South Korea	23.44
6	Brazil	40.76	15	Mexico	33.57
7	United Kingdom	48.90	16	France	44.41
8	China	20.65	17	Russia	86.45
9	India	84.60	18	Turkey	15.25

Source: Research finding.

After guaranteeing the quality of the products produced, the government also needs to carry out export promotions. For example, in pepper exports to Italy, apart from having to meet the quality standards of the European spice association,

Indonesia must increase promotions, so that it can compete with pepper products from other countries (Nugroho and Prasada, 2020). In the cocoa trade, Indonesia also needs commercial diplomacy and to become a member of the International Cocoa Organization (ICCO) to facilitate access to diplomacy with the European Union in reducing import tariffs on Indonesian cocoa (Inayah et al., 2022). These efforts are expected to increase the efficiency of Indonesia's plantation exports to G-20 countries in Europe such as Italy, the United Kingdom, and France, which respectively only have efficiencies of 69.32%, 48.90% and 44.41%.

An interesting thing to note from this technical efficiency score was Indonesia's technical efficiency with G-20 countries originating from the Asian continent (Saudi Arabia, China, India, Japan, South Korea, and Turkey) which tended to be smaller than countries from other continents. However, there was one Asian country with great technical efficiency, namely India (84.60%). In this case, India is one of Indonesia's potential export markets in South Asia (Ali Nur Sidiq, Findi, & Firdaus, 2019). Indonesian plantation export commodities to India are spice commodities such as pepper, cinnamon, nutmeg, and cloves, which are often used as cooking ingredients in India. On the other hand, the efficiency of Indonesia's plantation exports to China was very low (with a value of 20.65%), even though China is a country with the largest population, which has a potential market for Indonesian products. However, despite having the largest population, China is also one of the world's largest agricultural commodity exporters, so that some of its domestic needs can be met from domestic production. Therefore, Indonesia must implement a strategy in the form of increasing competitiveness in agricultural commodities that cannot be produced by China, so that Indonesia's exports to China can increase (Sulaiman et al., 2020).

4.3 Export Potential of Indonesia's Plantation Commodities to G-20 Countries

Indonesia's plantation commodity export potential in G-20 countries could be calculated using export efficiency data. The export potential gave an indication of the empty space filled by Indonesian plantation commodities in the G-20 countries by increasing the value of exports. Furthermore, those G-20 countries that have the largest potential export values were the United States (US\$ 1,020.586 million), China (US\$ 462.557 million), Japan (US\$ 219.557 million), Brazil (US\$ 111.339 million), and England (US\$ 114.055 million). If you compare the current export value with the export potential, you will find a gap in exports of Indonesian plantation products in G-20 countries. The export gap can be influenced by the GDP of the exporting country, the GDP of the importing country, the GDP per capita of the importing country, population, and trading cost.

Table 5. The Gap in Indonesia's Plantation Commodity Exports to the G-20 Countries

No	Trading partner	Current Export (US\$)	Export Potential (US\$)	Export Gap (US\$)
1	USA	610.866.935	1.020.586.480	- 409.719.545
2	China	95.529.460	462.557.292	- 367.027.832
3	Japan	141.960.617	219.622.184	- 77.661.567
4	Brazil	45.385.266	111.339.231	- 65.953.964
5	United Kingdom	55.775.361	114.055.705	- 58.280.344
6	Canada	43.619.134	101.101.719	- 57.482.586
7	France	45.310.575	102.039.354	- 56.728.779
8	South Korea	14.919.351	63.636.645	- 48.717.295
9	Mexico	19.019.032	56.652.603	- 37.633.571
10	Turkey	6.284.485	41.204.088	- 34.919.604
11	Italy	63.869.976	92.136.987	- 28.267.010
12	Argentina	1.606.067	25.674.143	- 24.068.077
13	India	112.301.044	132.736.067	- 20.435.023
14	Saudi Arabia	8.969.144	25.971.238	- 17.002.094
15	Germany	174.498.455	187.736.871	- 13.238.416
16	Australia	68.831.537	81.211.336	- 12.379.799
17	Russia	69.200.140	80.045.580	- 10.845.440
18	South Africa	20.099.928	22.173.149	- 2.073.220

Source: Research finding.

The largest gap in Indonesia's plantation commodity exports occurred in the USA. This gap was caused by the high value of the United States' Coverage Ratio (CR) and Frequency Index (FI) of Non-Tariff Measures (NTMs) for agricultural products, including plantation commodities. Coverage Ratio and Frequency Index of NTMs in the United States were 77.36% and 61.52%, respectively. This value illustrates the stringent procedures that must be met by exporting countries to carry out bilateral trade with the United States, especially regulations related to food safety (Xu et al., 2023). This could also be another factor causing Indonesia to lose its relatively large export potential from the United States, with a value of US\$ 409.719 million.

In responding to the gap in Indonesia's plantation commodity exports in G20 countries, Indonesia could encourage stakeholders to increase the application of plantation product certification. The implementation of agricultural product certification will be a catalyst in international trade, namely as a response to the implementation of the Non-Tariff Measures (NTMs) policy. Several certifications that can be implemented on plantation products in Indonesia are: RSPO and ISPO on palm oil, Organic and Geographical Indication on coffee and UTZ Certified and Rainforest Alliance on cocoa. Overall certification has been shown to have a positive effect on exports of plantation products (Ingram et al., 2018; Rosyadi et al., 2020; Wahyudi et al., 2020).

5. Conclusion

This study was aimed at analyzing the determinants, efficiency, and export potential of Indonesian plantation commodities to G-20 countries using data for the 2005-2020 period from 18 G-20 countries. To gain robust results, 2 equations were used with the basic theory of the gravity model, namely SFGM and Random Effect (RE). The feasibility of SFGM was supported by a γ value of 0.9346 or close to 1, so it can be concluded that SFGM was able to explain variations in Indonesia's plantation commodity exports to G-20 countries. Based on the Hausman and LM test, RE was better than FE and Common Effect.

SFGM and RE estimated produced coefficients with relatively similar signs, values and significance so that they supported robust results. In general, this study confirmed the postulates of the gravity model. Based on the SFGM, the GDP of exporters, GDP of importers, GDP per capita of importers, and population had a positive effect on Indonesia's exports of plantation products to G-20 countries, while trading cost had a negative effect on Indonesia's exports of plantation products to G-20 countries. The RE estimation results showed that the GDP of exporters, the GDP of importers, and the GDP per capita of importers had a positive effect on exports of Indonesian plantation commodities, while trading cost had a negative effect on exports of Indonesian plantation products to G-20 countries. These results had the implication that an increase in the GDP of exporters, GDP of importers, GDP per capita of importers, and the population of importers would increase Indonesia's plantation commodity exports, and conversely an increase in trading cost would reduce exports. In line with these results, Rasoulinezhad & Popova, (2017) reported that GDP and population has a positive effect on Iran-Russia trade. Rasoulinezhad, (2019) also reported that GDP has a positive effect on Iranian and Russian exports.

Unlike the general gravity model studies, this study also measured the efficiency of Indonesia's plantation commodity exports to G-20 countries. The results showed that Indonesia's exports to G-20 countries were not yet optimal, as indicated by a technical efficiency score of 52.45. The implication was that Indonesia still has a huge opportunity to increase exports to G-20 countries. As a comprehensive study, based on the value of export efficiency, Indonesia's export potential to G-20 countries was also calculated. The results revealed that countries with the largest export potential were the United States (US\$ 1,020.586 million), China (US\$ 462.557 million), Japan (US\$ 219.557 million), Brazil (US\$ 111.339 million) and the United Kingdom (US\$ 114.055 million).

This research was considered superior as a comprehensive study because it analyzed the determinants, efficiency, and potential of Indonesia's exports to G-20 countries. Most of the previous studies only focused on the analysis of the determinants of exports, either partially on the country or commodity context. This study also filled in the gaps in the literature regarding the efficiency of international trade, which was still very limited, both in Indonesia and internationally.

Several interesting works are proposed to complement this research. Further research is suggested to examine the effect of various other variables on exports of Indonesian plantation commodities, such as trade sanctions (Rasoulinezhad, 2019; Rasoulinezhad and Jabalameli, 2019; Rasoulinezhad and Popova, 2017). It is interesting to include other additional variables in the gravity model, so that more complete determinants can be determined. In addition to G-20 countries, it is advisable to analyze the efficiency of Indonesia's plantation commodity exports to other trading partner countries. Apart from that, it would be interesting to analyze the export efficiency of other leading Indonesian commodities. The very rapid development of the gravity model leads to many improvements, as was researched by Rasoulinezhad and Jabalameli (2019) who used the InterCountries Trade Force (ITF) theory. The main difference between the ITF and the gravity model lies in the use of the gravity index (GI). This would be very interesting to examine with further research.

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Investigating the Effectiveness of E-government in Improving Environmental Quality: Evidence from MENA Countries

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Abstract

In recent decades, the destruction of the environment and the emission of greenhouse gases such as CO₂ has become a national and transnational crisis for many governments worldwide. In this respect, information and communication technology (ICT) and its increasing growth in these years have given governments an appropriate opportunity to implement and expand e-government and to create a chain of changes in governance and macro-management. Also, by providing efficient electronic services, they can better deal with the existing challenges and play a more effective role in improving society's environmental quality and welfare. The present research investigates the relationship between the development of e-government and CO₂ emissions in the Middle East and North African countries (MENA) between 2007 and 2022, using the GMM approach. The obtained results show that the development of e-government has had a negative and significant impact on CO₂ emissions in the mentioned countries. Moreover, the results affirmed the EKC hypothesis in the MENA countries since economic growth is positively linked to CO₂ emissions. In contrast, the economic growth square is linked negatively to the environmental degradation indicator. Furthermore, per capita energy consumption, industry development, and urbanization positively affect CO₂ emissions, and trade openness has statistically insignificant effects on CO₂ emissions. Thus, the authorities in this group of countries must take necessary measures to reduce carbon dioxide emissions and help improve environmental quality by implementing and improving electronic government as much as possible.

Keywords: CO₂ Emissions, Economics, EGDI, Middle East and North African Countries (MENA), Panel Data.

JEL Classification: C33, H11, N70, O1, Q53.

1. Introduction

In the last two decades, environmental standards and environmental considerations have been the subject of intense research. With the growth and

development of societies, the quality of the environment has become more important. Despite the fundamental differences in nature and nature of the environmental problems, the whole issue is visible in all countries. In this regard, the environment is one of the main pillars of sustainable development (Arbab and Shabani, 2017). In recent years, the concentration of greenhouse gases has been increasing significantly. This factor is the main cause of global warming and a serious threat to environmental sustainability (Pachauri et al., 2014). Since greenhouse gas emissions, the ground temperature has risen about 0.6°C and reached the highest level in the past millennium. Meanwhile, carbon dioxide is a more durable gas in the atmosphere than other greenhouse gases. This gas is continuously distributed worldwide and leads to severe global warming (Ahmet et al., 2021). Global warming reports warn that if carbon dioxide emissions continue at the current rate, the average global temperature will increase by 4°C (5.4 and 7.2°F) until 2100. Such a temperature rise will lead to plant and animal species extinction, changes in agricultural patterns, and rising sea levels (Xiaoyan et al., 2021). However, natural factors such as topography and climate affect air quality. In this connection, the growing economic activities and population growth after the Industrial Revolution have been the main sources of carbon dioxide and air pollution. Factors such as population growth, the increased number of factories, the rapid expansion of transportation, the multitude of old and worn-out vehicles, and excessive fuel consumption are the basis for creating and expanding air pollution (Alliance Development Works and Unu-Ehs, 2013).

In recent years, e-Government has played an important role in the dimensions of human life as a product of the evolution of information and communication technology (ICT), and governments have been trying to establish an important step in its establishment. E-government has tried to tackle the move toward the information community by better offering services, promoting community welfare, and overcoming existing challenges, especially in environmental quality improvement.

In recent years, the electronic state's implementation and evolution have changed the way of governance and government management and entered a new era of urban management and industrial management, agriculture, and services (Ameli, 2017). In fact, e-government allows government, citizens, businesses, and customers to work more efficiently. It facilitates the relationship between a government with citizens (B2C), government relationship with the business (G2B), business relationship (B2B), and each other. Furthermore, it makes the

relationship of businesses (B2C) easier, less expensive, and more cost-effective. E-government can be defined in many dimensions, such as electronic society, electronic management, and electronic citizens. Successful e-government implementation can improve government services, reduce costs and energy, enhance participation through government and citizens' knowledge, empower citizens, improve business and industry interaction, increase effectiveness and efficiency in stakeholder satisfaction, and improve services (Huo et al., 2021). In general, digitization of information, non-physical transfers, reducing the need for large space in offices and warehouses, shortening the supply chain, lowering energy consumption, and increasing the recycling possibility are among the important and positive results of the development of e-government on the environment.

Recent research has emphasized the impact of economic and communication technology factors on the quality of the situation. However, the present study employs a political and functional framework to investigate the relationship between the e-government development index on environmental quality performance (carbon dioxide emission), which has been less considered in previous studies. This study reviews and analyzes the impact of the e-government development index (EGDI) on carbon dioxide dissemination in 17 countries in the Middle East and North Africa (MENA), including Iran, during the 2007 to 2022 period. It is worth noting that these countries were selected based on the statistics available for the required variables. Also, GDP variables, per capita energy consumption, industry development index, urbanization rate, and trade intensity index are introduced as control variables.

The remainder of this article is organized as follows: Sections 2, 3, and 4 are devoted to theoretical foundations, the background of the study, the method, and materials and materials of the study, respectively. Also, Sections 5 and 6 offer the research findings and conclusion & policy implications, respectively.

2. Theoretical Literature

2.1 An Overview of the E-Government

The term “e-government” is applied to describe a variety of interactions between public authorities on one side, vidual citizens and other residents, or businesses and other non-governmental entities on the other side, using information and communications technology (Reitz, 2006). One of the popular definitions provided by the World Bank for e-government is: “the use by government agencies of information technologies (such as Wide Area

Networks, the Internet, and mobile computing) that can transform relations with citizens, businesses, and other arms of government” (The World Bank, 2015). “e-government” generally refers to local or national government information and services being made available through the internet via web browsers or mobile apps. Examples of information provided may include new business regulations, announcements of public events, and general updates on current affairs. Examples of services provided may include the renewal of driver’s licenses, payment of taxes, and applications for business permits. E-government encompasses various sub-concepts describing specific types of interactions, such as “e-filing,” “e-publication,” “e-procurement,” and “e-payment” (Reitz, 2006). It is commonly recognized that one of the most important factors in public acceptance of e-government, i.e., the willingness of public constituents to partake in e-government services, is confidence in government (Bélanger and Carter, 2008). The main objective of e-government is to improve efficiency, reduce government cost and time (i.e., tangible outcomes), and achieve citizens’ satisfaction and trust in government (i.e., intangible results) (Malodia et al., 2021). The E-Government Digital Index (EGDI) is the concept to increase the development of Southeast Asia. EGDI can be defined as the use of information and communication technology (ICT) in communicating with governments and conducting business through electronic media (Turmanidze et al., 2020). The development of e-Government can be traced by analyzing the United Nations e-Government survey reports around the world. Since 2001, every two years, the United Nations Department of Economic and Social Policy has reviewed the level of development of e-government services in all 193 member countries. However, it is only since 2003 that the United Nations has presented the collected information in the form of a report. Eleven editions of the survey were published until June 2023: 2003, 2004, 2005, 2008, 2010, 2012, 2014, 2016, 2018, 2020, and 2022. The reports show the level of e-government development in each country. They also identify countries and regions where the potential of information and communication technology (ICT) and e-government is exploited and which countries should be supported in their development. The e-government development is measured according to the UN-developed EGDI (E-Government Development Index). This index is designed to assess the e-government development at the national level. It is a composite index based on a weighted average of three standardized indicators. Each of the three indicators, also composite measures, can be extracted and analyzed independently.

One-third of the EGDI relies on the Telecommunications Infrastructure Index (TII) calculated from data provided by the International Telecommunication Union (ITU). Another one-third of the EGDI depends on the Human Capital Index (HCI), which is calculated from data provided by the United Nations Educational, Scientific and Cultural Organization (United Nations Department of Economic and Social Affairs, 2022), which assesses the national online presence of all 193 UN member states. The above index also includes the E-Participation Index (EPI), an index complementary to the UN E-government survey that focuses on governments' use of online services in order to share electronic information, run e-consultation and make e-decisions. The methodological basis for calculating the EGDI remained consistent across all survey periods, while its components (the three index-building indicators) were updated to reflect current trends in e-government, telecommunications, and human capital. It is worth noting that until 2008 the EGDI was treated as a measurement of e-government readiness (E-Government Readiness Index, EGRI). Only since 2010 has the name of the index been changed to the E-Government Development Index (EGDI) (with minor changes to the methodology). The composite value of each component indicator discussed here is then normalized to fall between 0 and 1, and the overall EGDI value is obtained by taking the arithmetic mean of the three components (Ziolo et al., 2022).

2.2 The Relationship between EGDI and Environment

The natural environment has been unprecedentedly challenged because of the exponential growth of the human population, greater interest in economic development and industrialization, and increasing anthropogenic activities (Arora, 2018; Chakravarty and Mandal, 2020). To achieve environmental sustainability, many governments have allocated substantial investments to e-government initiatives, e.g., the development and use of information and digital technologies for improving government services and administrations (Medaglia et al., 2021). Providing a digital platform for citizens to participate, engage, and be empowered in environmental decision-making and other activities is critical for achieving sustainability goals (Koontz, 2006). Citizens are much more enthusiastic and eager than ever to use ICT technologies and engage (i.e., perform e-collaboration) in environmental preservation (He et al., 2017).

Since central and local governments are the main stakeholders that influence environmental sustainability (Zampo and Pramatar, 2011), many authors are

interested in better understanding the impact of the digital revolution on the environment and identifying the relationship between e-government and sustainable development. e-government affords citizens an opportunity to inform and participate in environmental issues (Hay and Griffiths, 2008) the importance of strategic alignment in e-government transformation layers is essential for environmental sustainability (Haigh and Griffiths, 2008). Some researchers believe that the safest way to improve the environment is for countries to move towards a service economy, the main driver of which is the development of ICT infrastructure and the evolution of e-government (Panayotou et al., 2000). Environmental sustainability is the result of e-government initiatives, and the development of e-government has a positive effect on environmental sustainability through saving fossil fuel consumption and reducing paper consumption and carbon footprint (Al-Khoury, 2013; Krishnan et al., 2013). Additionally, remote work options and teleconferencing facilities can decrease the travel-related carbon footprints of government employees. Digitization of affairs through the evolution of e-government can reduce energy demand or harmful emissions (GeSI, 2015). In addition, the development of e-government can greatly help governments in the successful management of natural resources (NICA, 2015). The development of e-government not only directly affects the sustainability of the environment, but it can also have indirect effects by increasing the effectiveness of the government on the environment, the implementation of e-government reduces urban transportation, traffic, and air pollution (Young Bum, 2017; Jouzbarkand et al., 2011; Ernst and Young, 2003). E-government can facilitate the collection, analysis, and dissemination of environmental data. Through online platforms and databases, governments can monitor various environmental indicators such as air quality, water pollution levels, waste management, and deforestation rates. Timely and accurate information enables better decision-making and targeted interventions to improve environmental quality. E-government platforms can promote citizen engagement in environmental issues. Online portals, forums, and social media channels provide opportunities for individuals to voice their concerns, provide feedback, and participate in environmental decision-making processes. This increased transparency and inclusivity can lead to greater public awareness, accountability, and collective action toward environmental conservation. E-government can also streamline administrative processes and improve coordination among different government agencies involved in environmental management. Electronic systems for permitting, licensing, and compliance monitoring can enhance efficiency, reduce bureaucratic delays, and ensure better

enforcement of environmental regulations. This can contribute to more effective policy formulation and implementation.

At a more general glance, Jafari Parviz et al. (2021) states that by developing ICT, previous production processes are corrected, and environmental quality is improved by reducing the consumption of raw materials and physical resources. In such a way, manufacturing mechanisms that require high energy consumption are replaced by more optimal methods that require low energy consumption and higher productivity. Replacing physical books with electronic books, electronic systems, virtual summits, smart transportation systems, geographic location determination systems (GPS), and smart traffic control systems can increase energy consumption and decrease the emissions of the environment.

On the other hand, few studies focus on the negative relationship between e-government and environmental sustainability. Haigh (2004) explained the contradictory effects of e-government on environmental sustainability in literature. this author notes plenty of research gaps in e-government literature. He argues that an accurate explanation of the relationship between e-government and environmental sustainability requires and focuses on potential factors that exceed the quality of e-government by living quality. He also recognizes the need to evaluate ICT infrastructure that may lead to inefficient energy consumption and to acknowledge the problem of electronic waste or high energy infrastructure and applications, e.g., cloud computing centers, data centers, ultra-fast servers, and cooling equipment. Al-Khoury (2013) argues that although the world has grown significantly with the help of ICT, it has increased social costs. Therefore, it can potentially and indirectly have negative effects on the environment. This author also argues that environmental stability must be a key principle in electronic state initiatives. carbon dioxide emissions significantly increase during the production and distribution process of IT and communication technology equipment. ICT equipment waste electronic waste (e.g., electronic devices consumed and their components such as phones, computers, and compact tablets) have harmful effects on the environment (Park et al., 2018).

3. Literature Review

The research related to the impact of electronic government on environmental quality has been conducted qualitatively and most of the studies have focused on the impact of information technology on the environment. Since e-government means the use of information technology in all fields, so this section refers to studies that are closely related to the subject of the present research.

Falahi et al. (2012) have shown that ICT directly impacts environmental quality in Iran.

Moradhasssel and Mozayeni (2013) showed that ICT in developed countries moderates the increasing trend of environmental pollution accumulation. In contrast, in developed countries, the impact of ICT on environmental pollution has not been noticeable. The results also showed that the increase in the number of Internet users had lowered environmental quality in Iran.

Zhang and Liu (2015) examined the impact of the ICT industry on CO₂ emissions at the national and regional China levels using the STIRPAT model and provincial panel data between 2000 and 2010. This study showed the significant effect of ICT development on carbon dioxide emissions.

In a study, Salahuddin et al. (2016) investigated the short- and long-run effects of Internet usage and economic growth on carbon dioxide (CO₂) emissions using OECD panel data from 1991 to 2012. They found that information technology in OECD has directly affected carbon dioxide emissions in the long run.

Arbab and Shabani (2017) examined the relationship between ICT and environmental pollution in D₈ member states during the 1994-2004 period. The results revealed a significant relationship between ICT and the reduction of air pollution, suggesting the improving quality of the environment in parallel with ICT development.

Aragis and Ozjan (2017) analyzed the impact of information and communication technology (ICT) on CO₂ emissions using a panel of 20 emerging economies from 1990 to 2015. The findings showed that increasing access to the Internet has led to a decrease in air pollution. In addition, the results of the panel causality test show unidirectional causality from Internet use to CO₂ emissions.

In another study, Añón Higón et al. (2017) studied the relationship between ICT and carbon dioxide emissions in 142 economies, (116 developing and 26 developed countries), over the period 1995 to 2010 using a panel data approach. The results confirmed that the relationship between ICT and CO₂ emissions is an inverted U-shaped relationship. Moreover, while for the sample of developing countries, the ICT turning point is well above the mean value, the opposite is true for the sample of developed countries. This implies that many developed countries have already attained the level of ICT development, at which CO₂ emissions decrease as the level of ICT development improves further.

Krishnan and Teo (2017) examined the relationship between e-government development and e-commerce development (e-business) with environmental

stability. For this purpose, they used statistical data from 122 countries from 2004 to 2008. The results showed that both e-government development and e-business development have a positive direct impact on environmental sustainability.

In another study, Asongu et al. (2017) examined the effect of information and communication technology (ICT) on carbon dioxide (CO₂) emissions in forty-four Sub-Saharan African countries for the period 2000–2012 using the GMM approach. The findings broadly show that ICT can be employed to dampen the potentially negative effect of environmental pollution on human development.

Park et al. (2018) investigated the impact of using the Internet on carbon dioxide emissions in EU-selected countries based on the group average method from 2001 to 2014. The experimental findings revealed that using the Internet has a long-term direct relationship with the release of carbon dioxide and reduced environmental quality in EU member states. In other words, their innovative findings show that using the Internet threatens sustainable development.

Haseeb et al. (2019) investigated the impact of Internet use and mobile subscriptions (ICTS) on carbon dioxide release in the Brix Group (Brazil, Russia, India, China, and South Africa) in 2014-1994 based on dynamic regression (DSU). The results showed that using the Internet and mobile subscriptions (ICTS) significantly negatively impacted carbon dioxide emissions. In other words, ICT positively contributes to environmental quality.

Avom et al. (2020) examined the impact of ICT on carbon dioxide emissions in the Persian Gulf countries through the method of panel data over the period 2000 to 2015. The results indicated that ICT directly affects carbon dioxide emissions, suggesting a U-shaped relationship between ICT and Carbon dioxide emissions.

Jafari Parviz Khanlou et al. (2021) concluded that ICT directly and significantly impacted carbon dioxide emissions in the Persian Gulf countries. As can be seen, earlier research has rarely examined the impact of e-government on environmental quality. Meanwhile, most of the research has examined the impact of ICT on environmental quality, indicating the importance and development of the present study.

Xiaoyan et al. (2021) investigated the impact of the digital economy on carbon dioxide emissions in 190 countries from 2005 to 2016 with the approach of the Data Panel with constant impacts with the regression method. The results indicated a U-shaped and non-linear relationship between carbon dioxide emissions and digital economics.

Dhaoui (2021) examined the role of e-government in various aspects of economic and social development and environmental development in 15 countries

in the Middle East and North Africa between 2003 and 2018 through the data panel. This author employed the environmental management index to measure environmental sustainability. The results showed that e-government development has no positive or significant impact on the various dimensions of development, especially the environment.

Ziolo et al. (2022) examined the relationship between the Electronic Government Development Index (EGDI) and ESG factors (environmental, social, and economic factors) in 26 European countries (in the period 2003-2020). For the study, the TOPSIS (order priority technique with similarity to the ideal solution) linear ordering method was used, followed by the Percal index and the method of selecting optimal predictors - Hellwig's method. The main findings show statistically significant relationships between EGDI and total variables representing environmental, social, and economic domains.

Dutta and Hazarika (2023) conducted research on the effect of urbanization along with the gross domestic product (GDP) per capita, foreign direct investment (FDI) inflow, trade openness, and mobile phone penetration on carbon dioxide emissions in 68 low-income and lower-middle-income countries across Asia, Africa, Middle East, and South America using the fully modified ordinary least squares method between 2000 and 2019. Results showed that urbanization followed by GDP per capita are the key promoters of CO₂ emissions across all countries, whereas the direction and significance of inward FDI and trade openness varied across regions. Furthermore, it was observed that mobile phone penetration (as an indicator of information and communication technology (ICT)) has a significant and negative relationship with CO₂ emissions.

4. Data and Methodology

4.1 Method

In this study, a dynamic panel model is required regarding the dynamic nature of the data included in the study and the dependence of their current behavior on their past behavior. Thus, the dynamic nature of the model prevents using standard Ordinary Least Squares (OLS) estimators, which might be biased and inconsistent due to the correlation between the unobserved panel-level effects and the lagged dependent variable (Hasanovic and Latic, 2017). Therefore, the fixed/random effect models used for panel data do not solve the econometric problems inherent in dynamic models. In this respect, Arellano and Bond (1991) introduced a new generalized method of moments (GMM) estimator for the dynamic panel model to address the endogeneity problem. This model generates biased findings and

handles unobserved heterogeneity between banks, which cannot be correctly measured. They proposed to incorporate additional instruments in the dynamic panel model and to use different transformations. Later, Arellano and Bover (1995) and Blundell and Bond (1998) proposed an improvement of the Arellano & Bond estimator by imposing additional restrictions on the initial conditions. These efforts allow for the introduction of more instruments to improve efficiency. Accordingly, the model combines the first difference in equations with equations at the level where the variables' first differences are instrumented. Besides, it generates a system of two equations (System GMM), one original and one transformed. GMM controls for endogeneity, unobserved panel, heterogeneity, autocorrelation, omitted variable bias, and measurement errors. Bond (2002) claims that the unit root property biases the difference GMM estimator, whereas System GMM produces more exact findings. The differenced GMM method corrects endogeneity by first differencing all regressors and removing fixed effects. However, the first difference transformation is flawed because it subtracts the prior observation from the current one, amplifying data loss gaps (Ullah et al., 2018). As a result, it affects the projected result to some extent. To correct endogeneity, the System GMM technique introduces more instruments for the lagged dependent variable and any other endogenous variable to drastically enhance efficiency. Besides, it transforms the instruments to make them uncorrelated (exogenous) with fixed effects. Finally, instead of removing the prior observation from the current one as Differenced GMM does, System GMM subtracts the average of all future available variable observations (Roodman, 2009). Generally, this method is used when the number of cross-cutting variables (N) is greater than the number of times and years (T) (Baltagi, 2008). In the present study, this condition is affected such that the number of countries ($N = 17$) exceeds the time period ($T = 16$). As a result, System GMM was used in this study to investigate the relationship between the explanatory and dependent variables under study.

4.2 Data

In the present study, the impact of e-government development on carbon dioxide dissemination is examined in 17 countries in the Middle East and North Africa (i.e., Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Lebanon, Libya, Morocco, Malta, Oman, Saudi Arabia, Syria, Tunisia, United Arab Emirates, and Yemen) from 2003 to 2018. To this end, the Generalized Method of Moment (GMM) approach in STATA14 software is applied. It is of note that the countries were chosen based on the statistics available for the required variables. The variables'

statistical data are compiled from the World Bank World Development Indicators (WDI), CO₂ Emissions of all world countries Report (2022), and the UN Department of Economic and Social Affairs. All variables have also been used as logarithmic to explain the elasticity. The model is inspired by Dhaoui (2021) and Liu and Bae (2018) as Equation (1):

$$LCO_{2it} = f(LEGDI_{it}, LGDP_{it}, LGDP^2_{it}, LEN_{it}, LIND_{it}, LUR_{it}, LTR_{it}) \quad (1)$$

LCO_{2it} : The dependent variable in this study is the logarithm of the per capita emission of carbon dioxide (Tons Per Capita).

$LEGDI_{it}$: It is the logarithm of e-government development. EGDI is the criterion for measuring and ranking countries for e-government development. Given the importance of this variable in the present study, inspired by the study of Dhaoui (2021), the data existing by the linearization method (assuming that the variables follow the linear process) were calculated and used. Electronic government development will reduce air pollution (carbon dioxide emissions) and environmental stability by improving government activities, saving energy, reducing urban trips, and reducing paper consumption.

$LGDP_{it}$: It is the logarithm of Per Capita Gross Domestic Product (constant 2015 US\$). In scientific literature, there are three major views on the effect of GDP on carbon dioxide. The first view is raised by many social scientists and natural sciences who believe that higher levels of economic activity (production or consumption) require more energy and raw materials, resulting in greater amounts of sub-materials. Extraction of the future of natural resources results in increased environmental degradation (Panayotou, 1993). The second view is raised by those who believe that the fastest way to improve the quality of the environment (reduced pollution) depends on the path of economic growth. The reason is that higher income levels increase demand for commodities that use fewer raw materials. The third view, raised in the early 1990s, became known as the Kuznets curve. This view considers the reversal relationship between economic growth and environmental quality criteria. According to this hypothesis, the relationship between economic growth and environmental quality, whether positive or negative, is not constant while a country develops (Pajouyan and Moradhassles, 2007).

$LGDP^2_{it}$: It is the square of the Logarithm of GDP (constant 2015 US\$). This index has been used to investigate the existence of the Kuznets relationship in the countries under study. Awan and Azam (2022) examined the validity of the EKC hypothesis for the five most influenced economies of the G-20 and findings

confirm that veto-power economies have an N-shaped relationship between CO₂ emissions and GDP per capita. Allard et al. (2018) evaluate the N-shaped environmental Kuznets curve (EKC) and realized there is a relationship between CO₂ emissions and GDP per capita for 74 countries. Shehzad et al. (2022) scrutinized the N-shaped environmental Kuznets curve (EKC) theory. The verdicts confirmed the subsistence of an N-shaped relationship amid economic growth and ecological footprints in Algeria.

LEN_{it} : It is the logarithm of per capita energy consumption (kg of oil equivalent). In recent years, fossil fuel production, nuclear power plants, extensive use of water resources, irreparable damage such as air pollution, acid rains, nuclear waste, surface and groundwater pollution, forest damage, and soil erosion have exposed countries to many problems. Therefore, it is expected that the increase in per capita energy consumption will lead to increased carbon dioxide emissions. In a study, Acheampong (2018) realized that energy consumption stimulates CO₂ emissions in the MENA region. The results of the study by Liu and Bae (2018) also show that an increase in energy consumption leads to an increase in carbon dioxide emissions in China. Massagony and Budiono (2023) found that fossil energy consumption has a positive effect on the rise of CO₂ emissions in Indonesia.

$LIND_{it}$: It is the logarithm of the index of countries' industry development. In this study, the value-added ratio of the industry to domestic production was calculated. Clearly, the formation of huge polluting industries is wearing out the land and increasing carbon dioxide emissions by destroying the environment and the ecological system. The results of the Liu and Bae (2018) study show that industrialization in China leads to an increase in the increase of carbon dioxide emissions. The findings of Voumik and Ridwan (2023) indicate that industrialization harms the environment in Argentina in the long run. Hence, the increase in industries is expected to increase carbon dioxide emissions.

LUR_{it} : It is the logarithm of the urbanization rate. Studies on the impact of population growth and urban growth on environmental pollution indicate the relationship between these variables and the amount of air pollution emissions. Increasing urbanization due to the movement of humans from the village to the city has increased energy demand. Therefore, it has led to changes in lifestyle such as increased electric consumption, public transport system and hot water, and others. Previous research has investigated the impact of urban population growth rate on environmental pollution from two different points of view: Some researchers, such as Panayotou (1993), believe that increasing urban growth rate is

the most important factor in increasing environmental pollution. The results of the study by Liu & Bae (2018) also show that the increase in the rate of urbanization in China contributes to the increase in carbon dioxide emissions in China. Sofuoğlu et al. (2023) found that urbanization increases environmental pollution by increasing CO₂ emissions in Turkey. Some other researchers, such as Tayibi (2015), show that an increase in urbanization through more efficient infrastructure, better use of the transportation system, and more powerful energy consumption led to improved environmental quality while declining the emission of destructive pollutants. Therefore, the impact of urban growth rate on environmental quality and air pollution can vary depending on the different conditions.

LTR_{it}: It is the logarithm of the trade openness. The openness of the trading index is the most common index for the degree of commercialization, which is calculated from a country's trade ratio (total exports and imports) to GDP. There are two contradictory views on the logic of communication and how the volume of trade affects environmental pollution. Bhagwati (1993) and Gallagher (2004), based on the trade hypothesis and pollution harbor, state that developed countries apply severe environmental policies to other countries. Therefore, during the trade, operations, and production process of pollutants in these countries, they are transferred to countries with mild environmental policies. As a result, developing countries become a shelter to attract pollutants. The results of the research of Khan et al. (2023) show that the openness of trade reduces the environmental quality in the long term as well as in the short term in Pakistan. The second view, presented by Grossman and Kruger (1991), refers to the positive impact of expanding trade volume on environmental quality. The researchers classified the effects of commercial liberalization on the environment into three classes: scales, composition, and technology. The effect of the scale indicates a change in the size of economic activities. The effect of the composition of change in the composition or basket of manufactured goods. Finally, the effect of technology also reflects the change in production technology, especially the change to clean and green technologies. With the realization of commercial liberalization, the effect of scale and the effect of technology leads to increased and decreased environmental degradation, respectively. The effect of the composition also varies depending on the relative advantage of manufactured goods in countries. Therefore, if a country has a relative advantage in producing clean goods, the composition of its manufactured goods will lead to more production of these commodities by commercial liberalization. It will be positive for the quality of the environment. Therefore, trade can reduce environmental pollution and spread carbon dioxide, on

the one hand, and increase carbon dioxide pollution and release, on the other hand. Accordingly, the effect of trade on the environment and the spread of carbon dioxide is vague.

4.3 The Panel Unit Root Tests

Using the panel unit root test, it is crucial to seek if the dependent and independent variables are stationary in a panel data analysis. In the current literature, we use the LLC test. The LLC test proposed by Levin, Lin, and Chu assumes the common unit root process across sections. While H_0 is a non-stationary process with a unit root, H_1 is stationary with no unit root. Table (1) shows the results of the panel unit root tests for both dependent and independent variables at 95% significance levels. As can be seen from the results, all variables except $LGDP^2_{it}$ are stationary at the level. Therefore, it is necessary to perform the Cointegration test to investigate the long-term relationship between variables.

Table 1. Unit Root Test Results

Variables	Levin, Lin, & Chu Test	
	Statistic	Probability
LCO_{2it}	-3.21	0.001
$LEGDI_{it}$	-2.21	0.013
$LGDP_{it}$	-1.55	0.062
$LGDP^2_{it}$	-1.58	0.047
LEN_{it}	-4.68	0.000
$LIND_{it}$	-2.50	0.006
LUR_{it}	-14.16	0.000
LTR_{it}	-3.42	0.003

Source: Research finding.

4.4 The Cointegration Test

The Cointegration test examines the existence of a long-term relationship between variables. If the variables are also stacked, they move together over time. As a result, short-term errors are corrected in the long run. In this regard, we focused on Pedroni Test (1999; 2004). The null hypothesis of Pedroni is the absence of cointegration, and its alternative is the existence of cointegration. The Cointegration test results (Table 2) indicate that the null hypothesis of no-cointegration is rejected at the 5% significance level for each panel data set. Therefore, our study's variables are cointegrated, and a long-run relationship exists between them.

Table 2. Pedroni Cointegration Test Results

Test	Statistic	Probability
Panel-PP-Statistic	-7.34	0.000
Panel-ADF-Statistic	-3.8	0.010
Group-PP-Statistic	-17.97	0.000
Group-ADF-Statistic	-1.59	0.045

Source: Research finding.

4.5 Diagnostic Test

To estimate the model with the GMM method, it is necessary to perform diagnostic tests. Sargan test assumes that the residuals or the error terms are not correlated with the instrument's variables. Test validity is established when the null hypothesis that the over-identifying instruments are valid is accepted (Roodman, 2009). Moreover, the autocorrelation/serial correlation test of the error term is displayed to test the null hypothesis of the differenced error term first and second-order serially correlated. This outcome means failure to reject the null hypothesis of no second-order serial correlation, suggesting that the original error term is serially uncorrelated and the moment conditions are correctly specified (i.e., $AR(2) > 0.05$). Table (3) presents the model results to identify the determinants of Environmental Quality (CO₂ emissions) in the Middle East & North African (MENA) countries. Based on the result reported in Table (3), the Wald-test statistics (Prob > F = 0.000) indicated the model's goodness of fit (GOF). As a result, the Sargan test (Prob > chi2 = 0.727) for the validity of the overidentifying restrictions in the GMM estimation is accepted for all specifications. Also, the second-order autocorrelation is rejected by the test for AR(2) (Prob> z= 0.293) as it indicates the absence of second-order autocorrelation.

Table 3. Diagnostic Test Results

Information & Tests		Amounts
Groups		17
Instruments		23
Observations		133
AR (1)	Statistic	-2.21
	Probability	0.027
AR (2)	Statistic	1.05
	Probability	0.293
Sargan-Test	Statistic	11.34
	Probability	0.727
Wald-Test	Probability	0.000

Source: Research finding.

4.6 Results

The variables' coefficients are interpreted and analyzed after ensuring the validity of the diagnostic test. Table (4) shows the results of the GMM estimate.

Table 4. Model Estimation Results with the GMM Method

Variables	Coefficient	Z-Statistic	St. Error	Probability
$L.LCO_{2it}$	0.15	2.22	0.067	0.026
$LEGDI_{it}$	-0.07	-2.8	0.025	0.005
$LGDP_{it}$	0.10	12.26	0.008	0.000
$LGDP^2_{it}$	-0.08	-13.66	0.005	0.000
LEN_{it}	0.66	26.55	0.024	0.000
$LIND_{it}$	0.04	4.91	0.008	0.000
LUR_{it}	0.37	2.39	0.015	0.017
LTR_{it}	-0.09	-1.41	0.063	0.159

Source: Research finding.

According to Table (4), for every percent of change in the independent variables, there is a corresponding percent change in the CO₂ emissions represented by the coefficient. The lagged coefficient of the dependent variable has positive and significant, suggesting that CO₂ emissions in the previous period have a positive effect on it in the current period. There is a negative and significant relationship between the e-government development index and CO₂ emissions. With an increase in the e-government development index by 1% in MENA countries, average CO₂ emissions decrease by an average of about 0.07%. This result is consistent with the findings of Ziolo et al. (2022) and confirmed views of Medaglia et al. (2021), Al Khouri (2013), Krishnan et al. (2013), Young Bum (2017), Jouzbarkand et al. (2011) and Ernst and Young (2003). However, it contradicts the views of Haigh (2004) and (Park et al. (2018)). The findings shows that the increase of GDP leads to high carbon dioxide emission and worsen environmental quality. Considering the two-step system GMM results, a rise in the level of Per Capita Gross Domestic Product in the MENA countries increase carbon dioxide emission by 0.10 percent if there is a one percent increase in Per Capita Gross Domestic Product, indicting that Economic growth reduces environmental quality. As the economic growth is positive and significantly increases carbon dioxide however this study also tests the environmental Kuznets curve by taking the square of economic growth per capita. the results validated this hypothesis as the square term coefficient gives negative and significant results which are consistent with previous studies, such as Awan and Azam (2022), Allard

et al. (2018), Shehzad et al. (2022). The effect of energy consumption on carbon dioxide is shown positively by the coefficients. Thus, a rise in energy use increase carbon dioxide. The findings further show that when there is an increase in carbon dioxide emission with the use of a high amount of energy worsens environmental quality. More specifically, a 0.66 percent increase will occur in carbon dioxide if the use of energy increases by one percent. The findings confirm that energy use in the MENA countries harms environmental quality by producing pollution. This result aligns with Acheampong (2018), Liu and Bae (2018), Massagony and Budiono (2023), which verified the positive impact of energy consumption on CO₂ emissions. Also, the findings shows that the estimated coefficient of industrialization is positive and significant that's leads to high bon dioxide emission and worsen environmental quality. Considering the two-step system GMM results, a rise in the level of industrialization in the MENA countries increase carbon dioxide emission by 0.04 percent with a one percent increase in industrialization, this result aligns with Liu and Bae (2018), and Voumik and Ridwan (2023). According to Table (4), urbanization leads to high carbon dioxide emission and worsen environmental quality. Considering the two-step system GMM results, a rise in the level of urbanization in the MENA countries increase carbon dioxide emission by 0.37% if urbanization goes upward by one percent; consistent with findings from Liu and Bae (2018) and Sofuoğlu et al. (2023). Also, a negative relationship is indicated between trade openness and carbon emissions, however, this relationship is not a significant trade openness.

5. Conclusion and Policy Implications

The term “electronic government” or “e-government”, used interchangeably as “digital government”, is a concept that merges various disciplines. One of the popular definitions provided by the World Bank for e-government is: “the use by government agencies of information technologies (such as Wide Area Networks, the Internet, and mobile computing) that can transform relations with citizens, businesses, and other arms of government” (The World Bank, 2015). In a nutshell, many definitions provide the idea of offering government services supported by ICTs to the public. The main objective of e-government is to improve efficiency, reduce government cost and time (i.e., tangible outcomes), and achieve citizens’ satisfaction and trust in government (i.e., intangible results) (Malodia et al., 2021). in terms of environmental issues, e-government can have a significant effect on maximizing the impact of actions addressing climate change and environmental protection. It also highlights the new opportunities, including remote monitoring

of water and air pollution as well as monitoring and optimizing the use of energy and natural resources, saving time on transactions and interactions, reducing costs associated with transportation, saving paper (Sapraz, 2023; Al-Khori, 2013). The current study employs dynamic panel data and the GMM approach to investigate the impact of e-government development and CO₂ emissions in 17 selected countries of the MENA region, including Iran, for the 2007-2022 period. The model estimation results show that the development of e-government has had a negative and significant effect on the emission of carbon dioxide emissions in MENA countries.

Based on these findings, some policy recommendations can be proposed to reduce CO₂ emissions in MENA countries. this group of countries has been able to take steps toward environmental sustainability and reduce pollution by developing e-government. In the analysis of the cause of this result, it can be stated that the development of the e-government will save energy and reduce paper consumption by changing the economic and bureaucratic structures and the tendency toward non-physical factors and information. Also, developing e-government through the intelligent and optimal use of natural resources will create economic growth by reducing environmental damage. Therefore, the authorities in this group of countries must pay due attention to the implementation and improvement of e-government to reduce CO₂ emissions and help to improve environmental quality. Secondly, given that the relationship between CO₂ emissions and economic growth validates an inverted U-shape curve, the economic growth level in MENA's economy seems sufficient to reach acceptable reductions in CO₂ emissions after the indicated income levels. Third, there is a need to increase the use of renewable energy sources and promote energy conservation practices to reduce energy consumption. Moreover, MENA countries should seek cost-effective and domestic opportunities to meet its energy demand through energy diversification. Furthermore, it is also necessary that MENA countries take appropriate steps to regulate and optimize the industrial structure from a strategic point of view.

It is important to recognize that e-government alone cannot solve all environmental challenges. Access to ICT infrastructure, internet connectivity, and digital literacy are prerequisites for effective e-government implementation. In many regions, particularly in developing countries or rural areas, these resources may be limited. Furthermore, there may be concerns regarding data privacy, cybersecurity, and the reliability of electronic systems.

To evaluate the overall effectiveness of e-government in improving environmental quality, comprehensive research studies and case-specific assessments are needed. Factors such as context, governance frameworks, technological capacities, and public engagement strategies should be taken into account to draw accurate conclusions about the impact of e-government on environmental outcomes.

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RESEARCH PAPER

Enhancing Financial Literacy through Fintech: A Study on Aceh's Millennials with Gender and Education as Moderators

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Abstract

Financial technology (fintech) has emerged as a transformative tool for promoting financial inclusion and enhancing financial literacy, particularly among the millennial generation. This study investigates the impact of fintech—specifically its dimensions of knowledge, usage, and accessibility—on the financial literacy of millennials in Aceh, Indonesia. Furthermore, the study examines whether gender and education level moderate these relationships. A quantitative approach was employed, utilizing both Structural Equation Modeling (SEM) and Moderated Multiple Regression (MMR) to ensure robust analysis. The sample consisted of 328 millennial respondents, selected through purposive sampling. The findings reveal that fintech knowledge, usage, and accessibility each have a significant and positive effect on financial literacy. Additionally, both gender and education were found to moderate these relationships; however, the moderation did not differ significantly between male and female groups or across educational levels. This indicates that while gender and education enhance the strength of the relationship between fintech and financial literacy, their moderating effects are consistent across groups. These results suggest the need for inclusive financial education strategies that cater to all demographic segments. Financial institutions and policymakers should focus on increasing access to fintech tools and strengthening financial literacy programs without bias toward gender or educational background. Future studies are encouraged to replicate this research in other regions and to explore additional moderating variables that may influence fintech adoption and financial capability among youth.

Keywords: Financial Technology, Financial Literacy, Millennials, Structural Equation Model (SEM), Moderated Multiple Regression.

JEL Classification: G1, G4, M2.

1. Introduction

The emergence of financial technology (fintech) has significantly transformed the landscape of financial services by offering digital alternatives to traditional banking (Broby, 2021). These innovations—ranging from mobile payments to

digital lending and investment platforms—have made financial services more accessible, efficient, and user-friendly. Among the primary adopters of fintech are Millennials, a generation characterized by high levels of digital literacy, familiarity with online platforms, and a strong preference for convenience and flexibility in financial transactions (Daqar et al., 2020). As digitalization accelerates, the ability to make informed financial decisions becomes increasingly essential for ensuring personal financial well-being (Lusardi and Mitchell, 2014).

Indonesia is one of the largest fintech markets in Southeast Asia, with rapid growth fueled by internet penetration, a young population, and increasing investor interest. According to the e-Conomy SEA 2022 report, the country's digital economy—including its fintech sector—is projected to reach a Gross Merchandise Value (GMV) of USD 307 billion by 2025. The number of fintech companies in Indonesia grew from 340 in 2019 to over 580 in 2021 and is expected to surpass 1,000 by 2025. Popular services include e-wallets such as GoPay, OVO, and DANA, as well as investment platforms like Bibit and Stockbit, which have become increasingly favored by retail investors. Meanwhile, digital lending continues to expand, with 102 fintech lending firms licensed by the Financial Services Authority (OJK) as of March 2023, collectively disbursing over IDR 65.4 trillion (USD 4.5 billion) in loans in the second quarter of 2021 alone.

While the fintech sector continues to flourish, financial literacy remains a persistent challenge—particularly among Millennials, who are simultaneously the most digitally active yet often underprepared to manage personal finances. Financial literacy refers to the ability to understand and effectively use various financial skills, including budgeting, saving, investing, and debt management. A lack of financial literacy can result in excessive debt, poor financial planning, and vulnerability to financial fraud. In Indonesia, surveys by the OJK indicate that only about 20% of Millennials demonstrate basic financial knowledge, with low levels of understanding in core areas such as interest rates, inflation, and credit scores. These gaps not only hinder financial inclusion but also limit the long-term economic empowerment of younger generations.

Financial literacy comprises four key dimensions: financial knowledge, attitudes, behavior, and the capacity to apply knowledge in decision-making. Education—both formal and informal—plays a central role in shaping these dimensions. Prior studies (e.g., Palameta, 2016; Darmawan and Pratiwi, 2020) consistently show that higher education levels are associated with better financial understanding and behavior. Informal learning, such as family financial discussions, also influences financial attitudes and practices. Additionally, gender

has emerged as a relevant factor in financial literacy, with studies indicating that men often report higher confidence in financial decision-making, while women may face additional barriers due to traditional roles and societal expectations (Ansong and Gyensare, 2012). Nevertheless, these general patterns can vary widely depending on context, emphasizing the need for intersectional and region-specific analysis.

Fintech holds significant potential to improve financial literacy by providing interactive and accessible tools for financial learning (Panos and Wilson, 2020). Mobile apps, gamified financial education, digital budgeting tools, and robo-advisors help users engage with financial content in real time and at their own pace. These technologies not only offer knowledge but also facilitate practical application, such as tracking spending, setting savings goals, and understanding investments. Social media platforms and online communities further support knowledge sharing and peer learning, especially among digitally native users like Millennials. Thus, fintech is increasingly positioned not just as a provider of financial services but also as a catalyst for financial capability and empowerment.

While national-level data highlight the promise of fintech, the impacts are unlikely to be uniform across Indonesia's diverse regions. Variations in digital infrastructure, education levels, and socio-cultural norms can influence how fintech is adopted and utilized. In this regard, Aceh presents a compelling case. Over the past few years, the region has experienced notable growth in digital connectivity, smartphone usage, and fintech initiatives introduced by local governments and financial institutions. Programs promoting mobile banking, QR-code payments, and online financial education are beginning to gain traction. However, the pace and pattern of adoption remain uneven, particularly among different gender groups and educational backgrounds. These disparities raise important questions about how digital financial tools are understood, accessed, and leveraged by local communities—especially by Acehnese Millennials, who are expected to become key actors in the region's socio-economic transformation.

Although fintech is widely believed to enhance financial literacy, empirical research focusing on specific local contexts—such as Aceh—remains limited. Existing studies tend to emphasize national trends or urban centers, overlooking peripheral regions where digital transitions may follow unique trajectories. This study seeks to fill that gap by examining the relationship between fintech usage and financial literacy among Millennials in Aceh, while also investigating how gender and education moderate this relationship. This research contributes both conceptually and empirically. Conceptually, it integrates technology adoption and

financial literacy within a localized socio-cultural framework. Empirically, it provides new evidence from a region that is underrepresented in the fintech literature, offering insights that can inform targeted interventions for enhancing financial inclusion and capability. By uncovering the ways fintech can support or fail to support financial literacy in Aceh, this study aims to generate practical recommendations for policymakers, educators, and fintech providers. Ultimately, the findings are expected to contribute to broader efforts in narrowing regional disparities in financial knowledge, promoting digital financial inclusion, and empowering young individuals to take greater control over their financial futures.

2. Literature Review

2.1 Financial Literacy

According to the Organization for Economic Co-operation and Development (OECD, 2016), financial literacy refers to an understanding and knowledge of financial concepts and risks, along with the skills, motivation, and beliefs necessary to apply that knowledge in making effective financial decisions. These abilities are essential for fostering positive financial behavior and improving the financial well-being of both individuals and communities, while also contributing to broader economic participation. In a similar vein, the National Strategy for Indonesian Financial Literacy defines financial literacy as a life skill that enables individuals to make informed decisions, manage their finances more effectively, and ultimately achieve personal and communal prosperity. Based on this framework, the Indonesian Financial Services Authority (OJK) categorizes financial literacy levels into four groups. The first is well-literate, referring to individuals or communities with strong knowledge and confidence in financial institutions and products, a thorough understanding of their features, benefits, and risks, and the ability to use them effectively while being aware of associated rights and obligations. The second category is sufficiently literate, which describes individuals who have a reasonable understanding and confidence in financial services and demonstrate basic comprehension of the characteristics and risks involved. Third, less literate individuals possess only limited knowledge and understanding of financial products and services; while they may be familiar with some basic concepts, they lack a comprehensive grasp of financial mechanisms. Lastly, those classified as not literate show minimal or no understanding of financial institutions or products, have low confidence in financial matters, and cannot manage or use financial tools appropriately.

Furthermore, an individual's level of financial literacy can vary significantly and is influenced by a range of demographic and socio-economic factors. Amaliyah and Witiastuti (2015) emphasized that gender and education level are among the key determinants of financial literacy. Supporting this view, the 2017 National Survey on Financial Literacy and Inclusion (SNLKI) conducted by OJK identified education, income level, and type of occupation as essential demographic variables for assessing a person's financial literacy level. These findings suggest that financial literacy is not merely an outcome of individual initiative but is also shaped by structural and contextual factors that warrant attention in both research and policy efforts.

2.2 Financial Technology

Financial technology, or fintech, encompasses a wide range of financial services—including payments, fundraising, lending, and asset management—that are enhanced through the use of technology to increase speed and efficiency. According to Chrismastianto (2017), fintech is essentially a combination of financial services and modern technology, or more broadly, it represents innovation in the financial sector driven by technological advancements. Similarly, the National Digital Research Center (NDRC, 2022) defines fintech as an innovative application of technology within the financial services industry. The term itself, derived from the fusion of “financial” and “technology,” refers specifically to the use of modern technological tools in banking and finance. In today's digital era, fintech has become an increasingly dominant means of delivering financial services, transforming the way individuals interact with financial systems.

Fintech's influence on financial literacy can be observed through three interrelated dimensions: fintech knowledge, fintech usage, and fintech accessibility (Li et al., 2020). First, fintech knowledge involves an individual's understanding and awareness of financial technology and its various applications. A solid grasp of how fintech products and services function—and how they can be used to support personal financial management and decision-making—is a vital element of financial literacy. As individuals become more knowledgeable about fintech through educational content, training initiatives, or information from fintech providers, they are more likely to explore and adopt these technologies, thereby enhancing their financial competencies. Second, fintech use refers to the actual engagement with fintech platforms and services. Through regular interaction with fintech applications, individuals gain firsthand experience in managing digital

financial transactions. This exposure helps users become familiar with various fintech tools and their functionalities—such as budgeting, tracking expenses, making online payments, or monitoring investments—which, in turn, contributes to the development of financial skills and overall literacy. Lastly, fintech accessibility relates to the ease and availability of accessing fintech services. Broad accessibility ensures that individuals, regardless of geographic location, socioeconomic background, or physical limitations, can engage with fintech tools. This aspect is closely linked to financial inclusion, as accessible fintech platforms enable underserved or previously excluded populations to participate in the digital economy. The more accessible fintech becomes, the more opportunities individuals have to interact with it and leverage its benefits for improving their financial literacy and well-being.

2.3 Gender and Education

According to the nurture theory, the differences between men and women are primarily the result of socio-cultural constructions that assign distinct tasks and roles to each gender. This theory suggests that women are often marginalized or overlooked in their contributions to society, family, and the nation. In contrast, nature theory argues that gender differences are innate, universal, and unchangeable. Research by Chen and Volpe (2002) found that gender influences the level of financial literacy among students, with male students generally exhibiting higher financial literacy than female students. This is attributed to men's logical thinking, decisiveness, independence, and self-confidence, which lead them to consider fewer emotional variables when making financial decisions. However, Margaretha and Pambudhi (2015) present a differing perspective, indicating that female students actually have higher financial literacy levels than male students. Apart from gender, academic ability is also identified as a significant factor influencing financial literacy and financial management behavior. Students with greater knowledge tend to apply this knowledge positively in managing their personal finances, resulting in wiser financial decisions. Thus, higher academic ability correlates with better financial literacy and more prudent financial management.

3. Research Methodology

This study employs an associative quantitative research design aimed at examining the role of financial technology in influencing financial literacy among millennials, with gender and education as moderating variables. The decision to focus on

millennials in Aceh Province was motivated by the increasing prevalence of digital finance and the need to understand how fintech affects financial literacy within this demographic.

Primary data was collected through a structured questionnaire distributed across all districts and cities in Aceh Province. The selection of this research area and population is justified by the Financial Services Authority (OJK) data from 2019, which shows that fintech lending loans in Aceh reached IDR 113.26 billion—equivalent to 0.3% of the national total of IDR 41.03 trillion. Furthermore, Aceh accounted for 105,885 borrower accounts nationally, with 37,796 borrower accounts specifically in Aceh, representing 0.435% of the 8.75 million national borrower accounts. The number of lender accounts in Aceh was recorded at 2,894, or 0.6% of the national total of 480,262 accounts. The majority of lenders belong to the millennial generation, with the remainder being individuals over 35 years old (Walfazri, 2019).

The target population for this research consists of millennials in Aceh, defined by the Central Statistics Agency and supported by William H. Frey's analysis of the 2020 Population Census as individuals born between 1981 and 1996 (Frey, 2018), currently aged 25 to 39 years. The sampling method applied was purposive random sampling, where participants were intentionally selected based on specific criteria relevant to the study's objectives (Sugiyono, 2014). The sample size was determined using the Slovin formula, with a total millennial population of 18,346 and a margin of error set at 10%. The inclusion criteria for respondents were: 1) millennials aged 25 to 39 years; 2) a monthly income starting at IDR 2,500,000; 3) a minimum education level of senior high school.

Data analysis was conducted using Structural Equation Modeling (SEM), which is well-suited for examining complex relationships involving multiple variables simultaneously. SEM allows for the evaluation of both measurement models—ensuring the reliability and validity of observed variables—and structural models that analyze relationships between latent constructs. This approach provides a comprehensive understanding of the interplay among financial technology components, financial literacy, and the moderating effects of gender and education.

This study also employed Moderated Multiple Regression (MMR) to analyze the moderating effects of gender and education on the relationship between financial technology and financial literacy. MMR is a multivariate technique that includes several independent variables, a dependent variable, and moderating variables. It helps determine whether moderation occurs by examining interaction

effects between independent and moderating variables (Jaccard and Turrissi, 2003; Aguinis, 2004). The moderating variables in this study are dichotomous, representing gender and education, and the moderation can either strengthen or weaken the influence of financial technology on financial literacy. This moderation analysis is based on the multiple regression framework with interaction terms to capture the moderating effects.

As illustrated in Figure 1, the dependent variable is Financial Literacy (Y), the independent variables are Knowledge Satisfaction (X1), Use (X2), and Accessibility (X3), and the moderating variables are Gender (M1) and Education (M2).

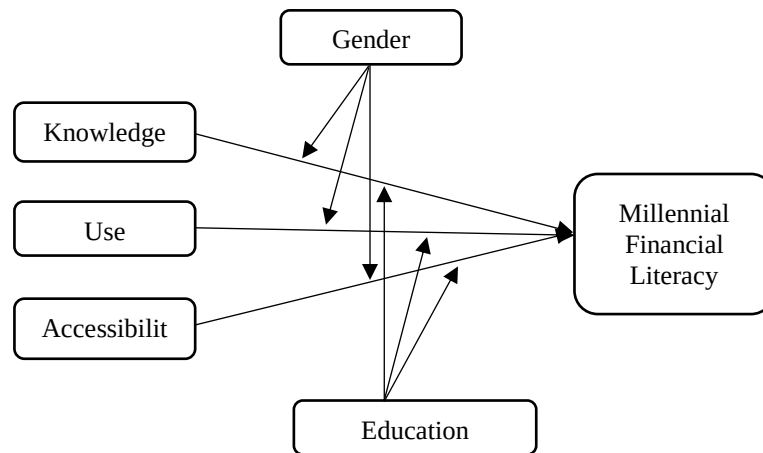


Figure 1. Conceptual Model

Source: Research finding.

Based on Figure 1, the mathematical equations for the direct and moderating effect models in this study can be written as follows:

1) Direct Effect Model:

$$MFL = \alpha + \beta_{11}KNO + \beta_{12}USE + \beta_{13}ACC + \beta_{14}GDR + \beta_{15}EDU + \zeta_1 \quad (1)$$

2) Moderating Effect Model of Education:

$$MFL = \alpha + \beta_{21}KNO + \beta_{22}USE + \beta_{23}ACC + \beta_{24}EDU + \beta_{25}KNO*EDU + \beta_{26}USE*EDU + \beta_{27}ACC*EDU + \zeta_3 \quad (2)$$

3) Moderating Effect Model of Gender:

$$\text{MFL} = \alpha + \beta_{31}\text{KNO} + \beta_{32}\text{USE} + \beta_{33}\text{ACC} + \beta_{34}\text{GDR} + \beta_{35}\text{KNO}*\text{GDR} + \beta_{36}\text{USE}*\text{GDR} + \beta_{37}\text{ACC}*\text{GDR} + \zeta_2 \quad (3)$$

Where MFL is Millennials' Financial Literacy, KNO is knowledge, USE is use, ACC is accessibility, GDR is Gender and EDU education, α denotes the intercept or constant term in the regression model, β_{1-3} are coefficients that indicate the strength and direction of the influence of each respective variable, and ζ_{1-3} represent the error terms in each respective equation, accounting for unobserved factors or random disturbances that may influence the outcomes.

Based on the research framework, the hypotheses proposed in this study are as follows:

H₁: Fintech knowledge has a significant effect on improving the financial literacy of the millennial generation in Aceh, Indonesia.

H₂: Fintech usage has a significant effect on improving the financial literacy of the millennial generation in Aceh, Indonesia.

H₃: Fintech accessibility has a significant effect on improving the financial literacy of the millennial generation in Aceh, Indonesia.

H₄: Education level moderates the relationship between fintech knowledge and the financial literacy of the millennial generation in Aceh, Indonesia.

H₅: Education level moderates the relationship between fintech usage and the financial literacy of the millennial generation in Aceh, Indonesia.

H₆: Education level moderates the relationship between fintech accessibility and the financial literacy of the millennial generation in Aceh, Indonesia.

H₇: Gender moderates the relationship between fintech knowledge and the financial literacy of the millennial generation in Aceh, Indonesia.

H₈: Gender moderates the relationship between fintech usage and the financial literacy of the millennial generation in Aceh, Indonesia, Indonesia.

H₉: Gender moderates the relationship between fintech accessibility and the financial literacy of the millennial generation in Aceh, Indonesia, Indonesia.

4. Results and Discussion

4.1 Descriptive Statistics

This study involved 328 respondents selected using a purposive sampling technique. A structured questionnaire consisting of 57 items was distributed directly to participants. Data collection was conducted from April 7 to July 15, 2022. Respondents were Millennials who met the sampling criteria. Descriptive

statistics were used to summarize the demographic characteristics and fintech-related behaviors of the participants. The details of the respondents' profiles, including gender, age, education, income, frequency of fintech use, and level of trust in fintech security, are presented in Table 1.

Table 1. Respondent Demographics

No	Characteristics of Respondents	Frequency	Percentage
1	Gender:		
	Female	250	76%
	Male	78	24%
2	Age:		
	Under 20 years old	181	55%
	20-25 years old	112	34%
	26-30 years old	9	3%
	31-35 years old	11	3%
	Over 35 years old	15	5%
3	Education:		
	High School (SMA/MAN)	219	67%
	Bachelor's Degree (S-1)	96	29%
	Master's Degree (S-2)	9	3%
	Other	4	1%
4	Income:		
	Less than IDR 2,500,000	282	86%
	IDR 2,500,000 – IDR 5,000,000	15	5%
	IDR 5,000,001 – IDR 10,000,000	12	4%
	More than IDR 10,000,000	19	6%
	Routine/Frequency of Use of Financial Technology:		
		212	65%
	Often	116	35%
	Rarely		
	Trust in Fintech Security:		
	Trust	216	66%
	Doubtful	106	32%
	Do not trust	6	2%

Source: Research finding.

Table 1 shows that 76% of the respondents are female, while 24% are male. The majority of respondents fall into the under-20 age category (55%), followed by those aged 20–25 years (34%). In terms of education level, 67% of respondents are at the high school level (SMA/MAN), while 34% hold a bachelor's degree (S1), and 4% have a master's degree (S2). Regarding income, the majority of respondents (86%) earn less than IDR 2,500,000, while 5% earn between IDR 2,500,000 and IDR 5,000,000, and 4% and 6% earn between IDR 5,000,000–10,000,000 and above IDR 10,000,000, respectively. The use of financial technology among respondents was assessed based on usage frequency. The results show that 65% of respondents frequently use financial technology, while 35% do not use it frequently. In terms of confidence in the security of financial technology, 66% of respondents trust its security, 32% are uncertain, and the remaining 2% do not trust the security of financial technology.

4.2 Measurement and Data Diagnostics

4.2.1 Validity Test

The validity test aims to examine the relationship between the observed indicators and their corresponding latent variables within the measurement model. Combining the testing of the measurement model and the structural model allows researchers to account for measurement error as an integral part of Structural Equation Modeling. This approach also enables simultaneous factor analysis and hypothesis testing. The measurement model test results are illustrated in Figure 2.

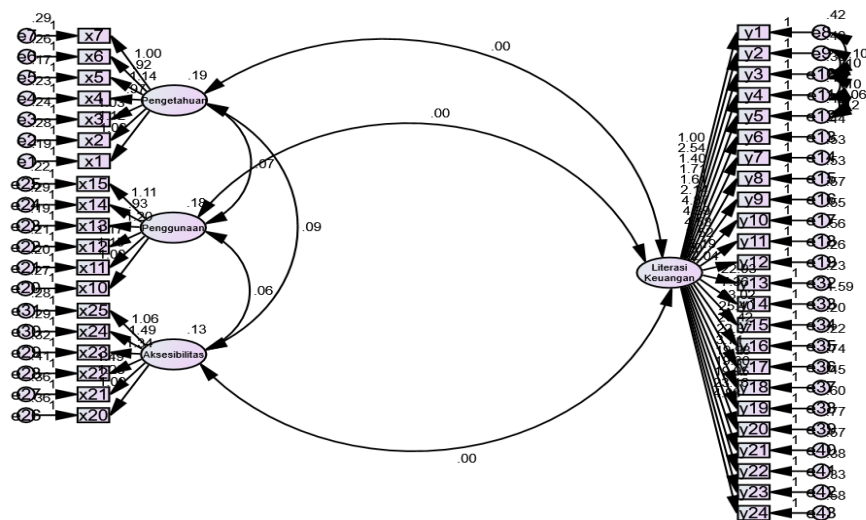


Figure 2. Measurement Model

Source: Research finding.

The results of the loading factor calculations, which represent the validity of each indicator in measuring the latent variables, are presented in Table 2.

Table 2. Loading Factors of the Measurement Model

		Variable	Estimate
x1	<---	Knowledge	0.703
x2	<---	Knowledge	0.675
x3	<---	Knowledge	0.675
x4	<---	Knowledge	0.663
x5	<---	Knowledge	0.767
x6	<---	Knowledge	0.615
x7	<---	Knowledge	0.629
y1	<---	Financial Literacy	0.044
y2	<---	Financial Literacy	0.114
y3	<---	Financial Literacy	0.073
y4	<---	Financial Literacy	0.071
y5	<---	Financial Literacy	0.071
y6	<---	Financial Literacy	0.092
y7	<---	Financial Literacy	0.188
y8	<---	Financial Literacy	0.17
y9	<---	Financial Literacy	0.171
y10	<---	Financial Literacy	0.097
y11	<---	Financial Literacy	0.231
y12	<---	Financial Literacy	0.78
x10	<---	Use	0.629
x11	<---	Use	0.737
x12	<---	Use	0.735
x13	<---	Use	0.758
x14	<---	Use	0.584
x15	<---	Use	0.709
x20	<---	Accessibility	0.518
x21	<---	Accessibility	0.593
x22	<---	Accessibility	0.644
x23	<---	Accessibility	0.654
x24	<---	Accessibility	0.706
x25	<---	Accessibility	0.587
y13	<---	Financial Literacy	0.806
y14	<---	Financial Literacy	0.165
y15	<---	Financial Literacy	0.825

		Variable	Estimate
y16	<---	Financial Literacy	0.839
y17	<---	Financial Literacy	0.563
y18	<---	Financial Literacy	0.69
y19	<---	Financial Literacy	0.136
y20	<---	Financial Literacy	0.545
y21	<---	Financial Literacy	0.59
y22	<---	Financial Literacy	0.681
y23	<---	Financial Literacy	0.754
y24	<---	Financial Literacy	0.178

Source: Research finding.

Based on the calculation results shown in Table 2, the factor loadings of the observed items were evaluated. Items Y1, Y2, Y3, Y4, Y5, Y6, Y7, Y8, Y9, Y10, Y11, Y14, Y19, and Y24 exhibited loading factors below the acceptable threshold of 0.5, indicating that these items do not adequately represent their latent variables. Consequently, these items were removed from the model.

Following the removal of items with loading factors below 0.5, the model was retested. The results of this re-estimation are presented in Figure 3 and Table 3. They show that all remaining items have loading factors above 0.5, which meets the validity criteria. This confirms that the measurement model has acceptable convergent validity.

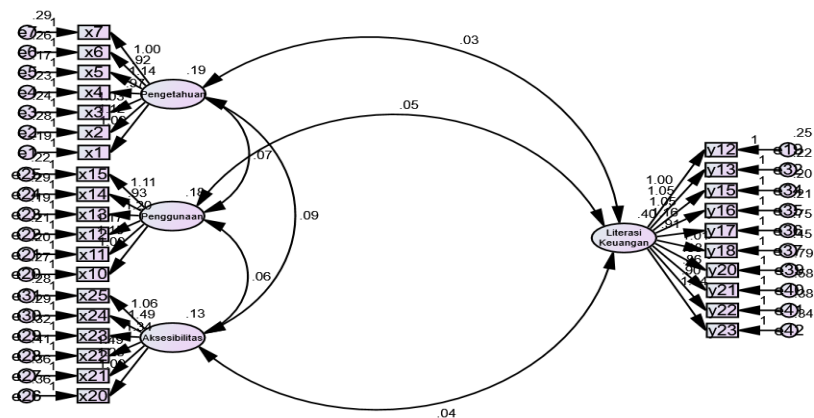


Figure 3. Confirmatory Factor Analysis Test Results

Source: Research finding.

Table 3 presents the loading factors of the measurement model after the removal of invalid items. All remaining items show loading factors above the 0.5 threshold, indicating improved model validity.

Table 3. Loading Factors of the Measurement Model

		Variable	Estimate
x1	<---	Knowledge	0.703
x2	<---	Knowledge	0.675
x3	<---	Knowledge	0.675
x4	<---	Knowledge	0.663
x5	<---	Knowledge	0.767
x6	<---	Knowledge	0.615
x7	<---	Knowledge	0.629
x10	<---	Use	0.629
x11	<---	Use	0.737
x12	<---	Use	0.735
x13	<---	Use	0.758
x14	<---	Use	0.584
x15	<---	Use	0.709
x20	<---	Accessibility	0.519
x21	<---	Accessibility	0.593
x22	<---	Accessibility	0.644
x23	<---	Accessibility	0.653
x24	<---	Accessibility	0.705
x25	<---	Accessibility	0.588
y12	<---	Financial_Literacy	0.782
y13	<---	Financial_Literacy	0.814
y15	<---	Financial_Literacy	0.833
y16	<---	Financial_Literacy	0.848
y17	<---	Financial_Literacy	0.554
y18	<---	Financial_Literacy	0.688
y20	<---	Financial_Literacy	0.534
y21	<---	Financial_Literacy	0.582
y22	<---	Financial_Literacy	0.677
y23	<---	Financial_Literacy	0.75

Source: Research finding.

4.2.2 Reliability Test

The reliability test measures the consistency of a measuring instrument in producing similar results when repeated on the same subject. A variable is

considered reliable if its Cronbach's alpha coefficient is 0.5 or higher. Table 4 below presents the results of the reliability test for the variables in this study.

Table 4. Reliability Test Results

No	Variable	Construct Reliability	Result
1	Knowledge	0.853	Reliable
2	Use	0.847	Reliable
3	Accessibility	0.785	Reliable
4	Financial Literacy	0.838	Reliable
5	Education	0.920	Reliable
6	Gender	0.586	Reliable

Source: Research finding.

Based on the results presented in Table 4, since all construct reliability values are above 0.50, it can be concluded that all constructs in this study are reliable and suitable for use.

4.2.3 Outliers Test

The outlier test aims to identify observations with extreme values that deviate significantly from the overall data pattern, either as univariate or multivariate outliers (Ghozali, 2005). In this study, the detection of multivariate outliers was conducted using the Mahalanobis distance approach. The results of the analysis indicate that none of the cases exceeded the critical Mahalanobis distance value of 480.954, which was determined based on the chi-square distribution at the appropriate degrees of freedom and significance level. This finding suggests that the dataset does not contain multivariate outliers and is therefore suitable for further analysis.

4.2.4 Multicollinearity Assumption

The multicollinearity test was conducted to examine the degree of correlation among the independent variables in the model. The results of this test are presented in Table 5.

Table 5. Multicollinearity Test

Model	(Constant)	Collinearity Statistics Tolerance	VIF
	Knowledge	0.743	1.346
	Use	0.862	1.160
	Accessibility	0.732	1.365
	Gender	0.623	1.620
	Education	0.207	1.567

Source: Research finding.

As shown in Table 5, all Variance Inflation Factor (VIF) values are below the commonly accepted threshold of 10, indicating that multicollinearity is not present among the independent variables. Thus, the assumption of no multicollinearity in the dataset is satisfied.

4.2.5 Normality test

The evaluation of data normality was conducted using the critical ratio (CR) of skewness, with a threshold of ± 2.58 at a 0.01 significance level (1%). Data are considered normally distributed if the skewness and kurtosis critical ratio values fall within ± 1.96 (Ghozali, 2005). The results of the normality test, conducted using AMOS 24, are presented in Table 6.

Table 6. Multicollinearity Test

Variable	skew	kurtosis
y24	-1.076	.467
y21	-.729	-.113
y20	-.530	-.362
y19	-.901	.556
y17	-.593	-.437
x25	-.888	.430
x23	-.909	.247
x21	-.705	-.310
x20	-.674	-.209
x14	-.548	-.058
x13	-.794	.269
x11	-.646	-.120
x10	-.933	.626
y7	-.372	-.670
x6	-.517	-.392
x5	-.855	.159

Variable	skew	kurtosis
x3	-.950	.416
x2	-.899	.539

Source: Research finding.

Based on the results presented in Table 6, all skewness and kurtosis critical ratio values fall within the acceptable range of ± 1.96 . This indicates that the data are normally distributed and thus suitable for further analysis.

4.2.6 Goodness of Fit

The goodness of fit evaluation assesses how well the proposed model fits the observed data, using several fit indices and corresponding cut-off values. Table 7 summarizes the results of the model fit assessment.

Table 7. Goodness of Fit Index

Goodness of Fit Index	Cut off Value	Model Test Result	Information
Degree of Freedom	Positive (+)	84	Positive
Chi-Square	177.21	230.79	Moderate
CMIN/DF	$\leq 2,00$	1.876	Acceptable
GFI	$\geq 0,90$	,929	Acceptable
RMSEA	0,05-0,08	,052	Acceptable
AGFI	$\geq 0,90$	0,901	Acceptable
TLI	$\geq 0,90$	0.964	Acceptable
CFI	$\geq 0,90$	0,971	Acceptable
NFI	$\geq 0,90$	0.940	Acceptable
PNFI	0,60-0,90	0.756	Acceptable

Source: Research finding.

Based on Table 7, all goodness-of-fit indicators meet the required thresholds, indicating that the model has a good fit with the empirical data. Although the chi-square value is relatively high, this is acceptable given the sensitivity of the chi-square statistic to sample size. Therefore, the overall model can be considered appropriate for further structural analysis.

4.3 Structural Model Analysis

Structural model analysis aims to examine the relationships among latent variables, assess the significance of path coefficients, and evaluate the explanatory power of the model using R-square values. This analysis follows the confirmation of the

measurement model's validity and the overall model fit, as previously presented. Figure 4 illustrates the full structural model, which includes the relationships among the latent variables: Knowledge, Usage, Accessibility, and Financial Literacy. These relationships are analyzed based on the Goodness of Fit (GoF) indices discussed in Table 7, which indicate that the model meets acceptable fit criteria and is suitable for further interpretation.

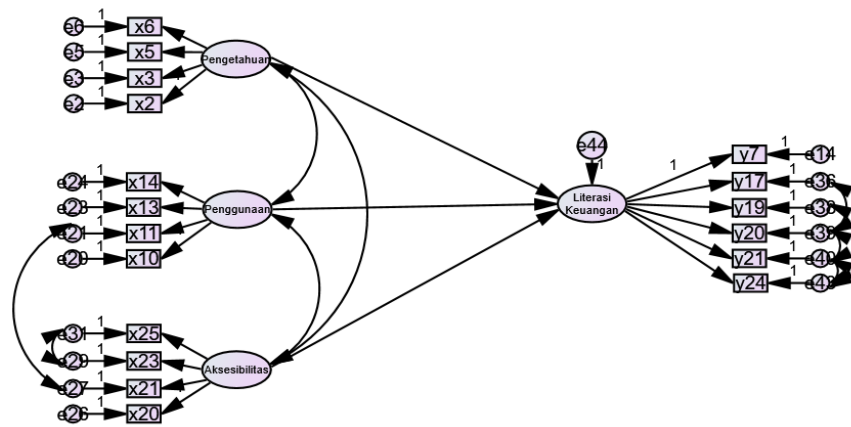


Figure 4. Full SEM Model

Source: Research finding.

The results of the path analysis, including estimated coefficients, standard errors, critical ratios, and p-values, are presented in Table 8 below.

Table 8. Direct Effect Test Results

Variable			Estimate	S.E.	C.R.	P
Financial_Literacy	<---	Usage	.335	.139	2.411	.016
Financial_Literacy	<---	Knowledge	.265	.107	2.470	.014
Financial_Literacy	<---	Accessibility	.349	.177	1.968	.049

Source: Research finding.

As shown in Table 8, all independent variables — Usage, Knowledge, and Accessibility — have a statistically significant effect on Financial Literacy, with p-values below 0.05. This indicates that each of these variables plays a meaningful role in influencing financial literacy levels. A visual representation of the path analysis results is also presented in Figure 5.

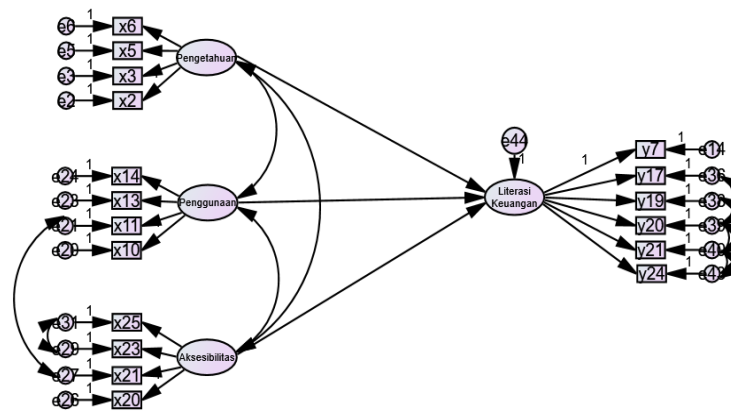


Figure 5. SEM Analysis Results

Source: Research finding.

4.3.1 The Effect of Fintech Knowledge on Financial Literacy

The structural estimation presented in Table 8 indicates that knowledge has a significant and positive influence on financial literacy, with a standardized coefficient of 0.265 (26.5%), a critical ratio (CR) of 2.470, and a p-value of 0.014. Given that the p-value is below the 0.05 threshold, this result supports the acceptance of Hypothesis 1, which posits that financial knowledge significantly affects the financial literacy of the millennial generation in Aceh. This finding suggests that as millennials in Aceh become more knowledgeable about financial concepts and practices, their level of financial literacy improves accordingly. Financial knowledge, therefore, serves as a foundational component in shaping individuals' ability to manage personal finances effectively. According to Palameta et al. (2016), acquiring financial knowledge from an early age is crucial, as it can evolve into applicable skills that enhance day-to-day financial decision-making. Furthermore, Rai et al. (2019) emphasize that financial knowledge underpins responsible financial attitudes and behaviors, including long-term financial planning such as retirement preparation. These results are in line with prior studies by Robb and Woodyard (2011) as well as Yuliani et al. (2019), both of which affirm that financial knowledge is a key determinant of financial literacy. Overall, the findings reinforce the importance of educational interventions and policies aimed at improving financial literacy by strengthening financial knowledge among young adults.

4.3.2 The Effect of Fintech Usage on Financial Literacy

As presented in Table 8, the structural model estimation shows that fintech usage has a significant and positive effect on financial literacy, with a standardized coefficient of 0.335 (33.5%), a critical ratio (CR) of 2.411, and a p-value of 0.016. These results confirm the acceptance of Hypothesis 2, which posits that the use of financial technology significantly contributes to the financial literacy of the millennial generation in Aceh. This implies that increased engagement with fintech platforms enhances millennials' ability to manage personal finances effectively. In practical terms, every 100-unit increase in fintech usage corresponds to a 33.5-unit improvement in financial literacy. The findings suggest that the adoption of fintech tools not only facilitates more efficient financial transactions but also fosters greater knowledge, confidence, and decision-making capabilities. Through frequent use of fintech services—such as digital banking, e-wallets, investment apps, or peer-to-peer lending—users are more exposed to financial products, terms, and best practices, which in turn improve their financial literacy. This result is consistent with studies by Mulasiswi and Julialevi (2020), Marpaung (2021), and Mustikasari and Noviardy (2020), all of which highlight the strong link between fintech adoption and enhanced financial literacy. These studies emphasize that fintech usage enables users to better understand and access financial services, thereby supporting informed financial behaviors and long-term financial well-being.

4.3.3 The Effect of Accessibility on Financial Literacy

Based on the results in Table 8, fintech accessibility is shown to have a significant and positive influence on financial literacy, with an estimated coefficient of 0.349 (34.9%), a critical ratio (CR) of 1.968, and a p-value of 0.049. These findings indicate that Hypothesis 3 is accepted at the 5% level of significance, affirming that increased accessibility to fintech services contributes to higher levels of financial literacy among the millennial generation in Aceh. This result suggests that as fintech platforms become more easily accessible—via mobile devices, internet connectivity, and user-friendly applications—individuals are more likely to engage with these technologies, which enhances their understanding of financial tools and services. Specifically, a 100-unit increase in fintech accessibility leads to an estimated 34.9-unit improvement in financial literacy. The convenience and flexibility offered by fintech reduce traditional barriers such as geographic limitations and banking hours, enabling millennials to explore, learn, and adopt financial services more effectively. These findings align with previous studies by

Usmayanti and Kadar (2022), Sugiarti et al. (2019), and Marpaung (2021), which emphasize that increased access to fintech not only promotes the usage of digital financial tools but also strengthens financial knowledge and skills. The ease of access allows users to explore features such as online savings, investment tracking, digital budgeting, and e-payment systems, ultimately encouraging responsible financial behavior. Thus, fintech accessibility serves as a gateway to broader financial inclusion and literacy, particularly for tech-savvy young adults in regions like Aceh.

4.4 Multigroup Moderation Effect Test

The results of the structural analysis of the multi-group moderating variables are shown in Figure 6.

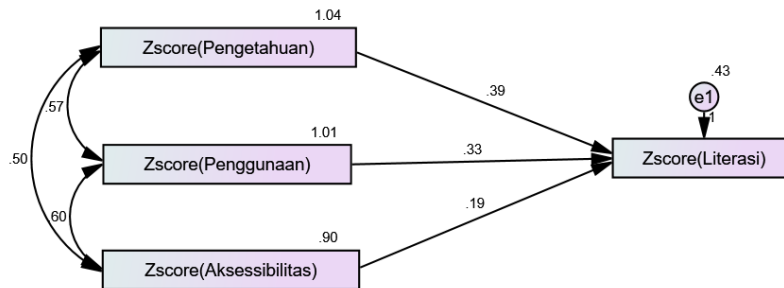


Figure 6. Multigroup Moderation Test Results

Source: Research finding.

4.4.1 Multigroup Moderation Effect of Education

The multigroup moderation test employed a Moderated Multiple Regression (MMR) approach to assess whether the relationship between the independent variables (knowledge, usage, and accessibility) and financial literacy differed across education levels. The initial evaluation was conducted using the structural weights invariance test, the results of which are presented in Table 9.

Table 9. The Significance of Education Level Multigroup Moderation

Model	DF	CMIN	P
Structural weights	3	1.264	.738

Source: Research finding.

As shown in Table 9, the p-value for the structural weights test is 0.738, which exceeds the 5% significance threshold. This indicates that there is no

significant difference in the structural path coefficients across different education levels. In other words, millennials, regardless of their educational attainment, exhibit similar patterns in how knowledge, usage, and accessibility affect their financial literacy. Therefore, education level does not have a significant moderating effect on the overall structural model. However, to further understand the contribution of each predictor within the educational subgroups, a path-specific analysis was conducted. The results of this path analysis are shown in Table 10.

Table 10. Results of Path Analysis for the Moderation of Multigroup Education

	Variable		Estimate	S.E.	C.R.	P	Label
ZLiteracy	<---	ZKnowledge	.357	.055	6.527	.000	b1_1
ZLiteracy	<---	ZUsage	.346	.061	5.710	.000	b2_1
ZLiteracy	<---	ZAccessibility	.176	.062	2.831	.005	b3_1

Source: Research finding.

Table 10 indicates that, in the multigroup moderation analysis, the education variable significantly moderates the influence of the exogenous variables on the financial literacy of millennials in Aceh, as evidenced by significance levels below 5%.

4.4.1.1 The Effect of Millennial Generations' Fintech Knowledge on Financial Literacy Moderated by Education

The results of the multigroup moderation analysis presented in Table 10 indicate that education significantly moderates the relationship between fintech knowledge and financial literacy among the millennial generation in Aceh. The estimated standardized coefficient is 0.357, with a critical ratio (CR) of 6.527 and a p-value of 0.000, which is well below the 5% significance threshold. This implies that for every 100-unit increase in fintech knowledge, financial literacy increases by 35.7 units, depending on the level of education. These findings confirm Hypothesis 4, suggesting that the education level of millennials plays a significant role in strengthening the positive impact of fintech knowledge on their financial literacy. The more educated the individuals are, the more effectively they can translate their fintech knowledge into improved financial decision-making. This result aligns with previous studies by Abreu and Mendes (2010), Ameer and Khan (2020), and Mahdzan and Tabiani (2013), who also found education to be a crucial moderating factor in enhancing the effects of financial knowledge on literacy outcomes.

4.4.1.2 The Effect of Millennial Generation Fintech Usage on Financial Literacy Moderated by Education

The multigroup moderation analysis presented in Table 10 reveals that education significantly moderates the relationship between fintech usage and financial literacy among the millennial generation in Aceh. The estimated path coefficient is 0.346, with a critical ratio (CR) of 5.710 and a p-value of 0.000, indicating statistical significance at the 5% level. This means that a 100-unit increase in fintech usage corresponds to a 34.6-unit improvement in financial literacy, contingent upon the level of education. These findings confirm Hypothesis 5, which posits that education plays a moderating role in the relationship between fintech usage and financial literacy. In essence, the ability of millennials to translate their fintech usage into financial literacy is strengthened when they possess a higher level of education. This result aligns with prior studies conducted by Abreu and Mendes (2010), Ameer and Khan (2020), and Mahdzan and Tabiani (2013), which emphasize the pivotal role of educational attainment in enhancing the effectiveness of financial technology in improving financial understanding and behavior.

4.4.1.3 The Effect of Millennial Generation Fintech Accessibility on Financial Literacy Moderated by Education

The multigroup moderation analysis shown in Table 10 indicates that education significantly moderates the effect of fintech accessibility on financial literacy among the millennial generation in Aceh. The estimated path coefficient is 0.176, with a critical ratio (CR) of 2.831 and a p-value of 0.005, confirming significance at the 5% level. This implies that a 100-unit increase in fintech accessibility is associated with a 17.6-unit increase in financial literacy, moderated by the educational level of millennials. These findings support the hypothesis that education plays a moderating role in enhancing the impact of fintech accessibility on financial literacy. This result is consistent with prior research by Abreu and Mendes (2010), Ameer and Khan (2020), and Mahdzan and Tabiani (2013), which emphasizes the importance of education in strengthening the positive influence of financial technology access on individuals' financial knowledge and skills.

4.4.2 Multigroup Moderation Effect of Gender

The multigroup moderation analysis was conducted to examine whether there are differences in the influence of the research variables on financial literacy based on gender groups. The results of this analysis are presented in Table 11.

Table 11. Gender Multigroup Moderation Significance Test Results

	Variable	Estimate	S.E.	C.R.	P	Label
ZLiterasi	<--- ZKnowledge	.369	.113	3.266	.001	b1_1
ZLiterasi	<--- ZUsage	.337	.109	3.088	.002	b2_1
ZLiterasi	<--- ZAccessibility	.131	.118	1.110	.267	b3_1

Source: Research finding.

Based on Table 11, the multigroup moderation path analysis indicates that fintech usage significantly influences financial literacy among millennial males and females in Aceh, with p-values well below the 5% significance threshold. However, fintech accessibility does not have a significant effect, as evidenced by its p-value of 0.267.

4.4.2.1 The Moderating Effect of Gender on the Relationship Between Fintech Knowledge and Financial Literacy among the Millennial Generation

The multi-group moderation analysis presented in Table 11 examines the moderating role of gender in the relationship between fintech knowledge and financial literacy among millennials in Aceh, Indonesia. The results reveal a significant indirect effect of 0.369, or 36.9%, indicating that an increase of 100 units in fintech knowledge, when moderated by gender, corresponds to a 36.9-unit increase in financial literacy within this population. The critical ratio (CR) of 3.266 and a probability value of 0.001 confirm that this effect is statistically significant at the 5% level. These findings provide strong empirical support for Hypothesis 7 (H7), which posits that gender moderates the relationship between fintech knowledge and financial literacy among the millennial generation in Aceh. This means that the influence of fintech knowledge on financial literacy varies between male and female millennials, highlighting gender as a key factor in shaping financial literacy outcomes in the context of fintech usage. The moderation effect suggests that interventions aiming to improve financial literacy through fintech education should consider gender-specific strategies to maximize effectiveness. This outcome aligns with prior research suggesting that gender differences impact financial behaviors and the acquisition of financial knowledge, emphasizing the need for tailored financial education programs (Albaity and Rahman, 2019; Silva et al., 2022). In conclusion, gender plays a crucial role in moderating how fintech knowledge translates into enhanced financial literacy among millennials in Aceh, underscoring the importance of inclusive and gender-sensitive financial literacy initiatives.

4.4.2.2 The Moderating Effect of Gender on the Relationship between Fintech Usage and Financial Literacy among the Millennial Generation

The multi-group moderation analysis, as shown in Table 11, investigates the moderating role of gender in the relationship between fintech usage and financial literacy among the millennial generation in Aceh, Indonesia. The results indicate a significant indirect effect of 0.337, or 33.7%, meaning that for every 100-unit increase in fintech usage, moderated by gender, financial literacy among millennials increases by 33.7 units. This effect is statistically significant, with a critical ratio (CR) of 3.088 and a probability level of 0.002, well below the 5% significance threshold. These findings provide strong evidence to support Hypothesis 8 (H8), which states that gender moderates the relationship between fintech usage and financial literacy of millennials in Aceh. The moderation effect reveals that the impact of fintech usage on financial literacy differs between male and female millennials, underscoring the importance of considering gender dynamics when developing fintech-related financial education programs. This conclusion aligns with previous studies by Albaity and Rahman (2019) and Silva et al. (2022), which emphasize that gender influences financial behavior and the assimilation of financial technologies. Therefore, to effectively enhance financial literacy through fintech platforms, gender-specific approaches should be incorporated to address the distinct needs and usage patterns of male and female millennials. In summary, gender significantly moderates the influence of fintech usage on financial literacy in Aceh's millennial population, highlighting the necessity for tailored financial literacy interventions that acknowledge gender differences.

4.4.2.3 The Moderating Effect of Gender on the Relationship between Fintech Accessibility and Financial Literacy among the Millennial Generation

The results of the multi-group moderation analysis in Table 11 indicate an indirect influence value of 0.131 or 13.1% for the relationship between fintech accessibility and financial literacy, moderated by gender. The critical ratio (CR) is 1.110, and the probability value is 0.267, which exceeds the 5% level of significance. These results suggest that gender does not significantly moderate the relationship between fintech accessibility and financial literacy among millennials in Aceh. Accordingly, Hypothesis 9 (H₉), which posits that gender moderates the relationship between fintech accessibility and the financial literacy of the millennial generation in Aceh, is not supported. Although fintech accessibility remains a relevant factor in improving financial literacy, its impact appears to be consistent across both male and female groups.

4.4.3 Coefficient of Determination (R^2) of Financial Literacy

The results of the structural model evaluation indicate a coefficient of determination (R^2) for the financial literacy variable of 0.698. This means that approximately 69.8% of the variance in financial literacy among millennials in Aceh can be explained by the fintech variables—namely, fintech knowledge, fintech usage, and fintech accessibility. This high explanatory power confirms that the model has strong predictive relevance, indicating that the chosen fintech indicators are substantial contributors to understanding financial literacy within this demographic. Furthermore, the model satisfies the required goodness-of-fit indices, affirming the robustness and validity of the structural relationships tested in this study.

5. Conclusion and Implications

This study concludes that fintech knowledge, fintech usage, and fintech accessibility significantly influence the financial literacy of millennials in Aceh. Furthermore, the results indicate that both gender and education level serve as moderating variables in these relationships. However, the effect of moderation does not differ significantly between male and female groups, nor across educational strata. In other words, while gender and education moderate the relationships between fintech factors and financial literacy, their moderating effects are equally applicable across demographic segments.

These findings offer several practical and theoretical implications. First, the strong impact of fintech-related variables underscores the importance of integrating fintech education into broader financial literacy initiatives. Policymakers and financial service providers should consider targeted strategies to enhance millennials' exposure to and understanding of fintech, particularly through accessible platforms and inclusive financial education programs. Second, the non-differentiated moderating effects across gender and education suggest that interventions aimed at improving financial literacy through fintech can be designed as broadly applicable programs rather than requiring group-specific tailoring. This reinforces the need for inclusive policy frameworks that ensure equitable access to financial knowledge and tools for all millennials, regardless of gender or educational background.

Nonetheless, the scope of this research is geographically limited to Aceh, Indonesia, which may constrain the generalizability of its findings. Future research should consider expanding the study to other regions or countries with varying fintech ecosystems and demographic profiles. Additionally, longitudinal studies

may help capture how fintech literacy evolves and interacts with other socio-economic dynamics. In summary, this research contributes to the growing discourse on digital financial inclusion by demonstrating that fintech knowledge, use, and accessibility are key drivers of financial literacy among millennials, and that both gender and education can enhance this effect—albeit uniformly across different groups. This insight is valuable for shaping inclusive and effective financial literacy strategies in the digital era.

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The Reaction of the Financial Conditions Index to the Macroeconomic Variables Shocks

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Abstract

The financial and real sectors are intrinsically related and the financial sector is affected by the systematic risks of the real sector. So, this study was done to investigate the reaction of the financial conditions index to the macroeconomic variables shocks in Iran with the time-varying parameter factor-augmented vector autoregressive model (TVP-FAVAR) and using quarterly data from 1991 to 2019. The results show that the macroeconomic variables shocks are an important factor in explaining the behavioral changes of the financial conditions index. In other words, the financial conditions index has shown different reactions to the macroeconomic variables shocks over time, and the intensity and extent of this reaction have not been the same for each of the macroeconomic variables. Therefore, policymakers should adopt appropriate policies according to the effects of macro variables on the economy so that they can ultimately improve the financial conditions of the country.

Keywords: Financial Conditions Index, Macroeconomic, Reaction, Shock, TVP-FAVAR Model.

JEL Classification: C22, E44, G18.

1. Introduction

Recent developments in the global economy have helped to re-evaluate and expand on some well-known economic concepts. Arguably, one of the most prominent changes in economic thinking is the importance of the relationship between the real and financial sectors (Plasil et al., 2016). If there is no logical relationship between the financial market and other sectors of the economy, there is a possibility of disturbances in the mechanism of the economy. For example, many emerging Asian economies have experienced deep financial crises after continuous booms in bank credit. The housing bubble burst, and the subsequent financial crisis

also led to the worst economic crisis since the Great Depression in 2008-2009. The severe impact of this crisis on many of the world's economies has led economists to seek tools to understand the financial sector better.

One of these instruments is the financial conditions index (FCI). This index primarily acts as a channel through which monetary policy affects the real economy (Mblu and Soobyah, 2019). Financial variables' importance in the transmission of monetary policy is the first impetus for constructing FCI. FCI based on monetary policy transmission is usually composed of financial variables such as interest rate, exchange rate, stock price, and housing price (Angelopoulou, 2014). After the financial crisis, some researchers also used lending to indicate credit conditions (Swiston, 2008). Changes in interest rates alone may not take into account all the interactions between the financial system and the real economy; As a result, tracking a set of financial variables seems necessary. Credit aggregates, loan amounts, risks, fluctuations, and returns can convey more information about the financial conditions and affect actual activities by influencing consumption and investment.

Any instability in the macroeconomic environment causes economic activists to be uncertain about future developments, and as a result, economic activists cannot draw a clear vision of the future, which affects their decisions and may even lead to deviations in decision-making. Today, the central banks of the world use the financial conditions index to measure the future state of the economy. It seems necessary to analyze the reaction of the financial conditions index to the shocks of macroeconomic variables.

In this paper, we aim to construct Iran's FCI and then evaluate the effects of macroeconomic variable shocks on the FCI from 1991 to 2019 in Iran. We use time-varying parameter factor-augmented vector autoregressive (TVP-FAVAR) to construct and evaluate the FCI's response to the macroeconomic variables' shocks. The created FCI can adapt to different modes of the Iranian economy. Random errors can increase the quality of the FCI and allow its fluctuations to increase over time.

The rest of the paper is structured as follows. Section 2 review of theoretical literature is done; Section 3 is dedicated to the research method and model specification; Empirical results and conclusions are presented in Sections 4 and 5, respectively.

2. Literature Review

2.1 Financial Conditions Index

FCI has been developed based on the Monetary Conditions Index (MCI). MCI is the weighted average of changes in the short-term interest rate and an exchange rate that the Bank of Canada first introduced in the 1990s. Providing information on the stance of economic and monetary policy was one of the goals of MCI. However, as modern finance grows in complexity and size, there is increasing attention on how financial indicators such as asset prices affect the economy. The inability to describe financial markets indicated that MCI was inappropriate as an intermediate goal. Eventually, more indicators were added to the MCI, and the FCI emerged as a broader measure of economic activity. Goodhart and Hofmann (2001) and Mayes and Viren (2001) were the first to develop an FCI by adding variables such as housing prices and stock prices to the MCI.

Hatzius et al. (2010) define an FCI as a compound index that provides financial information about the future situation of an economy. In the studies of Goodhart and Hofmann (2001) and Wacker et al. (2014), FCI is considered an expansion of MCI. FCI is more comprehensive than MCI and is developed using more variables.

FCI based on monetary policy transmission mechanisms usually consists of financial variables such as interest rate, exchange rate, stock price, and housing price. In this study, the variables that construct the FCI have been determined based on the monetary policy transmission mechanisms. Therefore, the relation between financial conditions and macro variables is discussed below.

2.2 Financial Conditions and the Macroeconomy

Financial conditions are important because they affect future real activity in ways that are not fully captured by short-term interest rates. Their macroeconomic relevance rests on two pillars. First, "monetary policy works by affecting financial conditions" (Adrian and Liang, 2016). Thus, financial conditions determine macroeconomic outcomes of monetary policy decisions. Second, financial conditions are thought to play an independent role in driving business cycle fluctuations by determining financial stability and thereby posing risks to real activity. Because financial conditions and funding costs in the economy are very closely related, a discussion of the various monetary policy transmission mechanisms helps understand the macroeconomic relevance of FCI. Boivin et al. (2010) distinguish between two broad categories of transmission channels. The first category comprises 'traditional' or New Keynesian channels in which financial

markets are perfect or frictionless. The main emphasis is put on the direct effects of short-term policy rates and how expectations regarding the future trajectory determine the shape of the yield curve and, therefore, investment, trade, and consumption. In a frictionless environment, financial conditions still matter because they contain information on long-term interest rates and asset prices, which determine the cost of capital and demand for physical capital (Herculano, 2022).

Financial conditions also play an important role by influencing the transmission of monetary policy decisions through a second category of 'non-traditional' channels that allow for market imperfection in credit supply. Financial frictions, to which borrowers and lenders are subject, give rise to an external finance premium that is well captured by FCI. Such frictions include asymmetric information, agency costs, financial firm's risk models, institutional investor strict return targets, and limited liability (Adrian and Liang, 2016).

Non-traditional transmission channels include balance sheet channels - whereby a decline in borrower's net worth and collateral, results in tighter credit supply due to moral hazard (Bernanke and Gertler, 1986; Kiyotaki and Moore, 1997) and bank-based channels - which recognize the importance of asset prices as determinants of the strength of banks balance sheets (bank capital channel) and the market power of banks as providers of funding in an economy (bank lending channel). Recent and ongoing research investigates the existence of a risk-taking channel of monetary policy. Adrian and Shin (2010) suggest that monetary policy changes the risk-taking capacity of financial intermediaries due to moral hazard problems that change the quantity and composition of credit supply. The risk-taking channel refers to the effects working through the risk appetite of financial intermediaries, which are reflected by FCI. Theory offers unclear predictions on the effect of monetary policy on bank risk-taking. Altunbas et al. (2010), Adrian and Liang (2016) review the various mechanisms and conclude that the impact of short-term interest rates on risk-taking is ultimately an empirical question due to several underlying mechanisms that offset each other. On one hand, traditional portfolio allocation models predict that a higher interest rate incentivises financial institutions to rebalance their portfolios toward safe assets. Therefore, a higher hurdle rate on investment will divert funding from risky projects. In contrast, an increase in interest rates may lead to greater risk-taking due to risk-shifting in lending. The increase in the amount banks have to pay on deposits will aggravate agency problems associated with limited liability, especially for banks with less 'skin in the game' (i.e., higher leverage) (Herculano, 2022).

Low interest rates can increase risk taking by increasing bank leverage (Dell'Ariccia et al., 2017), reducing the cost of holding collateral or required reserves (Stein, 2012), incentivizing 'search for yield' behavior (Rajan, 2006), increasing liquidity and relaxing lending standards (Acharya and Naqvi, 2012), by loosening bank capital constraints (Adrian and Shin, 2010) or by altering aggregate uncertainty and risk aversion and thereby shifting global financial conditions (Miranda et al., 2015). Taken together, the literature suggests that financial conditions are an important aspect of monetary policy transmission. However, the question of how financial conditions should be taken into consideration by monetary authorities is controversial. Adrian and Liang (2016) highlight the inter-temporal trade-off between improving financial conditions at a cost of future financial vulnerabilities.

Beyond their role as determinants of the transmission of monetary policy, financial conditions are found to have an independent role as drivers of business cycle fluctuations. He and Krishnamurthy (2012), Adrian and Boyarchenko (2012), and Brunnermeier and Sannikov (2014) study the consequences of the inclusion of a financial sector in a dynamic general equilibrium economy, where production relies on credit supply from a financial intermediary. Results suggest that vulnerability of the financial sector decreases the supply of credit, potentially causing headwinds to GDP growth. Christiano et al. (2014) augment a dynamic general equilibrium model to include a financial accelerator mechanism. Changes to the volatility of cross-sectional idiosyncratic uncertainty, which measure the severity of agency problems, which the author labels 'risk shocks,' are found to explain a relevant portion of business cycle fluctuations. The idea that financial shocks are independent sources of business cycle fluctuations is also highlighted by Gilchrist and Zakrajsek (2012), Jermann and Quadrini (2012), and Liu et al. (2013).

2.3 Empirical Studies

The FCI is built with different methods for various purposes in many countries, such as forecasting macroeconomic variables, linking with monetary policy, and also as a warning system. For example, Mayes and Viren (2001) constructed FCI by the reduced aggregate demand equation model, arguing that FCI plays a role in formulating the monetary policy of European countries. Montagnoli and Napolitano (2005) used the Kalman filter algorithm and allowed the weights to change over time to construct the FCI of the US and the Euro area. Swiston (2008) used the VAR impulse response function to calculate the United States' FCI and

showed that FCI could be used as a predictor of US economic growth. Hatzius et al. (2010) built FCI with principal components analysis (PCA) and examined its relationship to economic activity. Gomez (2011) used the PCA for constructing Colombia's FCI and suggested that FCI can be used as an effective tool to regulate macro prudence and financial stability. Angelopoulou (2013) constructed FCI by the PCA for European countries and evaluated the impact of monetary policy on the FCI. Taghizadeh and Zamaniyan (2015) calculated the FCI and MCI for Iran by using the PCA method. The results show that the FCI, like the MCI, reflects the changes in inflation and GDP. Deng et al. (2016) constructed China's financial conditions with the TVP-VAR model, showing that the FCI significantly affects inflation and economic fluctuations. Mohseni et al. (2018) extracted the FCI for Iran and used the PCA method. The results show that the FCI has caused a decrease in the growth rate of GDP and private sector investment, while this index has had a positive effect on the real exchange rate and has increased the unemployment rate since the fourth period. Li and Yuanchun (2019) used the TVP-VAR model to build the FCI for China and showed that the FCI with time-varying weights can reflect China's financial situation. Ganchev and Paskaleva (2020) build FCI by PCA for 11 European economies and show that the FCI is a reliable measure of financial shocks sensitive to exogenous shocks and leads to changes in Economic activities. Morana (2021) introduced a new macro-financial conditions index for the euro area, constructed a composite index by principal components analysis, and argued that financial crises could have significant and continuous negative effects on the medium to long-term GDP growth. Kazdal et al. (2022) constructed Turkey's FCI using high-frequency data and examined the link between the FCI and economic activity. Armen et al. (2022) used the TVP-VAR model to build the FCI for Iran. The results show that the FCI has high predictability. Huang et al. (2022) investigated the effects of financial conditions and macroeconomic uncertainty shocks on output growth in the United States using a structural VAR. The results show that output growth decreases disproportionately in response to both shocks.

So, when it comes to shocks of macro variables and the FCI, there is a gap in the literature, and a study has not been done that examines the FCI's response to the macroeconomic variables' shocks. Therefore, the subject of the present study is new.

3. Research Method and Model Specification

3.1 Research Data

In this study, we have been used quarterly data from 1991 to 2019 to analyze the effects of macroeconomic variables shocks on Iran's FCI and research variables are divided into two categories; 1- The variables of inflation rate, unemployment rate, economic growth rate, budget deficit growth rate, Gini coefficient have been used as macro variables; 2- The variables that make up the financial conditions index to extract the index and also estimate the latent factor are: Net foreign assets of the banking system, debts of banks to the central bank, Net public sector debt to the banking system, Net debt of the non-governmental sector to the banking system, Total facilities of the banking system to different economic sectors, Ratio of non-current receivables to total facilities, Real interest rates on banking facilities in various economic sectors, Real interest rate on one-year investment deposits, Real exchange rate changes, Housing price index of all urban areas, Price of gold coins, Stock price index and financial index¹. The FCI variables were used as growth rates in the TVP-FAVAR model.

Data related to variables of Gini coefficient, inflation rate, and unemployment rate have been extracted from Iran's Statistics Center; data related to the variables of the budget deficit, gross domestic product, and FCI variables have been extracted from Iran's Central Bank.

It should be noted that to extract seasonal data from existing annual data, the Denton method has been used, which is one of the appropriate methods to convert annual data of variables into seasonal data.

3.2 Modeling of Research Variables

Suppose y_t for $t = 1, \dots$, is a $S \times 1$ vector of macroeconomic variables in the model, which in the present study includes the Gini coefficient, unemployment rate, budget deficit growth rate, GDP growth rate, and inflation rate (Changes in the Consumer Price Index). f_t is the latent factor in the model. x_t is also a vector of $n \times 1$ variables (used in constructing the FCI) to estimate the non-observable variables in the model. In the empirical model used in this research, x_t and y_t are equal to:

$$x_t = (x_{1t}, x_{2t}, x_{3t}, x_{4t}, x_{5t}, x_{6t}, x_{7t}, x_{8t}, x_{9t}, x_{10t}, x_{11t}, x_{12t}, x_{13t}) \quad (1)$$

¹. Financial index is the weighted average of the stock price ratios of companies operating in the financial sector (investment companies, multidisciplinary industrial companies, banks and credit institutions, etc.) With a weight equal to the value of their shares at the base time.

$$y_t = (\pi_t, u_t, g_t, gn_t, db_t) \quad (2)$$

In relation (1), (x_1) is equal to the net foreign assets of the banking system, (x_2) debts of banks to the central bank, (x_3) Net public sector debt to the banking system, (x_4) Net debt of the non-governmental sector to the banking system, (x_5) Total facilities of the banking system to different economic sectors, (x_6) Ratio of non-current receivables to total facilities, (x_7) Real interest rates on banking facilities in various economic sectors, (x_8) Real interest rate on one-year investment deposits, (x_9) Housing price index of all urban areas, (x_{10}) Price of gold coins, (x_{11}) Real exchange rate changes, (x_{12}) Stock price index and (x_{13}) financial index.

In relation (2), π_t is equal to the inflation rate, u_t is the unemployment rate, g_t is the GDP growth rate, gn_t is the Gini coefficient and db_t is equal to the government budget deficit growth rate. So, the TVP-FAVAR model is presented as :

$$\begin{aligned} x_t &= \lambda_t^y y_t + \lambda_t^f f_t + u_t \\ \begin{bmatrix} y_t \\ f_t \end{bmatrix} &= c_t + \beta_{t,1} \begin{bmatrix} y_{t-1} \\ f_{t-1} \end{bmatrix} + \dots + \beta_{t,p} \begin{bmatrix} y_{t-p} \\ f_{t-p} \end{bmatrix} + \varepsilon_t \end{aligned} \quad (3)$$

$$\begin{aligned} \lambda_t &= \lambda_{t-1} + v_t \\ \beta_t &= \beta_{t-1} + \eta_t \end{aligned} \quad (4)$$

where λ_t^y are regression coefficients, λ_t^f are factor loadings, f_t is the latent factor, c_t is a vector of intercepts, $(\beta_{t,1}, \dots, \beta_{t,p})$ are VAR coefficients and u_t and ε_t are zero-mean Gaussian disturbances with time-varying covariances V_t and Q_t , respectively (Koop and Korobilis, 2014).

In this model λ_t^f , λ_t^y , and $(\beta_{t,1}, \dots, \beta_{t,p})$ are extracted based on a random walk, and all errors in the equations are not correlated with each other over time. Estimating the TVP-FAVAR model is computationally hard, so the Exponentially Weighted Moving Average (EWMA) and Kalman filter methods are used to reduce the computational load.

Therefore, we adapt ideas from Doz et al. (2011) and the state-space literature and develop a dual, conditionally linear filtering/smoothing algorithm, which allows us to estimate the unobserved state f_t and the parameters $\theta_t = (\lambda_t, \beta_t)$ in a fraction of a second.

4. Empirical Results

4.1 Estimates of Financial Conditions Index in TVP-FAVAR Model

In the present study, the financial conditions index (FCI) is extracted from TVP-FAVAR.

Figure 1 shows the FCI in the form of the time-varying parameter factor-augmented vector autoregressive and dynamic model averaging TVP_FAVAR (DMA), assuming the coefficients of the model variables and the set of variables selected to construct the FCI are varied from 1991 to 2019. The FCI obtained in the mentioned model indicates that many instabilities have accompanied the financial conditions of the country's economy; This has periodically weakened the efficiency of the country's economy by creating disequilibrium in the economy's financial system. As shown in Figure 1, the FCI has been declining from the third quarter of 1992 to the end of 1995 and has gone an upward trend from the end of 1995 to the third season of 1999 and has continued downward trend of FCI from the end of 1999 to the end of 2011 and there has been a growing trend from the end of 2011 to the third quarter of 2017. Still, since the fall of 2017, the country's FCI situation has changed again and has started a downward trend. It seems that the imposition of severe economic sanctions has faced the country's financial conditions with a difficult situation.

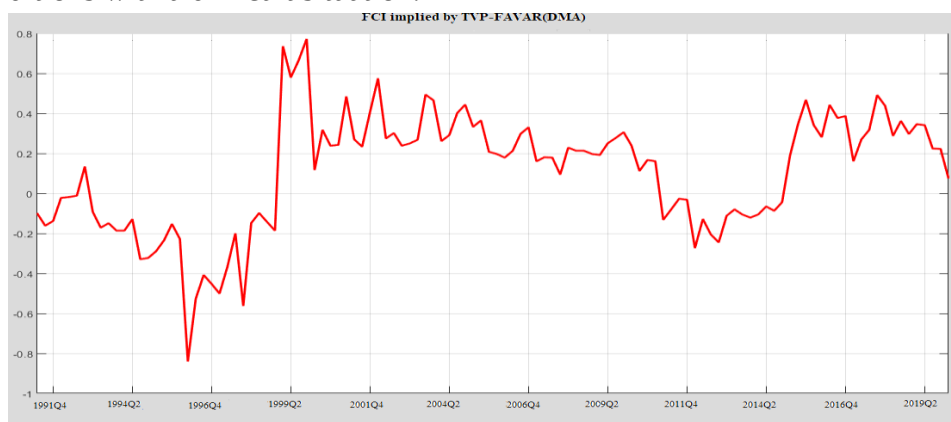


Figure 1. FCI Assuming the Coefficients of the Variables and the Variable Set are Varied Over Time

Source: Research finding.

4.2 Estimation of Latent Variables FCI in the (TVP_FAVAR) Model

Estimating latent variables in models is associated with limitations, and to overcome these limitations, there are various methods: the dynamic factor model, the principal component analysis (PCA) method, and ideas from Doz et al. (2011).

The difference between the above methods is in the assumptions that are considered for the estimation of latent variables. The premise of dynamic factor models (DFMs) is that the common dynamics of a large number of time series variables stem from a relatively small number of unobserved (or latent) factors, which in turn evolve. In the PCA approach, more variables are combined, and each variable is considered as a vector, each of which represents a facet of the latent factor. Then a vector is created, which is the result of all these vectors, and this vector is the latent factor. Doz et al. (2011) use a fast two-step estimation algorithm, which vastly reduces the computational burden and greatly simplifies the estimation of the FCI.

In this study, we follow Koop and Korobilis (2013) and ideas from Doz et al (2011) to estimate the latent variables of the model. The latent variables of the model have been estimated according to the variables selected to construct FCI in the form of a time-varying parameter factor-augmented vector autoregressive (TVP-FAVAR), which allows coefficients and loadings to change in each period. The results of which are shown in Figure 2.

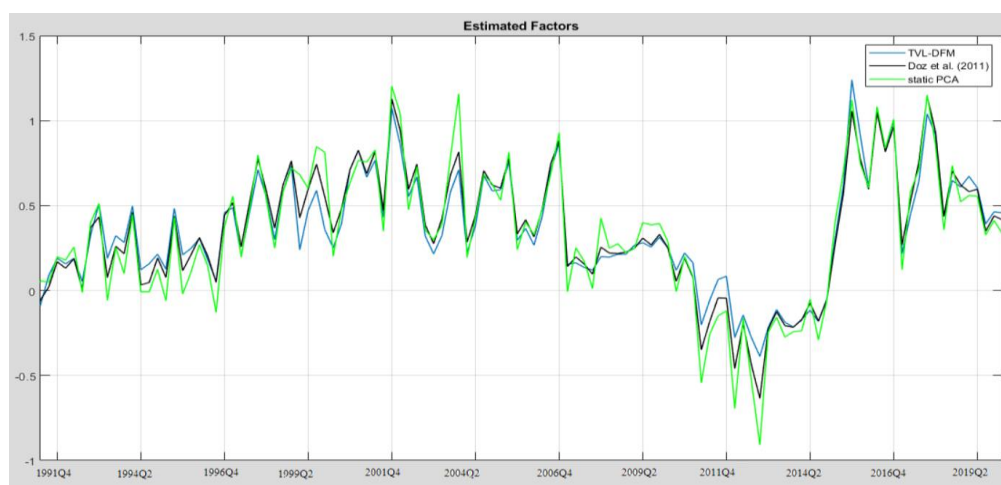


Figure 2. Latent variables FCI

Source: Research finding.

3.4 Evaluation of the Effects of Macroeconomic Variables Shock on FCI in the TVP-FAVAR Model

The present section uses two lags of model variables. The results of impulse response analysis of variables unemployment rate, economic growth rate, inflation rate, budget deficit, and Gini coefficient on the financial conditions index variable are investigated with TVP-FAVAR. In the three-dimensional graphs of this

section, the Z-axis is examined in terms of variables; the Y-axis is the period that occurs after the shock, and the X-axis shows the years of the research.

Therefore, we analyze the effects of the FCI variable on the unemployment rate, economic growth rate, inflation rate, Gini coefficient, and budget deficit shocks.

4.3.1 The Effect of Unemployment Rate Shock on FCI Variable

Table 1 shows the coefficients of the effects of unemployment rate shocks on the variables of the present study. As shown in Table 1, a comparison of the coefficients of model variables indicates that the maximum amount of the coefficients belonged to the first lag of the unemployment rate variable, with a value of 0.778, and the highest mean coefficients of model variables were also related to the first lag of the unemployment rate variable with a value of 0.537.

Table 1. Coefficients of the Effects of Unemployment Rate Shock

coefficients(beta): Endogenous: U	Max	Min	Standard deviation	Mean
FCI(-1)	0.059	-0.043	0.026	0.001
FCI(-2)	0.067	-0.041	0.027	0.012
INF(-1)	0.425	-0.486	0.233	-0.049
INF(-2)	0.418	-0.505	0.212	-0.001
GDB(-1)	0.070	-0.114	0.046	-0.017
GDB(-2)	0.070	-0.106	0.047	0.000
GDP(-1)	0.501	-0.480	0.255	0.032
GDP(-2)	0.448	-0.586	0.281	0.033
GINI(-1)	0.069	-0.832	0.230	-0.308
GINI(-2)	0.249	-0.410	0.179	-0.092
RU(-1)	0.778	0.328	0.116	0.0537
RU(-2)	0.170	-0.301	0.117	-0.045
Constant	0.040	-0.039	0.021	-0.000

Source: Research finding.

Figure 3 shows the response of the FCI variable to an unemployment rate shock. According to the figure, the effects of the unemployment rate shock on the FCI appear after one period. The FCI variable in the whole period under study (1991-2018) in the first three impact periods showed a negative response to the

unemployment rate shock. However, during the years 1991-2005, the negative impact of the unemployment rate shock disappeared after almost 3 periods. From the fourth period, the response of the FCI was positive to the unemployment rate shock, and these positive effects have been lasting. From the second half of 2001s to the late 2011s, the negative effects of the unemployment rate had a more lasting effect, and these negative effects disappeared after almost 13 periods. The most negative response of the FCI to the unemployment rate shock occurred in the second half of the 1991s, and the most positive response of the FCI to the unemployment rate shock also occurred during the years 1994-2001.

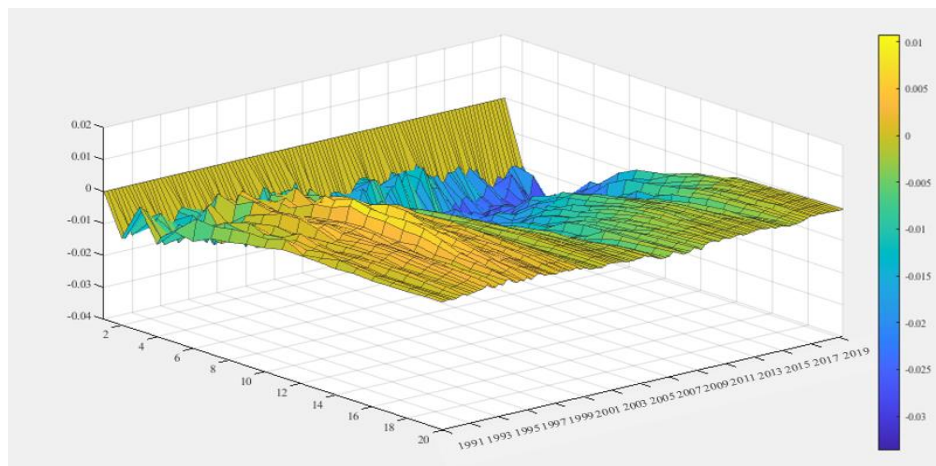


Figure 3. The Response of the FCI Variable to Unemployment Rate Shock

Source: Research finding.

4.3.2 The Effect of Inflation Rate Shock on FCI Variable

Table 2 shows the coefficients of the effects of inflation rate shocks on the variables of the present study. As shown in Table 2, a comparison of the coefficients of model variables indicates that the maximum amount of the coefficients belonged to the first lag of the inflation rate variable with a value of 0.669, and the highest mean coefficients of model variables were also related to the first lag of the inflation rate variable, with a value of 0.325.

Table 2. Coefficients of the Effects of the Inflation Rate Shock

coefficients(beta): Endogenous: π	Max	Min	Standard deviation	Mean
FCI(-1)	0.056	-0.007	0.016	0.018
FCI(-2)	0.020	-0.046	0.017	-0.013

INF(-1)	0.669	0.009	0.141	0.325
INF(-2)	0.285	-0.155	0.126	0.054
GDB(-1)	0.111	-0.027	0.040	0.049
GDB(-2)	0.086	-0.075	0.042	0.029
GDP(-1)	0.112	-0.056	0.039	-0.003
GDP(-2)	0.072	-0.059	0.034	0.002
GINI(-1)	0.205	-0.360	0.145	-0.056
GINI(-2)	0.332	-0.446	0.184	-0.067
RU(-1)	0.235	-0.167	0.106	0.052
RU(-2)	0.327	-0.076	0.099	0.068
Constant	0.058	-0.135	0.052	-0.027

Source: Research finding.

Figure 4 shows the response of the FCI variable to an inflation rate shock. The results show that the effects of the inflation rate shock after one period affect the FCI variable, and the response of the FCI variable to the shock was negative at the beginning of the impact period. This negative response has continued for five periods, and the FCI from the sixth period showed a positive response to the inflation shock. These positive effects continued for seven periods. After that, the effects of the above shock have converged to zero.

The inflation rate shock worsened the country's financial conditions at the beginning of the impact period.

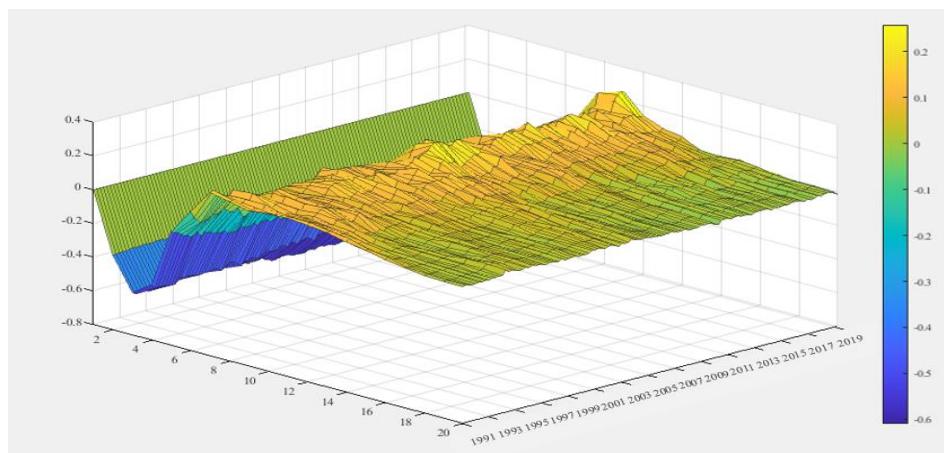


Figure 4. The Response of the FCI Variable to Inflation Rate Shock

Source: Research finding.

4.3.3 The Effect of the Economic Growth Rate Shock on the FCI Variable

Table 3 shows the coefficients of the effects of economic growth rate shocks on the variables of the present study. As shown in Table 3, the comparison of the coefficients of model variables indicates that the maximum amount of the coefficients belonged to the first lag of the economic growth rate variable with a value of 0.432, and the highest mean coefficients of model variables were related to the first lag of the economic growth rate variable with a value of 0.238.

Table 3. Coefficients of the Effects of the Economic Growth Rate Shock

coefficients(beta): Endogenous:G	Max	Min	Standard deviation	Mean
FCI(-1)	0.024	-0.036	0.017	-0.012
FCI(-2)	0.034	-0.037	0.020	0.006
INF(-1)	0.222	-0.326	0.124	0.005
INF(-2)	0.171	-0.296	0.119	-0.049
GDB(-1)	0.040	-0.082	0.032	0.007
GDB(-2)	0.052	-0.058	0.026	0.001
GDP(-1)	0.432	-0.011	0.121	0.238
GDP(-2)	0.290	-0.195	0.131	0.085
GINI(-1)	0.131	-0.134	0.076	-0.009
GINI(-2)	0.125	-0.137	0.073	-0.021
RU(-1)	0.083	-0.117	0.051	-0.021
RU(-2)	0.076	-0.116	0.049	-0.016
Constant	0.033	-0.040	0.180	-0.007

Source: Research finding.

Figure 5 shows the response of the FCI variable to the economic growth rate shock; The results show that the effects of economic growth rate shock appear after one period, and the response of the FCI to the economic growth rate shock has been negative in the entire period under review (1991-2018) up to the first three periods. The effects of the economic growth rate shock have affected the FCI with a delay of one period. After three periods of the negative impact of the economic growth rate shock, the response of the FCI to the above shock was positive in the fourth period. The most positive response to the FCI and, in other words, the most positive effect of the economic growth rate shock on the FCI occurred from 2005 to 2017. However, the positive effects of the economic growth rate have not been

lasting and have disappeared after one period. The most negative response of the FCI to the above shock occurred in the period 8-10 due to the impact of the economic growth rate in 2019.

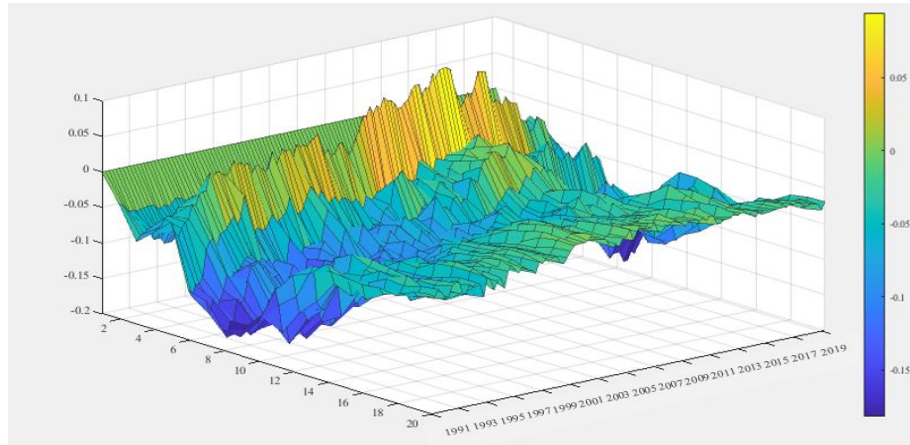


Figure 5. The Response of the FCI Variable to the Economic Growth Rate

Source: Research finding.

4.3.4 The Effect of Gini Coefficient Shock on FCI Variable

Table 4 shows the coefficients of the effects of the Gini coefficient shock on the variables of the present study. As shown in Table 4, the maximum amount of the coefficient of the first lag of the financial conditions index variable in response to the shock of the Gini coefficient variable is equal to 0.028, which is the lowest amount compared to the first lag of other variables used in this model. The maximum number of coefficients in the first lag belongs to the Gini coefficient and GDP variables.

Table 4. Coefficients of the Effects of the Gini Coefficient Shock

coefficients(beta): Endogenous: GN	Max	Min	Standard deviation	Mean
FCI(-1)	0.028	-0.046	0.019	-0.010
FCI(-2)	0.068	-0.005	0.017	0.031
INF(-1)	0.247	-0.314	0.139	-0.037
INF(-2)	0.552	0.071	0.122	0.340
GDB(-1)	0.076	-0.068	0.033	-0.001
GDB(-2)	0.097	-0.098	0.043	-0.007
GDP(-1)	0.316	-0.280	0.159	-0.017
GDP(-2)	0.065	-0.699	0.190	-0.325

GINI(-1)	0.311	-0.113	0.107	0.075
GINI(-2)	0.007	-0.396	0.117	-0.208
RU(-1)	0.140	-0.144	0.067	-0.008
RU(-2)	0.183	-0.033	0.060	0.083
Constant	0.074	0.005	0.017	0.028

Source: Research finding.

Figure 6 shows the response of the FCI variable to the Gini coefficient shock. The results of the effects of the Gini coefficient shock on the FCI indicate that the effects of the above shock in the entire period under review (1991-2018) are shown after one period, and the response of the FCI during 1991-2011 to the Gini coefficient shock in the first period of impact was positive. The reduction of income inequality has positively affected the FCI in the first period. However, the response of the FCI to the Gini coefficient shock was negative in the second and third periods, and this negative response disappeared in the 1990s after two periods. The highest positive response of the FCI to the Gini coefficient shock occurred in the fifth period. The positive effects of the Gini coefficient shock have been lasting since the 1990s. Also, the most negative response of the FCI to the Gini coefficient shock occurred in 2011s and during the years 2014-2019, and increasing the income inequality gap has had a negative impact on the FCI.

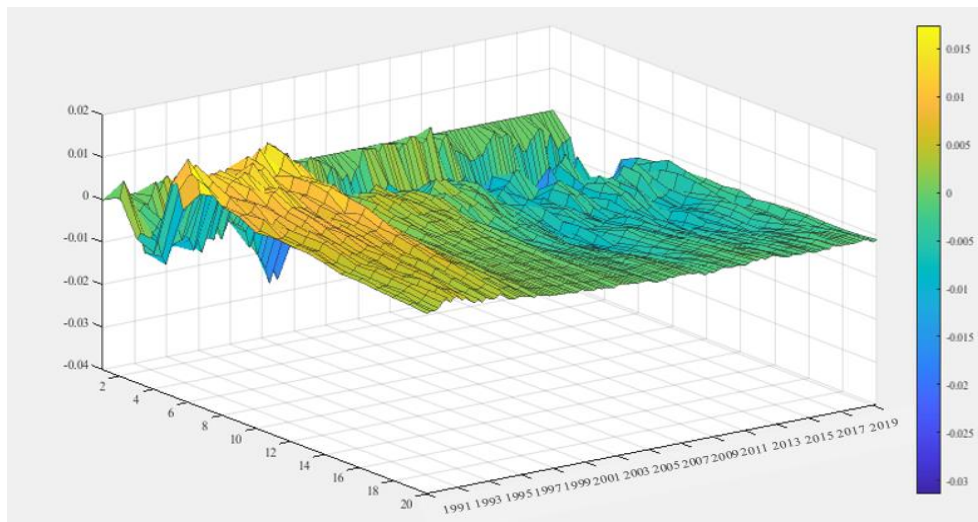


Figure 6. The Response of the FCI Variable to the Gini Coefficient Shock

Source: Research finding.

4.3.5 The Effect of Budget Deficit Shock on FCI Variable

Table 5 shows the coefficients of the effects of the budget deficit shock on the variables of the present study. As shown in Table 5, comparing the coefficients of model variables indicates that the maximum amount of the coefficients belonged to the first lag of the unemployment rate variable, with a value of 0.982, and the highest mean coefficients of model variables were related to the first lag of the budget deficit variable, with a value of 0.459.

Table 5. Coefficients of the Effects of the Budget Deficit Shock

coefficients(beta): Endogenous: DB	Max	Min	Standard deviation	Mean
FCI(-1)	0.215	0.011	0.048	0.099
FCI(-2)	0.011	-0.212	0.056	-0.096
INF(-1)	0.453	-1.172	0.436	-0.218
INF(-2)	0.599	-1.049	0.393	-0.037
GDB(-1)	0.394	-0.413	0.209	-0.069
GDB(-2)	0.397	-0.302	0.185	-0.043
GDP(-1)	0.614	0.289	0.089	0.459
GDP(-2)	0.146	-0.223	0.098	-0.063
GINI(-1)	0.872	-0.730	0.412	0.026
GINI(-2)	0.782	-0.770	0.406	0.042
RU(-1)	0.982	-0.628	0.132	0.096
RU(-2)	0.794	-0.615	0.364	0.063
Constant	0.451	-0.426	0.250	0.097

Source: Research finding.

Figure 7 shows the response of the FCI variable to the budget deficit shock. The results show that the effects of the budget deficit shock after one period affect the FCI variable, and at first, the response of the FCI to the budget deficit shock was negative. This negative response has continued for four periods, and the most negative impact of the budget deficit shock occurred in the second period of impact. From the fifth period of the impact of the budget deficit shock, the response of the FCI to the above shock was positive; However, the intensity of this positive effect was very small and had a shorter duration compared to the negative effects of the budget deficit shock.

The budget deficit is one of the problems that has plagued the economy in recent years. The country's economy has always faced a continuous budget deficit for many years. Due to its pervasive effect on economic variables, it has left many destructive effects on economic and financial conditions.

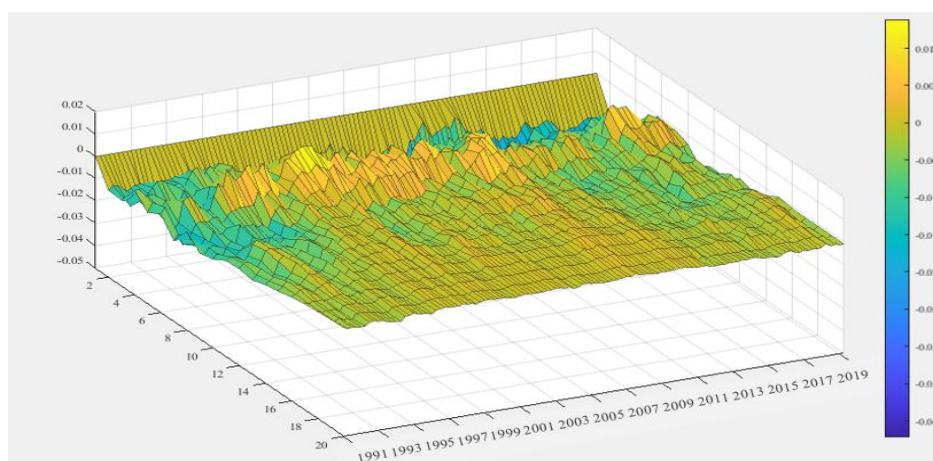


Figure 7. The Response of the FCI Variable to Budget Deficit Shock

Source: Research finding.

5. Conclusion

We investigated the reaction of the financial conditions index to the macroeconomic variables shocks in Iran using quarterly data. The results indicate that the effects of unemployment and economic growth rate variables shocks on the financial conditions index in the short and long term are negative. According to the country's economic conditions, the effects of the Gini coefficient shock on the financial conditions index are also different in the short and long term. The financial conditions index variable has shown a negative and positive reaction to the behavioral changes of inflation and budget deficit variables in the short and long term.

In other words, the financial conditions index has a different reaction to the macroeconomic variables shocks over time, and the reaction rate has not been the same.

According to the results of this study, the country's macroeconomic environment has been associated with many instabilities. With increasing uncertainties and the upsetting of the balance of different markets over time have led to instability of the country's FCI. In other words, the instabilities of macroeconomic variables have caused many changes in the country's FCI, and

behavioral changes have been macroeconomic variables in the country one of the important factors affecting the movement trend of the FCI.

Unfortunately, the policy maker in Iran has islanded operation and the adopted policies were not following the economic and financial conditions of the country. The reason for this was that the structure of the economy was not considered a connected whole and a system; When a part becomes unstable, it destabilizes the whole system. In other words, if macroeconomic variables do not have the necessary stability, they cause instability in other economic sectors. Therefore, policymakers should adopt appropriate policies according to these effects until they can finally improve the country's financial conditions.

Accordingly, although macroeconomic policies are necessary to stabilize the financial sector, they are never sufficient. Therefore, economic policymakers are advised to consider macro-prudential tools and policies as a sufficient condition for stability in the financial conditions and pay special attention to monitoring the country's financial conditions and how it interacts with macroeconomic variables to ensure the effectiveness of policies.

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The Impact of Financial Development Indicators on Sukuk Issuances in Indonesia between 2005 and 2021, Using the Autoregressive Distributed Lag (ARDL)

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Abstract

The recent financial development has witnessed the interest of many researchers and specialists in the field of Islamic finance due to the financial services and tools it provides that support the economy. Sukuk are one of the most important products of the Islamic financial industry because of their use in generating savings and raising funds to finance infrastructure projects and meet the requirements of economic development. The study aims to clarify the impact of indicators of financial development on the issuance of instruments in Indonesia between 2005 and 2021. To study the statistical relationship between the study variables, the issuances of instruments were relied upon as a dependent variable and the indicators of financial development as independent variables. (Real interest rate, private sector loans, money supply, investments) based on daddy growth of distruted time gaps, the resultats have demonstrated a morally positive impact for both private sector loans (DCPS) and Money Supply (M2) on SIs in the short term, and there is a moral positive impact for both investment (INV) and loans to the private sector (DCPS) on long-term issuances of instruments (SI). Finally, There is also stability in long and short-term milestones and therefore structural stability in the study model and the data used in the study do not have any structural changes, the study recommended the need to broaden the scope of instruments to ensure their dissemination and to look for factors promoting their development, to follow up on change in the financial system and to study their impact on the issuances of Islamic instruments in Indonesia.

Keywords: Cointegration, Financial Development, Investment, Islamic Sukuk, Money Supply.

JEL Classification: C23, F43, F65.

1. Introduction

Sukuk is an Islamic financial instrument included in an important sub-sector to move the country's and the world economy's wheels. Today, the Sukuk market represents the second-largest Islamic finance industry component after Islamic banking (Basyariah, 2020).

Islamic Sukuk has witnessed remarkable development in many countries due to the positive results achieved by the volume of their issuance in the field of finance, specifically in the economic sectors. It is considered one of the most important products offered by Islamic financial engineering, which contributes

effectively to the development of the financial market by employing financial surpluses. It is based on a set of legitimate formulas, based on the principle of profit and loss sharing. Islamic Sukuk contribute to achieving the requirements of economic development by contributing to financing infrastructure projects and filling the deficit in government budgets. However, they are affected by many indicators, especially economic and financial ones, which allow for many investment opportunities and thus increase the volume of issuance.

Sukuk, as an investment or financial instrument, has long been used in trade, both domestically and internationally, by Muslim traders since the 6th century AD. Sukuk is one of the investment instruments that became popular in the 21st century, which is used to mobilize funds for certain projects according to Sharia by the government and companies. Sukuk or commonly referred to as Islamic bonds, are financing instruments in the Islamic capital market in the form of certificates or proof of ownership based on sharia law (Nur Habibah Asri, 2021).

The rapid change in world economic growth has caused many changes in many aspects of life. One of them is the growth in the Islamic financial system. The Financial Services Authority once said that the Islamic financial system has an indirect contribution to Indonesia's economy. In this modern era, the Islamic financial system can be a source of economic power due to its traits proven during the World Financial Crisis; this financial institution could avoid bankruptcy. There are four main sectors of the Islamic financial system, which consist of full-fledged Islamic banks, Islamic Unit Business, Islamic non-bank institutions, and social and religious funds (Muasia, 2020).

Indonesia as a Muslim-majority country develops the economy by applying sharia principles that began with the establishment of Bank Muamalah as the first Islamic banking in Indonesia, then currently there are 743 Islamic banks with 1,371 branch opportunities for Muslims and non-Muslims who want to invest in the bank that is following Islamic principles, where the main principle is to provide comfort and confidence in halal transactions (Enny Kartini, 2020). Conventional investment is not the only investment instrument in the Indonesian capital market at this time, but there are also Islamic investment products, namely Sukuk, Islamic mutual funds, Islamic exchange traded fund, Islamic asset-backed security, Islamic real estate investment trust and Islamic stocks. The phenomenon of the existence of Sharia investment products is good news for investors in the Indonesian capital market as a reflection of the corporation's performance. Islamic bonds, counted as Islamic investment instruments, are different from conventional bonds. Since there is an agreement of opinion that interest is usury, then instruments that have an

element of interest are excluded from the list of halal or sharia investments (Muhammad Sahirul Alim, 2022).

Financial development plays an important role in determining the volume of suq issuance through its financial services and instruments that support the country's economy, in addition to the optimal allocation of resources and working to mobilize savings and reallocate them to economic units, resulting in flexible and rapid issuance to convert them into liquidity and thus finance countries' fiscal deficits without resorting to debt. Indonesia, like other countries, continues to strive to develop the volume of issuance of its instruments by providing stimulating methods. In return, it works to monitor changes in economic indicators of financial development to ensure appropriate conditions for achieving the largest possible issuance. On this basis, this study seeks to explain the impact of financial development indicators on the issuance of Sukuk by asking the following main question:

-To what Extent Do Financial Development Indicators Impact the Issuance of Islamic Sukuk in Indonesia?

Through the problems of study, the following question arises:

- There is a statistical effect of the Real Interest Rate Index (IR) on the volume of instrument issuances (SI) in Indonesia.
- There is a statistical effect of Loans to the private sector (DCPS) on the volume of instrument issuances (SI) in Indonesia.
- There is a statistical effect of Money supply (M2) on the volume of instrument issuances (SI) in Indonesia.
- There is a statistical effect of the Investments (INV) on the volume of instrument issuances (SI) in Indonesia.

1.1 Hypotheses

Based on the main problem, the following hypotheses can be formulated:

- There is an impact between indicators of financial development and the long-term issuances of Islamic Sukuk in the long term.
- There is an impact of indicators of financial development and the long-term issuances of Islamic Sukuk in the short term.

1.2 Importance of the Study

The importance of our study lies in our attempt to address:

- Concepts on financial development and Islamic Sukuk.

- The impact of financial development indicators on the issuance of Sukuk in Indonesia between 2005 and 2021.

1.3 The Objectives of the Study

This study aims to:

- Give a comprehensive overview of the experience of Islamic Sukuk in Indonesia.
- Determine the impact and trend of the relationship between financial development and issuance of Sukuk in Indonesia based on previous studies.

1.4 Study Methodology

To test the research hypotheses and achieve its objectives, a descriptive methodology will be used through describing the research variables; and an analytical method by addressing Indonesia's experience with Islamic Sukuk; in addition to the inductive method through the use of statistical analysis methods to study the relationship between financial development indicators and issuance of Sukuk in Indonesia.

1.5 Study Themes

The study included the following topics:

The first axis: the theoretical rooting of the study

The second axis: a standard study of the impact of financial development indicators on the issuance of Sukuk in Indonesia from 2005 to 2021.

1.6 Previous Studies

With regard to previous studies on indicators of financial development and issuances of instruments, the variables used vary, and thus the way they are addressed. The most important previous studies on indicators of financial development and the issuance of Sukuk can be summarized as follows:

Rien Muasia (2019): The purpose of this study is to analyze the impact of macroeconomic factors on the growth of Islamic bonds (Sukuk) in Indonesia. This study uses the Ordinary Least Squares (OLS) method with a monthly time series starting from January 2013 until December 2016. The results of this study indicate that the Production Index (IP) and Bank Indonesia Syariah Certificate (BSBIS) variables positively and significantly affect the growth of state Sukuk issuance in Indonesia, then inflation negatively and significantly affects the growth of state Sukuk issuance, while the Jakarta Islamic Index (JII) variable has a negative effect but not significant on the growth of Indonesian state Sukuk.

Nursilah Ahmad (2021): The study investigates the relationship between macroeconomic indicators and Sukuk market performance for the period 2004 to 2019 in 10 Sukuk issuing countries using a panel data approach. The macroeconomic indicators are Gross Domestic Product (GDP), consumer price index, trade openness, exchange rates, and financial crisis. The findings reveal that GDP, trade openness, and exchange rates have a significant impact on Sukuk market performance. In addition, the study analyses the growth components of GDP in these countries five years before the COVID-19 pandemic outbreak. The countries' performance in terms of changes in the percentage contribution of consumption, investment, government spending, and net export to GDP.

Reifa (2017): This study discusses the impact of Sukuk market developments on the Indonesian economy, and vice versa. It will use the 2009–2016 quarterly longitudinal data of outstanding Sukuk as a proxy of the size of the Sukuk markets, as well as Indonesia's GDP as a proxy of the size of the economy. The basic model used in this study is a VAR model, and a Granger causality test is utilised to determine the direction of causality. The study also uses the impulse response function and variance decomposition to determine the impact of a shock on each variable on the others. The result shows that, in aggregate, the Sukuk market has a positive influence on Indonesian GDP.

Ahmed (2012): This study aimed to show the impact of macroeconomic variables on Sukuk issuance in Malaysia during the period 1996–2011 using the VAR model. To test the impact of inflation rates, GDP, and the product price index on the volume of Sukuk issuance, it was concluded that there is a causal relationship between Sukuk issuance and GDP, meaning that the development of Sukuk causes an increase in GDP. Therefore, decision makers should design new policies to develop the Islamic capital market, and inflation has a positive impact on the development of Sukuk issuance in the short term.

Zanudin (2019): This study aimed to analyze the determinants of institutional macroeconomic stability in the development of the global Sukuk market using the Fixed-effects model to test the impact of trade openness, inflation, and economic growth on the evolution of the size of Islamic instruments. It was found that there is a positive impact of trade openness, inflation, and economic growth rates on the development of Sukuk issuance in the countries studied.

Heba Abdullah Ahmed Suleiman (2022): This study aimed to show the impact of economic determinants on the issuance of Islamic Sukuk, such as inflation rate, exchange rates, size of the economy and size of banking systems, by relying on 277 financial institutions and government agencies located in the Gulf

Cooperation Council countries in addition to Malaysia and Turkey, and that is by using regression analysis. It was concluded that the size of the economy, the rate of inflation, and the size of the banking system have a positive impact on the growth of the Sukuk market, in addition to the lack of a moral relationship between the volume of Sukuk issuance and exchange rates.

Grassa and Said (2013): aim to clarify the economic factors affecting the volume of Sukuk issues applied to the GCC countries during the period 2003-2012, using the least squares method for random effects. It was found that there is a positive effect between the size of the economy, per capita gross income, and the volume of issuance of Sukuk, while interest rates have an intangible negative effect.

Samir Tami, Yassin Hafsi's (2022): This study aims to identify the causal relationship between Sukuk issuance and economic growth in Sudan during the period 2000-2019. Four variables were relied upon (Islamic Sukuk, final consumption expenditure, total fixed capital formation, and GDP, using the Yamamoto and Toda methodology for the long-term causal relationship, in addition to studying the movement of the self-downward vector model VAR. It was found that there is a one-way causal relationship between Islamic instruments and per capita total income in the long term. Through the impulse response, it was found that shocks that occur in terms of the volume of issuance of Sukuk have a weak positive impact on GDP per capita by period. It has become clear that instruments need a long time to show their impact on economic growth rates.

The current study agrees with previous studies that its use is one or more variables. This study differs from previous studies in the variables included in the problem and thus obtains different results (focus on indicators of financial development). It also differs in the use of statistical methods that determine the relationship between indicators of economic development and the issuance of instruments.

2. Theoretical Rooting of the Study

Islamic Sukuk has become an important tool of Islamic finance that is of great interest to many countries because of its importance at the macroeconomic level, whether in terms of stimulating financial markets or financing development projects.

2.1 Islamic Instruments

Islamic Sukuk is considered a contemporary financing tool. Recently, it has experienced rapid growth. This can be attributed to the expansion of the base of Islamic financial products because of their effective role in achieving the requirements of economic development.

2.1.1 The Concept of Islamic Sukuk

The Islamic Financial Services Board defines certificates that represent the holder's proportionate ownership in an undivided part of the underlying asset, where the holder assumes all rights and obligations to such asset (Mahi and Lebig, 2021).

Sukuk is the standard Arabic term for Securities or Bonds structured according to the principles of Sharia and referred to as Sukuk, Islamic bonds, Islamic trust certificates, or Islamic debt securities (Essia, 2014).

In addition, Sukuk are securities that comply with the Islamic Shariah Law and its investment principles, which prohibit the payment, charging of interest. Sukuk are certificates of equal value representing undivided shares in ownership of tangible assets, usufruct, and services, or in the ownership of the assets of particular projects or investment activity (Others, 2015).

Sukuk consider securities have similarity features to conventional bonds, which many reason why the financial media label them those types of securities as Islamic bonds. However, Ariff and Safari showed there are significant differences in the yield of Sukuk against the yield of conventional bonds. In addition, the study did not show a causal relation between the yields of these two types of securities (Ali Said, 2013).

There are two types of Sukuk: ased and asset-backed. Under the asset-based Sukuk, the Sukuk holders have beneficial ownership in the asset. The Sukuk holders have recourse to the originator if there is a shortfall in payments. The beneficial ownership is a legal term where specific property rights, such as its use and title, belong to a person even though the legal title of the property belongs to another person. A common example of a beneficial owner is the owner of funds held by a nominee bank or for stocks held in the name of a brokerage firm. Under asset-backed Sukuk, the Sukuk holders owned the asset and, as a result, do not have recourse to the asset but to the originator if there is a shortfall in payment (Afshar, 2013).

2.1.2 Benefits of Sukuk

Among the benefits of Sukuk, we can refer to these: Sukuk is a tradable capital market product providing medium to long-term fixed or variable rates of return. It

is assessed and rated by international rating agencies, which investors use as a guideline to assess risk/return parameters of a Sukuk issue. It has regular periodic income streams during the investment period with easy and efficient settlement and a possibility of capital appreciation of the Sukuk. Finally, Sukuk are liquid instruments and tradable secondary market (Zolfaghari, 2017).

2.1.3 The Economic Importance of Islamic Instruments

The importance of Islamic Sukuk lies in the fact that they are a financing tool compatible with the pillars of the Islamic economy. Thus, they provide an opportunity for investors to invest financial surpluses and achieve many of the following economic development requirements (Hafsi, 2022):

- Mobilizing savings from those who wish to deal following the provisions of Islamic Sharia.
- Expanding and developing the stock market base through tradability.
- Developing the diversification and variety of Islamic tools to manage its surplus liquidity;
- Help cover the deficit in the state budget.

2.2 Financial Development

The subject of financial development has gained an important place in many developing and developed countries, as it is an important indicator for measuring the development of the financial system and the liberalization of the financial sector. This has resulted in a difference in concepts related to it due to different economic leaders and thinkers.

2.2.1 The Concept of Financial Development

Financial development is a multidimensional process. Over time, financial sectors have evolved across the globe, and modern financial systems have become multifaceted. For example, while banks are typically the largest and most important, investment banks, insurance companies, mutual funds, pension funds, venture capital firms, and many other types of nonbank financial institutions now play substantive roles (Svirydzenka, 2016). Financial development also consists of a range of improvements in financial institutions, ranging from the establishment of a competitive banking system to dynamic financial markets (Eggoh, 2009). It can also be defined as the financial process through which financial transactions appear in both quantitative and qualitative terms. This development is considered through the various products provided by the financial system, whether by

brokerage firms or financial markets (Lynch, 1996). According to Venet is a different concept of financial development. According to his view, financial systems seek to free the financial sector from all restrictions and obstacles, such as setting interest rates, which have a negative impact on the mobilization of savings, in addition to imposing high mandatory reserves that reduce the volume of financing commercial banks and thus restrict their economic activities. Regardless of the liberalization of the financial sector in a way that allows it to keep pace with economic developments by freeing capital movement and foreign investment licenses (Venet, 2000).

2.2.2 Financial Development Indicators

Many economists differed in determining the financial indicators that measure the degree of financial development, including the following (Yaici, 2014):

- The volume of financial intermediation: It expresses the money supply, which represents the sum of money stock about GDP.
- The ratio of total quasi-money to the volume of GDP: This indicator measures the ability of the banking system to attract long and medium-term savings, which reflects the ability of banks to provide financing for long-term investment operations. It reflects the extent to which banks are committed to financing economic development.
- The ratio of loans to the private sector to GDP: This indicator measures the contribution of local banks in granting loans and facilities to the private sector. The higher the percentage of loans that the private sector benefits from concerning GDP, this indicates the development of the banking system, especially its role in collecting information, monitoring managers, diversifying risks, in addition to mobilizing savings and facilitating exchanges more effectively, increases.
- Interest rate margin: This index measures the profitability of the banking sector. It represents the difference between interest rates on loans and deposits provided by banks. It also indicates the level of competitiveness and efficiency of the banking sector. This index allows measuring the effectiveness of financial intermediation activity. The weaker the value of the index, the greater the effectiveness of financial intermediation, meaning that banks provide financial services at the lowest possible cost and vice versa (Shanafa, 2022).

2.3 The Experience of Islamic Instruments in Indonesia

The Islamic banking system in Indonesia has witnessed many developments. It witnessed a composite annual growth of 47% between 2009 and 2013, ahead of

traditional banks that recorded 12% growth in their deposits in 2013. Islamic bank deposits have also witnessed a strong composite annual growth, as a result of initiatives put in place by the Central Bank to develop Islamic banking, which has worked to establish supervision guidelines and precautionary measures and increase efficiency through the support of an Islamic financial market that has been characterized by safety, adherence to international Islamic banking standards and the integration of Islamic banking into the Islamic finance industry. The development plan was also based on growing religious awareness among customers, which helps increase the popularity of Islamic banking products. One of the results of achieving this growth is the provision of government support and improved confidence in Sharia-compliant financial products. In addition to the reasons for this growth are some economic legislations, including not allowing individuals or financial groups to own more than one banking company unless the second one is Islamic, in addition to the abolition of the composite tax law on Islamic banks. The Indonesian Parliament has also passed legislation to allow foreigners to establish Islamic banks in partnership with Indonesian citizens or local entities. It has also provided commercial banks with the option of converting their activities into Islamic banking activities. This legislation, in addition to customer confidence in Islamic banks, has contributed to the opening of eight new banks, bringing the number to 13 Islamic banks that serve about 1440 branches and finance offices in 2013 (Siamat, 2018).

In a move aimed at stimulating the sector, the Indonesian government has launched a national plan to develop the local Islamic finance industry, which is still limited in the world's Muslim population. Despite the launch of Islamic finance activities in Indonesia more than 20 years ago, it has achieved only limited gains in the country with a population of 250 million people, despite multiple regulatory efforts and popular initiatives, according to Sky News. The government of Indonesia is pursuing a set of strategies to fill the budget through the regular issuance of instruments in the international market. These issues have allowed it to find an alternative budget by providing a new source of funding for the government and local companies. The following graph shows the evolution of Sukuk issues from 2005 to 2021.

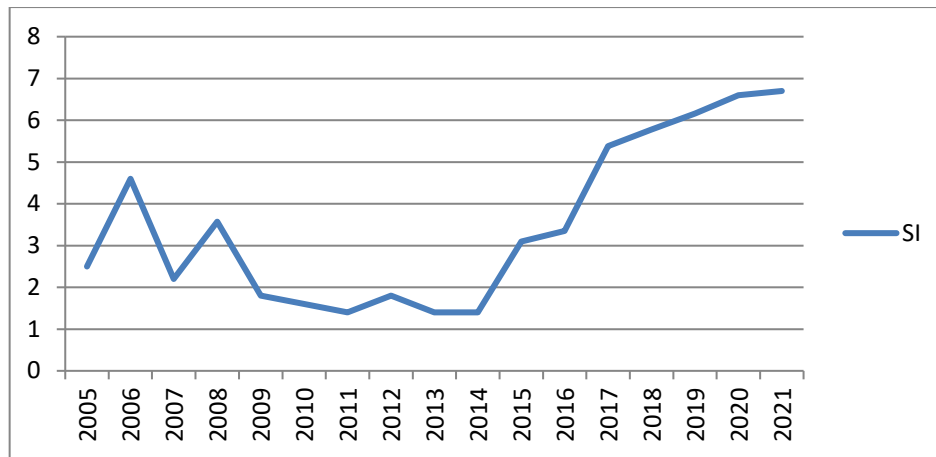


Figure 1. An Evolution of Issuance of Instruments in Indonesia

Source: Research finding, based on IIFM annual reports.

The above figure shows the evolution of Sukuk issues in Indonesia from 2005 to 2021. It was found that the volume of these issues fluctuated throughout the study period. The period 2009-2005 witnessed a fluctuation as a new experience due to several crises, including the mortgage crisis and the global financial crisis. However, the Sukuk market tried to recover every period and improve the pace of its issuance.

While the period 2009-2015 witnessed remarkable growth due to the expansion of the base of issuance of Sukuk, due to the surplus in liquidity in banks, after 2015, issuance has declined and fluctuated due to a sudden decision by the Central Bank to stop issuing short-term Sukuks. The decline in issuance of Sukuks has harmed Islamic banks and reduced the tools required to manage the profitability of their funds and achieve liquidity requirements. The International Monetary Fund has urged governments to ensure regular issuance by integrating Sukuks into local debt management strategies.

The period 2018-2021 witnessed positive growth despite the environmental conditions in this period and despite the slow pace of global economic growth, which affected Islamic financial markets. This growth is due to a series of issues made by the Government of Indonesia through a variety of instruments in addition to company issuances in various sectors. This has made Indonesia one of the main players in the international Sukuk market.

3. An Econometric Study of the Impact of Financial Development Indicators on Sukuk Issuance in Indonesia (2005-2021)

To estimate the relationship between financial development indicators and Sukuk issuances in Indonesia, an econometric study will be carried out using the autoregressive distributed lag (ARDL) model between 2005 and 2021.

3.1 Study Methodology

The study model depends on Indicators of financial development as an explanatory variable for Sukuk issuances, while neglecting the other variables that are included in the model residuals. To determine the effect of the independent variables on the dependent variable, the World Bank's (WDI) data on indicators of financial development were relied upon, and the issuances of instruments were obtained from IIFM (the global standard-setting body of the Islamic Financial). The following formula can be helpful:

$$SI(t) = f(IR(t), M2(t), DCPS(t), INV(t), \varepsilon t)$$

SI(t): Sukuk Issuance

IR(t): Real interest rate

DCPS(t): Loans to the private sector

M2(t): Money supply

INV(t): Investments

The following table presents the variables:

Table 1. Study Variables

Variable	Variable Code	Type	Data source
Sukuk Issuance	SI	Variable dépendante	IIFM
Money supply	M2	Variable indépendante	WDI data
Loans to the private sector	DCPS	Variable indépendante	WDI data
Real interest rate	IR	Variable indépendante	WDI data
Investments	INV	Variable indépendante	WDI data

Source: Research finding.

Investment expresses a percentage of GDP and is calculated by dividing the fixed capital formation by the total GDP. For this, the general model formula of (Bessouyah, 2022) is adopted, which includes the dependent variable SI and the independent variables X, which can be expressed by a set of explanatory variables X1, X2, ..., Xt, as follows:

$$\Delta SIt = c + \sum_i^p \beta_1 \Delta y_{t-1} + \sum_{i=0}^{q_2} \beta_3 \Delta x_{2t-1} + \dots + \Delta \sum_{i=0}^{q_k} \beta_k \Delta x_{kt-1} \alpha_1 y_{t-1} + \alpha_2 y_{t-1} + \alpha_3 x_{2t-1} + \dots + \alpha_k x_{kt-1} + \varepsilon_t$$

where:

c: is any constant;

Δ : first-order difference;

k: the independent variable number;

p: slowdown period of the dependent variable y;

$q_1, q_2, \dots, q_k$: the intervals of the independent variables $x_1, x_2, \dots, x_k$, respectively;

$\beta_1, \beta_2, \dots, \beta_k$: coefficients of short-term relationship;

$\alpha_1, \alpha_2, \dots, \alpha_k$: long-term relationship coefficients;

ε : random error.

The steps of the ARDL model can be summarized according to the following:

- Time-series stability test
- Optimum slowdown periods.
- Co-integration Test.
- ARDL Estimation results.
- Stability Test:
- ARDL Validity: Short-run and long-run estimation results.

-Time-Series Stability Test

Before estimating the ARDL model, it is necessary to test whether the time series used in the study are stable or not, in a way that requires the degree of integration for each series must be either of zero rank $I(0)$ or first rank $I(1)$. In this context, it must be ensured that there is no integrated second-order time series. The Augmented Dickey-Fuller (ADF) test for a unit root is used to test whether the time series is stable or not. The results are as follows:

Table 2. Unit Root Test Results Using ADF

Augmented Dickey-Fuller Level			
variable	None	Trend And Intercept	Intercept
SI	-6.069582	-7.074600	-0.989461
	0.0000	0.7745	0.7260
M2	-0.911198	-4.829656	-4.462815
	0.3054	0.0109	0.0050
DCPS	2.701547	-2.352369	-0.912460
	0.9961	0.3822	0.7547
INV	1.115405	-2.714010	-2.504860
	0.9227	0.2462	0.1337
IR	0.515329	-4.794728	-0.747822
	0.8141	0.0090	0.8026

Augmented Dickey-Fuller First Difference			
variable	None	Trend And Intercept	Intercept
SI	-6.222598	-8.640102	-6.224472
	0.0000	0.0000	0.0002
M2	-3.904546	-3.890896	-3.784061
	0.0008	0.0428	0.0148
DDCPS	-6.431841	-4.601040	-4.836730
	0.0000	0.0175	0.0032
DINV	--5.412512	-4.993463	-5.181064
	0.0001	0.0085	0.0015
IR	-7.690365	-7.541010	-7.833937
	0.0000	0.0002	0.0000

Source: Research finding, using Eviews 12.

Based on the panel unit root test results demonstrated in the above table, it was found that the series of SI, IR, and M2 are stationary in first difference. In describing this, it might say that the series does not contain a unit root and accordingly, it is stationary; it is integral (of degree 1), i.e., $I(1)$.

After making the first-degree differences for the series DINV, DDCPS, and based on the results obtained, we note that the series of the variable DINV, DDCPS are stationary in first difference. This model indicates that the series does not have a unit root and is therefore stationary; i.e., it is integral (of degree 1); i.e., $I(1)$.

3.3 Optimum Slowdown Periods

To determine the optimal slowdown periods, the Akaike information criterion (AIC) was used to reach the optimal model. The results are shown in the following figure:

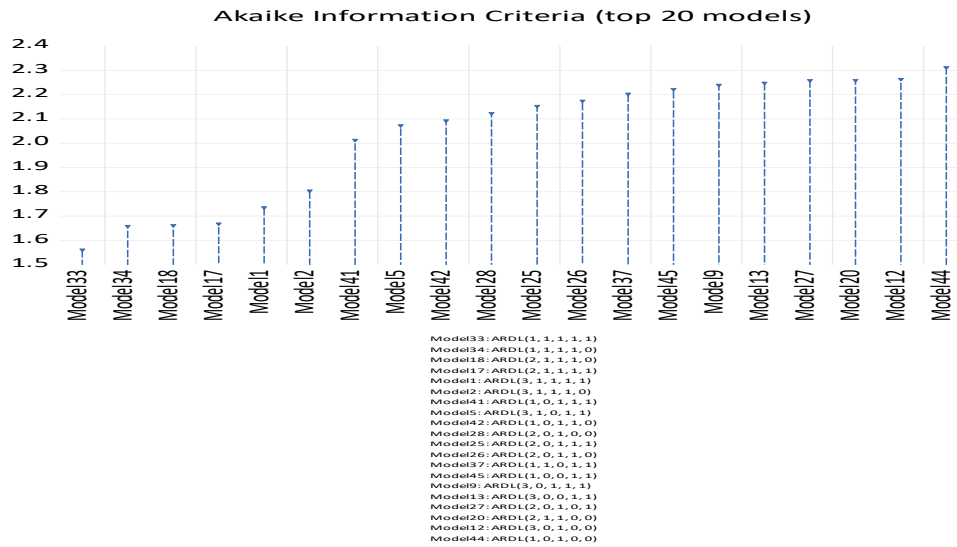


Figure 2. Optimal Slowing Periods for the ARDL Model

Source: Research finding, using Eviews 12.

Based on the results obtained from AIC, it can be concluded that the optimal slowdown periods were represented as follows: ARDL (1,1,1,1,1).

3.4 Co-integration Test

Before applying the ARDL bound test, it is necessary to test the possibility of co-integration between the study variables by doing a bound test to ascertain the existence or absence of a long-run equilibrium relationship between the variables using the following two hypotheses:

$$H_0 : \delta_0 = \delta_1 = \delta_2 = \delta_3 = 0$$

$$H_1 : \delta_0 \neq \delta_1 \neq \delta_2 \neq \delta_3 \neq 0$$

To ensure the existence of a long-run equilibrium relationship, the comparison between the F-statistic value and the tabular value is done as follows (Zoutri, 2021).

- If the F statistic is greater than the higher tabular value at a specific level of significance, then the null hypothesis is rejected and the alternative hypothesis is accepted; i.e., there is a long-run relationship between the study variables.
- If the F-statistic value lies between the upper and lower values, then the test result is undetermined; and

- If the F-statistic value is at a lower level than the minimum tabular value at a specific level of significance, the null hypothesis is accepted; i.e., there is no long-run relationship between the study variables.

The following table shows the bound test results for the variables under study:

Table 4. Bound Test Results

F-Bound Test		Null Hypothesis: No level Relationship		
Test Statistic	Value	Signif	I (0)	I (1)
F-Statistic	9.603232	10%	2.2	3.09
		5%	2.56	3.49
K	4	2.5%	2.88	4.87
		1%	3.29	4.37

Source: Research finding, using Eviews 12.

Based on the bound test results, it is clear that the statistic F-value reached 9.60, which is greater than the upper bound for the critical values at all levels of significance, and therefore the null hypothesis was rejected and the alternative hypothesis was accepted; i.e., there is a long-run relationship between the study variables.

3.5 ARDL Estimation Results

After doing the bound test and determining the optimal slowdown periods, the ARDL model was estimated as follows:

Table 5. ARDL Model Estimation Results

Variable	Coefficient	Std-Error	T-Statistic	Prob
SI(-1)	0.334124	0.1811692	0.183955	0.1253
IR	-0.090064	0.056120	-1.604831	0.1694
IR(-1)	-0.253641	0.118090	-2.147873	0.0845
DCPS	0.156037	1.77606	0.878557	0.4199
DCPS(-1)	0.355964	1.145357	2.448900	0.0580
M2	0.467665	0.357567	1.307910	0.2478
M2(-1)	-0.918936	0.270833	-3.393003	0.0194
INV	-0.306005	0.150098	-2.038698	0.0970
INV(-1)	-0.193587	0.162052	-1.194593	0.2858
C	21.87457	13.65275	1.602210	0.1700
R-Squared	0.984343	Mean dependent var		3.482667
Adjusted R-Squared	0.956160	S.D dependent var		2.072805
S.E. of Regression	0.434003	Akaike info criterion		1.403190
Sum squared resid	0.941792	Schwarz criterion		1.875223

Log likelihood	-0.523922	Hannan-Quinn criterion	1.398161
F-Statistic	34.92720	Durbin-Watson stat	3.325164
Prob(F-statistic)	0.000549		

Source: Research finding, using Eviews 12.

Based on the results of the ARDL model, it has been noted that the r-value = 0.98; i.e., the independent variables explain the dependent variable by 98%. The Fisher-exact P value (F-statistic) = 0.000549, which explains that the study model is statistically significant. Additionally, Durbin's C statistics reached =3.325164, which indicates the lack of error correlations.

3.5.1 Short-Run Estimation Results

After the ARDL estimation process, we will check whether the ARDL model is free from economic problems. The error correction factor in the ARDL model must be significantly negative, as revealed below:

Table 6. Results of Estimating Short-Term Coefficients

Variable	Coefficient	Std-Error	T-Statistic	Prob
D(IR)	-0.090064	0.027279	-3.301602	0.0214
D(DCPS)	0.156037	0.050446	3.093161	0.0271
D(M2)	0.467665	0.083797	5.580962	0.0025
D(INV)	-0.306005	0.069238	-4.419624	0.0069
CointEq(1)*	-0.665876	0.062029	-10.73493	0.0001
R-Squared	0.948974	Mean dependent var		0.140000
Adjusted R-Squared	0.928564	S.D dependent var		1.148204
S.E. of Regression	0.306886	Akaike info criterion		0.736523
Sum squared resid	0.941792	Schwarz criterion		0.972540
Log likelihood	-0.523922	Hannan-Quinn criterion	0.734009	
Durbin-Watson stat	3.325164			

Source: Research finding, using Eviews 12.

Through the estimation results shown in the table above, it is clear that the error correction coefficient (CointEq) is negative (0.665876) and has a statistically significant result ($P = 0.0001$) at a 5% level of significance ($p < 0.05$). This reflects the presence of a cointegration relationship between the variables under study, where the obtained value explains the degree of the standard deviation of Sukuk Issuance during the short-term by t-1 from the long-term equilibrium value. Then, approximately 66% of disequilibrium (or imbalance) is corrected in the period t to maintain the long-term equilibrium position.

The results reveal that there is a significant negative impact of Real interest rate (IR) on Sukuk Issuance (in the value of SI) in the short-run, as the decrease in one unit of IR leads to a Sukuk Issuance by 0.090064 units.

There is a significant positive impact of Loans to the private sector (DCPS) on Sukuk Issuance (in the value of SI) in the short run, as the increase in one unit of DCPS leads to an increase in Sukuk Issuance by 0.156037 units.

Additionally, there is a positive impact of Money supply (M2) on Sukuk Issuance (in the value of SI) in the short run, as the increase in one unit of M2 leads to an increase in Sukuk Issuance by 0.467665 units.

Finally, there is a significant negative impact of Investments (INV) on Sukuk Issuance (in the value of SI) in the short run, as the increase in one unit of INV leads to a decrease in Sukuk Issuance by 0.090064 units.

3.5.2 Long-run Estimation Results

To accurately analyze the long-run equilibrium relationship, it would be preferable to clarify the values via the following table:

Table 7. Results of Estimating Long-Term Coefficients

Variable	Coefficient	Std-Error	T-Statistic	Prob
IR	-0.516169	0.288041	-1.792001	0.1331
DCPS	0.768914	0.170262	4.516063	0.0063
M2	-0.677710	0.371047	-1.826480	0.1273
INV	-0.750277	0.219779	-3.41374	0.0190
C	32.85080	18.13975	1.810984	0.1299
EC=SI-(-0.5162* IR+0.7689DCPS-0.6777* M2-0.7503INV+32.8508)				

Source: Research finding, using Eviews 12.

Before presenting the interpretation, it is useful to adopt the values given in the above table to generate the following equation:

$$EC=SI-(-0.5162* IR+0.7689DCPS-0.6777* M2-0.7503INV+32.8508)$$

Based on the equation, it can be revealed that there is a significant positive impact of Loans to the private sector (DCPS) on Sukuk Issuance (in the value of SI) in the long run, as the increase in one unit of DCPS leads to an increase in Sukuk Issuance by 0.768914 units.

Additionally, there is a significant negative impact of Investments (INV) on Sukuk Issuance (in the value of SI) in the long run, as the increase in one unit of INV leads to a decrease in Sukuk Issuance by 0.750277units.

As for the two indicators, Money supply (M2), Real interest rate (IR), through the results, we notice that there is no impact on the volume of Sukuk issuances in the long-run (negative and non-significant effect).

3.6 ARDL Validity

To ensure that there are no problems with the model under study, a set of tests (Breusch-Pagan-Godfrey Heteroskedasticity Test and Jarque-Bera Test) would be used.

Table 8. Brush God Fry Test Results

Brush God Fry ARCH Test			
F-statistic	0.217807	Prob F(2,7)	0.7269
Obs*R-Squared	0.147537	Prob ChiSquare(2)	0.7009

Source: Research finding, using Eviews 12.

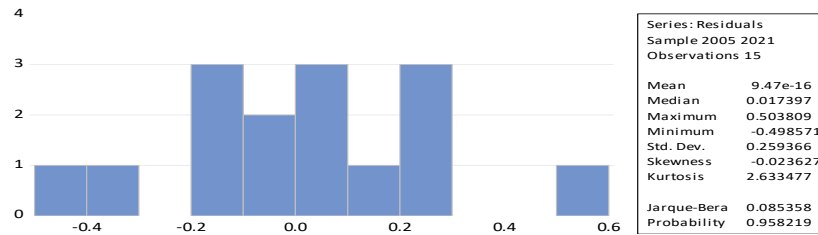


Figure 3. Jarque Bera Residuals Normal Distribution Test Results

Source: Research finding, using Eviews 12.

Based on Breusch-Pagan-Godfrey Heteroskedasticity test results shown in Table 8 revealed that the calculated F-value is greater than the level of Significance ($P > 0.05$), and accordingly, there is no heteroskedasticity.

Again, Jarque-Bera test results are plotted in Figure 2, which shows evidently that the skewness coefficient is 0.06 (≈ 0), and the kurtosis coefficient is 2.63. The results state that Jarque-Bera test statistics are 0.95 ($P > 0.05$), and this means that the residuals follow a normal distribution.

3.7 Stability Test

There is a further need to check the structural changes (or structural breaks) and the long-run and short-run parameters stability. If the value of the test statistic falls inside the critical region, then there is enough evidence that the structural stability is improved at a 5% level of significance (i.e., $p < 0.05$). To check the structural stability of the estimated coefficients, the CUSUM and CUSUMSQ tests are used.

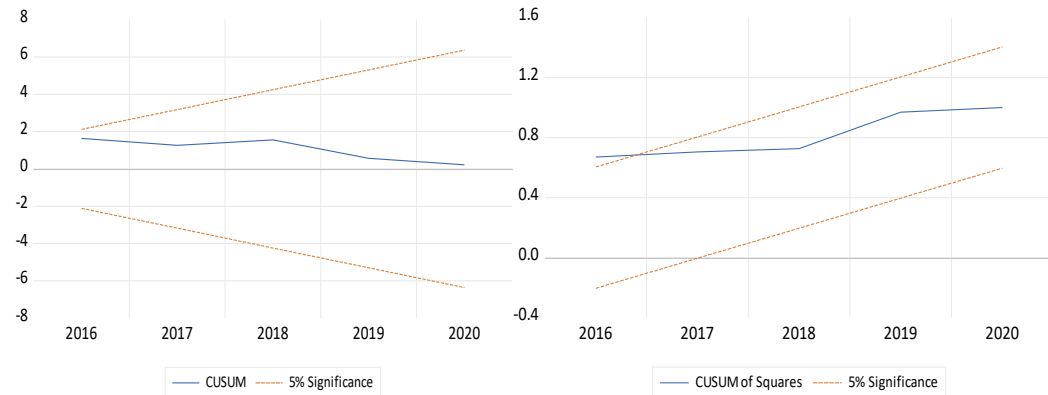


Figure 4. Estimated Model Stability Test

Source: Research finding, using Eviews 12.

It can be seen from the two above figures that the two tests' statistics fall into the critical regions at a 5% level of significance ($p < 0.05$), in a way that indicates the parameters' structural stability. This, therefore, confirms that the parameters remain stable over the entire study period.

4. The Results of the Standard Study

Based on standard modelling, time chain stability testing, and the degree of integration of the variables being studied, it has been shown that:

- Based on applying an econometric modelling, testing the stability in time-series data, and determining the degree of integration, it was found that the following:
- All series are complementary of class $I(1)$ and $I(0)$. We can apply the ARDL model to test long-term relationships and estimate parameters.
- Based on the results of the ARDL model estimation, it was found that the slowdown periods were distributed according to the study model equally, i.e., one slowdown period for each of the independent variables and the dependent variable.
- The independent variables (IR, DCPS, INV, M2) explain the dependent variable SI by 98%, and the value of Fisher's probability $P(F\text{-Statistic}) = 0.000549$, that is, the study model is significant and statistically significant. The Durbin-Watson statistic was 3.235164, which indicates the absence of error correlations.
- There is a positive and significant impact of the Private Sector Loans Index (DCPS) on the volume of Sukuk issuances (SI) in the long term, as an increase of one unit of the Private Sector Loans Index leads to an increase in the volume of Sukuk issuances by 0.768914.

- After testing the boundaries of the ARDL model, it was found that there is a long-term relationship between the study variables, there is a positive effect of both the money supply index M2 (and loans granted to the private sector (DCPS) statistically significant in the short term on Sukuk issuances (SI), and a negative effect of the real interest rate index (IR) statistically significant in the short term on Sukuk issuances (SI).
- In the long term, it was found that the indices have an impact on the long-term impact of loans to the private sector (DCPS) and investment (INV) on Sukuk issuances (SI).
- When studying the validity of the ARDL model, to ensure that there are no problems with the model under study, it was found that there were no errors in the stability of the homogeneity of variance; in addition to that, the residuals follow the normal distribution.
- When studying the structural stability of the coefficients, we found that there is stability in the long- and short-term features and therefore, there is structural stability in the study model and the data used in the study are devoid of any structural changes.

5. Conclusion

This research paper presents an econometric modelling of the impact of financial development indicators on Sukuk issuances in Indonesia using the autoregressive distributed lag (ARDL) model for the period, and the results proved (2005-2021). The volume of Islamic Sukuk issuances in Indonesia achieved positive results through its local and even international issuances, making it one of the most important major dealers in the international Sukuk market as a result of the initiatives developed by the Central Bank to develop Islamic banking products. It can be said that the establishment of an Islamic financial market and the development of financial Sukuk compatible with Islamic sharia law have a positive impact on the development of financial indicators and thus attract many savings and attract them to economic development processes. According to the results obtained:

- There is a significant positive impact of Loans to the private sector (DCPS), Investments (INV), on Sukuk Issuance (in the value of SI) in the long-term.
- As for the two indicators, Money supply (M2), Real interest rate (IR), through the results, we notice that there is no impact on the volume of Sukuk issuances in the long run (negative and non-significant effect).

Through the foregoing can be accepted the first hypothesis that: There is an impact between indicators of financial development and the long-term issuances of Islamic Sukuk in the long term.

The results reveal that there is a significant negative impact of Real interest rate (IR), Investments (INV), on Sukuk Issuance (in the value of SI) in the short-term.

There is a significant positive impact of Loans to the private sector (DCPS), Money supply (M2), on Sukuk Issuance (in the value of SI) in the short-term.

Additionally, there is a positive impact of Money supply (M2) on Sukuk Issuance (in the value of SI) in the short-term.

Through the foregoing can be accepted the second hypothesis that: There is an impact between indicators of financial development and the long-term issuances of Islamic Sukuk in the short term.

Based on the above, the following recommendations can be made:

- Achieving financial stability and maintaining financial balance to face all borders and crises.
- Improving the efficiency of Islamic financial markets and introducing innovative products.
- Activating the role of financial markets to raise the levels of issuance of Islamic Sukuk.
- Diversify Islamic Sukuk issuances to ensure more options for customers.
- Follow up on changes in the financial system and study their impact on Islamic Sukuk issuances.

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Appendix

Method: ARDL Date: 09/11/22 Time: 23:22 Sample (adjusted): 2005 2021 Included observations: 15 after adjustments Maximum dependent lags: 3 (Automatic selection) Model selection method: Akaike info criterion (AIC) Dynamic regressors (1 lag, automatic): IR DCPS M2 INV Fixed regressors: C Number of models evaluated: 48 Selected Model: ARDL(1, 1, 1, 1, 1) Note: final equation sample is larger than selection sample				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
SI(-1)	0.334124	0.181692	1.838955	0.1253
IR	-0.090064	0.056120	-1.604831	0.1694
IR(-1)	-0.253641	0.118090	-2.147873	0.0845
DCPS	0.156037	0.177606	0.878557	0.4199
DCPS(-1)	0.355964	0.145357	2.448900	0.0580
M2	0.467665	0.357567	1.307910	0.2478
M2(-1)	-0.918936	0.270833	-3.393003	0.0194
INV	-0.306005	0.150098	-2.038698	0.0970
INV(-1)	-0.193587	0.162052	-1.194593	0.2858
C	21.87457	13.65275	1.602210	0.1700
R-squared	0.984343	Mean dependent var	3.482667	
Adjusted R-squared	0.956160	S.D. dependent var	2.072805	
S.E. of regression	0.434003	Akaike info criterion	1.403190	
Sum squared resid	0.941792	Schwarz criterion	1.875223	
Log likelihood	-0.523922	Hannan-Quinn criter.	1.398161	
F-statistic	34.92720	Durbin-Watson stat	3.325164	
Prob(F-statistic)	0.000549			

*Note: p-values and any subsequent tests do not account for model

ARDL Long Run Form and Bounds Test Dependent Variable: D(SI) Selected Model: ARDL(1, 1, 1, 1, 1) Case 2: Restricted Constant and No Trend Date: 09/12/22 Time: 00:40 Sample: 2005 2021 Included observations: 15				
Conditional Error Correction Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	21.87457	13.65275	1.602210	0.1700
SI(-1)*	-0.665876	0.181692	-3.664860	0.0145
IR(-1)	-0.343705	0.131416	-2.615399	0.0474
DCPS(-1)	0.512001	0.095764	5.346465	0.0031
M2(-1)	-0.451271	0.263027	-1.715681	0.1469
INV(-1)	-0.499592	0.195758	-2.552087	0.0511
D(IR)	-0.090064	0.056120	-1.604831	0.1694
D(DCPS)	0.156037	0.177606	0.878557	0.4199
D(M2)	0.467665	0.357567	1.307910	0.2478
D(INV)	-0.306005	0.150098	-2.038698	0.0970

* p-value incompatible with t-Bounds distribution.

ARDL Error Correction Regression Dependent Variable: D(SI) Selected Model: ARDL(1, 1, 1, 1, 1) Case 2: Restricted Constant and No Trend Date: 09/12/22 Time: 00:40 Sample: 2005 2021 Included observations: 15				
ECM Regression Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(IR)	-0.090064	0.027279	-3.301602	0.0214
D(DCPS)	0.156037	0.050446	3.093161	0.0271
D(M2)	0.467665	0.083797	5.580962	0.0025
D(INV)	-0.306005	0.069238	-4.419624	0.0069
CoIntEq(-1)*	-0.665876	0.062029	-10.73493	0.0001
R-squared	0.948974	Mean dependent var	0.140000	
Adjusted R-squared	0.928564	S.D. dependent var	1.148204	
S.E. of regression	0.306886	Akaike info criterion	0.736523	
Sum squared resid	0.941792	Schwarz criterion	0.972540	
Log likelihood	-0.523922	Hannan-Quinn criter.	0.734009	
Durbin-Watson stat	3.325164			

* p-value incompatible with t-Bounds distribution.

F-Bounds Test Null Hypothesis: No levels relationship				
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	9.603232	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.5%	2.89	3.87
		1%	3.29	4.37

Model Selection Criteria Table Dependent Variable: SI Date: 09/12/22 Time: 00:39 Sample: 2005 2021 Included observations: 15						
Model	LogL	AIC*	BIC	HQ	Adj. R-sq	Specification
33	-0.921504	1.560215	2.016684	1.517960	0.947955	ARDL(1, 1, 1, 1, 1)
34	-2.602092	1.657442	2.068264	1.619413	0.947066	ARDL(1, 1, 1, 1, 0)
18	-1.622522	1.660360	2.116830	1.618106	0.942473	ARDL(2, 1, 1, 1, 0)
17	-0.670015	1.667145	2.169261	1.620665	0.933055	ARDL(2, 1, 1, 1, 1)
1	-0.136212	1.733745	2.281508	1.663039	0.906968	ARDL(3, 1, 1, 1, 1)
2	-1.619055	1.802722	2.304839	1.756242	0.923335	ARDL(3, 1, 1, 1, 0)
41	-5.080375	2.011482	2.422305	1.973453	0.924578	ARDL(1, 0, 1, 1, 1)
5	-3.498886	2.071269	2.573386	2.024789	0.899717	ARDL(3, 1, 0, 1, 1)
42	-6.61551	2.091650	2.458826	2.057847	0.921445	ARDL(1, 0, 1, 1, 0)
28	-6.852274	2.121753	2.486929	2.087950	0.919044	ARDL(2, 0, 1, 0, 0)
25	-5.059575	2.151368	2.607837	2.109113	0.906003	ARDL(2, 0, 1, 1, 1)
26	-6.209293	2.172756	2.583579	2.134727	0.911379	ARDL(2, 0, 1, 1, 0)
37	-4.10868	2.201527	2.612350	2.163488	0.908792	ARDL(1, 1, 0, 1, 1)
45	-7.544264	2.220609	2.585785	2.186805	0.910632	ARDL(1, 0, 0, 1, 1)
9	-4.666982	2.238140	2.740257	2.191660	0.881506	ARDL(3, 0, 1, 1, 1)
13	-5.726150	2.246593	2.703062	2.204338	0.896612	ARDL(3, 0, 0, 1, 1)
27	-6.800023	2.257146	2.667969	2.219117	0.903576	ARDL(2, 0, 0, 1, 0)
20	-6.805283	2.257898	2.668720	2.219868	0.903503	ARDL(2, 1, 1, 0, 0)
12	-6.834547	2.262078	2.672901	2.224049	0.903099	ARDL(2, 0, 1, 0, 0)
44	-9.121133	2.310305	2.628833	2.280726	0.903344	ARDL(1, 0, 1, 0, 0)
32	-9.201907	2.314558	2.634087	2.284980	0.902932	ARDL(2, 0, 0, 0, 0)
10	-6.203920	2.314846	2.771315	2.272591	0.889309	ARDL(3, 0, 1, 1, 0)
21	-6.304435	2.328634	2.785103	2.286379	0.887772	ARDL(2, 1, 0, 1, 1)
38	-8.366116	2.338017	2.703192	2.304213	0.899499	ARDL(1, 1, 0, 1, 0)
46	-9.461911	2.351702	2.671230	2.322123	0.899259	ARDL(1, 0, 0, 1, 0)
29	-7.515457	2.359351	2.770174	2.321322	0.893199	ARDL(2, 0, 0, 1, 1)

Heteroskedasticity Test: ARCH

F-statistic	0.127807	Prob. F(1,12)	0.7269
Obs*R-squared	0.147537	Prob. Chi-Square(1)	0.7009

Test Equation:

Dependent Variable: RESID*2

Method: Least Squares

Date: 09/12/22 Time: 00:43

Sample (adjusted): 2005 2021

Included observations: 14 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.060393	0.030117	2.005281	0.0680
RESID*2(-1)	0.102115	0.285636	0.357501	0.7269
R-squared	0.010538	Mean dependent var	0.067197	
Adjusted R-squared	-0.071917	S.D. dependent var	0.084355	
S.E. of regression	0.087336	Akaike info criterion	-1.906554	
Sum squared resid	0.091530	Schwarz criterion	-1.815260	
Log likelihood	15.34588	Hannan-Quinn criter.	-1.915005	
F-statistic	0.127807	Durbin-Watson stat	2.050306	
Prob(F-statistic)	0.726925			

Test Equation:

Dependent Variable: RESID

Method: ARDL

Date: 09/12/22 Time: 00:41

Sample: 2005 2021

Included observations: 15

Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
SI(-1)	0.319717	0.103969	3.075134	0.0543
IR	-0.077804	0.030183	-2.577696	0.0619
IR(-1)	-0.064042	0.052492	-1.220031	0.3096
DCPS	-0.040595	0.080527	-0.504115	0.6489
DCPS(-1)	-0.037349	0.065422	-0.570891	0.6080
M2	0.192584	0.153639	1.253485	0.2988
M2(-1)	-0.108374	0.119824	-0.904446	0.4324
INV	0.063658	0.063733	0.998834	0.3915
INV(-1)	0.157211	0.074313	2.115505	0.1247
C	-8.107863	6.059099	-1.338130	0.2732
RESID(-1)	-1.847530	0.406684	-4.542910	0.0200
RESID(-2)	-0.901197	0.370406	-2.432997	0.0931

R-squared	0.896015	Mean dependent var	-2.84E-15
Adjusted R-squared	0.514735	S.D. dependent var	0.259366
S.E. of regression	0.180677	Akaike info criterion	-0.593648
Sum squared resid	0.097933	Schwarz criterion	-0.027208
Log likelihood	16.45236	Hannan-Quinn criter.	-0.599682
F-statistic	2.350017	Durbin-Watson stat	1.739635
Prob(F-statistic)	0.261394		

Breusch-Godfrey Serial Correlation LM Test:

Null hypothesis: No serial correlation at up to 2 lags

F-statistic	12.92510	Prob. F(2,3)	0.3354
Obs*R-squared	13.44022	Prob. Chi-Square(2)	0.1200

Levels Equation				
Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
IR	-0.516169	0.288041	-1.792001	0.1331
DCPS	0.768914	0.170262	4.516063	0.0003
M2	-0.677710	0.371047	-1.826480	0.1273
INV	-0.750277	0.219779	-3.413774	0.0190
C	32.85080	18.13975	1.810984	0.1299
EC = SI - (-0.5162*IR + 0.7689*DCPS - 0.6777*M2 - 0.7503*INV + 32.8508)				
F-Bounds Test				
Null Hypothesis: No levels relationship				
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	9.603232	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37
Actual Sample Size	15	Finite Sample:		
		n=30	2.525	3.56
		10%	3.058	4.223
		5%	4.28	5.84

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A Comparative Study of the Calculation Method of the Monetary Damages in International Arbitration

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Abstract

Different factors contribute to the assessment of monetary damage, whose ignoring results in an inaccurate evaluation of monetary damage. One such factor is the approach used to calculate monetary damages. Concrete and abstract methods of calculation, namely, have been adopted for this purpose. Applying one of the aforementioned methods may result in no monetary compensation for the aggrieved party, whereas the other method may result in substantial monetary damages. Articles 75 and 76 of the United Nations Convention on Contracts for the International Sale of Goods 1980 Vienna (CISG) have embraced both of these methods. Nonetheless, the Convention does not specify the priority or prerequisites for applying these methods, which has led the tribunal to employ them arbitrarily. A circumstance that not only renders the rights of the aggrieved party unpredictable, but also causes inconsistency in the application of the Convention. This article is descriptive and analytical, which analyzes these methods and their application conditions, and concludes that the concrete method for calculating monetary damages has precedence over the abstract method. When the abstract method's prerequisites are not met, it is utilized.

Keywords: Calculation of Monetary Damages, CISG, Mitigation of Monetary Damages, PECL, UPICC.

JEL Classification: K12, K33, K39.

1. Introduction

In legal systems, two approaches of calculation, the “Concrete” method and the “Abstract” method, may be used to calculate monetary damages. In the first approach, the amount of monetary damage is assessed concerning the actual circumstances of the aggrieved party, whereas in the latter approach, a fixed formula is always applied. For example, if the seller fails to deliver the agreed-upon goods, the quantity of monetary damages equals the difference between the

contract price and the current price. This approach disregards the behavior of the aggrieved party and assumes that all losses will be compensated through a replacement transaction at the current price. In contrast, the concrete method requires the injured party to take reasonable measures to mitigate monetary damages. For example, if the price of the products is on an ascending scale, the injured party must conduct a replacement transaction as soon as possible. In this instance, the amount of monetary damages equals the difference between the price of the replacement transaction and the current price. If the aggrieved party fails to do so, they are precluded from recovering the amount of loss that could have been avoided. And in the event that the buyer breaches the contract, the seller must sell the products at the best possible price under the circumstances, with the profit margin earned being factored into the calculation of monetary damages. This approach has been criticized by proponents of the *abstract method*, who contend that this profit is the result of the individual's risk-taking and not a breach of contract (Saidov, 2008).

The method of calculation may have a substantial impact on the amount of monetary damages and, consequently, the compensation of the aggrieved party. It is also possible that the tribunal in a given dispute awards no monetary damages using the concrete method of calculation, but a substantial amount using the abstract method, and vice versa. Therefore, the aggrieved party regarding the specifics of the case may base its claim on one of the aforementioned methods in order to assert its rights.

These two methods have been adopted by the United Nations Convention on Contracts for International Sale of Goods 1980 Vienna (CISG), the UNIDROIT Principles of International Commercial Contracts (UPICC), and the Principles of European Contract Law (PECL). However, none of these instruments specify the prerequisites or application of these methods, or the precedence of one over the other.

Article 75 of the CISG allows concrete calculation methodologies. As stated in this Article, if the contract is avoided and if, in a reasonable manner and within a reasonable time after avoidance, the buyer has purchased replacement goods or the seller has resold the goods, the party claiming monetary damages may recover the difference between the contract price and the price in the replacement transaction, in addition to any additional monetary damages recoverable under

Article 74¹.” Consequently, Article 76 provides the abstract method as follows: “If the contract is avoided and there is a current price for the goods, the party claiming monetary damages may, if they have not made a purchase or resale pursuant to Article 75, recover the difference between the price fixed by the contract and the current price at the time of avoidance, as well as any additional monetary damages recoverable pursuant to Article 74. If, however, the party claiming monetary damages has rescinded the contract after taking possession of the products, the price in effect at the time of such rescinding shall be applied instead of the price in effect at the time of cancellation.” On the surface, it appears to be quite straightforward. If the aggrieved party has entered into a reasonable replacement agreement, then Article 75 applies; otherwise, Article 76 applies. It should be noted that this viewpoint represents a superficial comprehension of these Articles. Nonetheless, even in numerous awards based on these Articles, this incorrect interpretation has been adopted or they have been applied indiscriminately.

This article seeks to investigate and analyze methods of calculating monetary damages in order to put forward a solution that establishes the manner and requirements for applying each of the aforementioned methods and eliminates ambiguities and disagreements in this field.

2. Concrete Method

According to Article 75 CISG, “if the contract is avoided and if, in a reasonable manner and within a reasonable time after avoidance, the buyer has purchased replacement goods or the seller has resold the goods, the party claiming monetary damages may recover the difference between the contract price and the price in the replacement transaction, in addition to any further monetary damages recoverable under Article 74.” The UNIDROIT Principles of International Contracts and the Principles of European Contract Law similarly express this rule. However, because the two sets of Principles may apply to transactions other than sales transactions, their provisions make a broad reference to “replacement” transactions. Consequently, the concept of replacement transaction is broader than what is outlined in the CISG. This approach is commonly referred to as the *Concrete method* because it focuses on the actual behavior and circumstances of the

¹. Damages for breach of contract by one party consist of a sum equal to the loss, including loss of profit, suffered by the other party as a consequence of the breach. Such damages may not exceed the loss which the party in breach foresaw or ought to have foreseen at the time of the conclusion of the contract, in the light of the facts and matters of which he then knew or ought to have known, as a possible consequence of the breach of contract.

aggrieved party. It is safe to say that the concrete method of calculation conveys the meaning of mitigation. This method has a close relationship with the *mitigation* rule, as making a replacement transaction is a common and reasonable way to mitigate monetary damages (Enderlien and Maskow, 1992). This provision establishes monetary damages through the actions of the injured vendor in reselling the goods and the actions of the injured buyer in obtaining coverage, i.e., purchasing the goods elsewhere (Sutton, 1989).

This method of calculating monetary damages will compensate for the profit margin the harmed party would have anticipated under the contract. If the claimant completes a replacement transaction at a reasonable price and in a reasonable amount of time, one can say that awarding the difference between the contract price and the current price will fully compensate the injured party (Honnold, 2009).

3. Conditions for Applying of Concrete Method

The following are the prerequisites for employing the tangible method of calculation. First, all three instruments indicate that this method is utilized only when the contract has been avoided, as it is the avoidance of the contract that releases the party from their contractual obligations and enables them to procure a replacement transaction (Saidov, 2008). Second, an alternative transaction must have been arranged. This replacement transaction is required to replace the original contract. To accomplish this, the replacement transaction must be related to the original contract and capable of protecting the injured party's interest in the performance of the original contract (Schlechtriem, 2016; Borisova, 2007). Third, the replacement transaction must be completed in a reasonable amount of time and manner after a breach of contract (Bates, 1991). Despite the fact that a uniform practice has been developed in this regard, the determination of a reasonable period of time depends on the encompassing circumstances of the case at hand. In the majority of cases, judges and arbitrators have determined that a period of 2 or 3 months is reasonable for the completion of a replacement transaction. Depending on the specifics of the case, this timeframe can range from a few days to several months. Nature, descriptions of the goods, and the rationale for the conclusion of the contract all play a significant role in determining the reasonable time (Honnold, 2009). In the cases, eight years appears to be the greatest time period after a violation. In the 1980 case, *Dodd Properties (Kent) Ltd. v. Canterbury City Council*, 1 All E.R. 928 (C.A.), the 1968 pile driving operations of the defendant caused monetary damage to the plaintiff's commercial structure. 1970 was the earliest year in which the plaintiffs could have initiated restorations. At that time,

the price would have been £11,375. The chief financial officer of the plaintiff testified that they delayed making the repairs due to the plaintiff's cash flow situation and the defendant's denial of liability. The trial judge concluded that the evidence indicated commercially reasonable behavior (Bates, 1991).

Referring to the second requirement, this method is only applicable if the aggrieved party has complied with the CISG's obligation to mitigate monetary damages.¹ Mitigation of monetary damages implies that the non-breaching party must take reasonable steps to prevent or minimize loss (Saidov and Cunnington, 2008). However, this obligation is not a legal obligation in the strict sense; the non-breaching party is not required to perform any act for this purpose. If the non-breaching party fails to take any action to mitigate the harm, the monetary damages may be reduced to the extent that the injured party could have reduced or mitigated the loss (Saidov, 2002). According to the UPICC, the non-performing party is not liable for the aggrieved party's loss to the extent that the damage could have been mitigated by the aggrieved party's reasonable measures.²

The only effect of this duty is when the party in breach attempts to avoid liability for monetary damages in whole or in part by invoking this rule. Therefore, under the well-known concept of mitigation of monetary damages in common law, the non-breaching party is obligated to take reasonable measures to mitigate any potential harm or loss resulting from a breach of contract. If that party fails to take reasonable precautions, they cannot recover the amount of loss that could have been avoided. For the purpose of mitigating monetary damages, the non-breaching party should take only reasonable measures, and it is not necessary to resort to measures that involve excessive cost, a complex lawsuit, or monetary harm to the reputation of the innocent party; otherwise, they are not entitled to claim the costs incurred (Bates, 1991). However, these are general facts; the difficulty arises when determining the meaning of a replacement transaction in a particular circumstance. For example, a scenario in which the buyer has stock goods that were acquired before entering into a contract with the seller. Moreover, suppose that the buyer uses the inventory to secure the orders that were to be fulfilled under the second contract. Can we state, based on the specific method of calculation, that the buyer is entitled to the difference between the price of the goods in stock and the price of the breached contract's goods? It could be argued that such costs cannot be recovered, as the replacement transaction is the one that is entered into after a

¹. This obligation has been provided for under Article 77 of CISG and also Articles 7-4-8 and 9:505 of UPICC and PECEL respectively.

². Article 7-4-8(1), *See also* Article 9:505 PECEL.

breach of the original contract. Hence, the products acquired before the breach of contract were not intended for replacement. Despite this, one could argue that international instruments do not state (at least expressly) that replacement transactions must be intended to supplant the original contract. For a transaction to be deemed a “replacement transaction,” the intent of the parties at the time the contract was executed is irrelevant (Schlechtriem, 2016). As international instruments permit a reasonable replacement transaction, it can also be argued that using products in stock is a reasonable alternative in this situation. Although the requirement that a replacement transaction occur after a breach is based on a sensible rationale, it may be reasonable for a party to use goods from its stock as a replacement before the breach.

In practice, judges and arbitrators frequently consider the market price when determining whether a replacement transaction was reasonable. If the price in a buyer’s replacement transaction is less than the market price, it is likely that this replacement will be deemed to be reasonable.¹ In instances where the price in a replacement transaction corresponds to the market pricing, the same logic most likely applies.² In some instances, the price in the seller’s replacement transaction, which is below the market price, may be deemed reasonable. In one case, where the seller was in a disadvantageous position due to the nature of the products, the tribunal determined that it was reasonable for the price in a replacement transaction to be slightly lower than the market price.³ The existence or absence of more advantageous alternatives is also relevant to proving that a replacement transaction’s price was reasonable.

Despite the fact that a replacement transaction is the typical method of mitigating monetary damages, the aggrieved party may not have recourse to a replacement transaction in certain situations. In other words, there may be no solution in some instances. For instance, one can envision a scenario in which the buyer has already paid the purchase price in advance of receiving the goods and therefore lacks the monetary resources to enter into a new contract (Bates, 1991). Another circumstance in which the mitigation rule cannot be applied is the so-called lost volume situation, in which the supply of products exceeds their demand.

¹. See CIETAC Arbitration proceedings 10 June 2002
<<http://cisgw3.law.pace.edu/cases/020610c1.html>>.

². ICC Arbitration Case No. 10329 of 2000 (Industrial product case) <<http://cisgw3.law.pace.edu/cases/000329i1.html>>

³. CIETAC Arbitration Proceeding, 4 June 1999 (Industrial raw material case) <<http://cisgw3.law.pace.edu/cases/990604c1.html>>

Even if the buyer had not breached the agreement, the seller would have been able to continue supplying products to other customers. Therefore, in this circumstance, we cannot speak of a replacement transaction. As an illustration, the seller has a thousand televisions in stock and sells 100 of them to the first buyer, who then breaches the contract by refusing to accept delivery of the products. Even though the original contract would have been honored, it cannot be argued that the seller could mitigate monetary losses through the resale of the televisions because they had sufficient quantities for potential purchasers (Saidov, 2008). Other circumstances exist in which the resale of the goods is impractical, such as when the goods are designed for a specific purpose. In one instance, the seller attached the buyer's trademark to the merchandise to prevent resale.¹

Another instance is when the aggrieved party is logically unable to enter into a replacement contract. For instance, in a contract for the production of seasonal clothing with an order placed several months in advance, the seller failed to fulfill its obligations, preventing the buyer from entering into a new contract.²

4. Implementation of the Concrete Method

As stated, the amount payable as monetary damages under this method equals the difference between the original contract's price and the price of the replacement transaction. However, it should be noted that in some instances, one of the comparability prices must be adjusted because the provisions of the contracts may not be identical (Chengwei, 2003). In one instance, the original contract was governed by CFR (Cost & Freight) terms, while the replaced contract was governed by FOB (Free on Board) terms. Because freight was not included in the latter contract, the arbitral panel considered it when calculating monetary damages.³ Another circumstance is when VAT⁴ is charged on domestic sales but not on international sales (export). In one instance where the vendor breached the contract (VAT was not collected), they resold the products to a buyer in their home country (VAT included). For this reason, the tribunal deducted the amount of VAT from the price of the replaced contract.⁵

Yet, a situation involving a more complex pricing adjustment is when one contract requires payment in cash while the other requires credit payment.

¹. ICAC Case 107/2002, decision dated 16 February 2004.

². <http://cisgw3.law.pace.edu/cases/940114g1.html>

³. CIETAC Arbitration, dated 15 November 1996. <http://cisg3.law.pace.edu/cases/961115c1.html>

⁴ Value added tax (VAT)

⁵. CIETAC Arbitration, dated 16 August 1996. <http://cisg3.law.pace.edu/cases/960816c1.html>

Consider a contract with a thirty-thousand-dollar price payable within three years. After contract infringement, a replacement contract is negotiated for 21 thousand dollars to be paid in cash. It is illogical to state that the aggrieved party is entitled to nine thousand dollars in monetary damages, given that thirty thousand dollars payable in currency is not equivalent to 30 thousand dollars payable over three years. For calculation purposes, one must consider the effect of time on monetary value; otherwise, the aggrieved party will be overcompensated (Saidov and Cunningham, 2008).

5. Other Varieties of Loss

In accordance with international instruments¹, in addition to the difference between the contract price and the price of the replaced contract, the aggrieved party may also seek compensation for any losses or damages incurred. These losses are of different types. The seller may, for instance, be entitled to warehouse costs from the time the contract was violated until the replacement transaction is executed. They may also intend to collect interest on loans they had to obtain. The buyer may also seek reimbursement for expenses such as hiring a broker or compensating the seller's customers. Since the calculation of monetary damages based on the concrete method does not include these categories of damages, the aggrieved party must claim them in addition to the direct loss resulting from the breach of contract (Honnold, 2009).

In this section, it is appropriate to discuss the legal position of Iran in this regard. In contrast to civil liability, contractual liability issues have been almost ignored by the legislator; this is largely because the Iranian Civil Act was modeled after *fiqh* (Islamic law)² literature. Islamic jurists have primarily elaborated on the formation/termination of contracts and parties' obligations; sanctions for contract breach have not been emphasized. By analyzing legal foundations, we hope to cast some light on the issue of calculating monetary damages under Iranian law. As stated, the prerequisite for employing this method is the completion of a replacement transaction. Therefore, it should be made plain in the first instance whether replacement transactions have been permitted neither in the Iranian legal system nor in *fiqh*, the primary source of our law, nor in statutes. In addition, legal scholars have not addressed it in their writings. In actuality, this institution can be

¹. Article 75 CISG, 7.4.5 UPICC and 9:506 PECL

². The word *fiqh* is an Arabic term meaning "deep understanding" or "full comprehension." Technically it refers to the body of Islamic law extracted from detailed Islamic sources.

traced back to the English legal system in the *British Westinghouse Electric* case (1912)¹ (Bates, 1991), and even in the French legal system, which has left its mark on the Iranian Civil Code, replacement transaction has no place (Le Pautremat & LQ, 2006). In contrast, the primary sanction for contract breach under Iranian law is specific performance as stated in Article 237 of the Iranian Civil Code (Shahidi, 2012), which conflicts with replacement transactions. In brief, it can be argued that replacement transactions are prohibited under Iranian law; there may be no concrete method for calculating monetary damages.

6. Abstract Calculation Method

The *Abstract Method* is the alternative method of calculation expressly specified in international instruments. Article 76 of the CISG states, “If the contract is avoided and there is a current price for the goods, the party claiming monetary damages may, if they have not made a purchase or resale under Article 75, recover the difference between the price fixed by the contract and the current price at the time of avoidance, as well as any additional monetary damages recoverable under Article 74.” If, however, the party claiming monetary damages has rescinded the contract after taking possession of the products, the price in effect at the time of such rescinding shall be applied instead of the price in effect at the time of cancellation.” UPICC² and PECL³ also stipulate it in comparable language. As previously stated, these latter two instruments are not limited to sales contracts but rather apply to any contract, regardless of its nature. In domestic legal systems, the abstract calculation procedure is well-known. This method disregards the aggrieved party’s unique circumstances (Lando and Beale, 2000). Instead, this is a depersonalized formula based on the simple premise that by reimbursing the current price, the injured party is able to conduct a replacement transaction. Since the claimant is not obligated to make a replacement transaction, this method does not provide for the mitigation of monetary damages (Bridge, 2007).

¹. *British Westinghouse Electric and Manufacturing Co. Ltd. v. Underground Electric Railways Co. of London Ltd.*

². Article 7.4.6: “Where the aggrieved party has terminated the contract and has not entered into a replacement transaction, but there is a current price for the performance contracted for, the aggrieved party may recover the difference between the contract price and the current price at the time the contract was terminated, in addition to monetary damages for any further harm.”

³. Article 9:507: “Where the aggrieved party has terminated the contract and has not entered into a replacement transaction, but there is a current price for the performance contracted for, the aggrieved party may recover the difference between the contract price and the current price at the time the contract is terminated, as well as monetary damages for any further loss recoverable under this Section.”

This method of calculation may, in some instances, result in excessive or inadequate compensation. Suppose, for example, that the contract price and resale price are \$40,000 and \$50,000, respectively. If the current price is expected to be \$60,000, then the quantity of monetary damages payable is \$20,000, which is \$10,000 more than what the injured party has suffered. In contrast, if the current price declines to 35,000 dollars, the claimant will not be entitled to any compensation because the current price is below the contract price. Nonetheless, the following arguments have been presented in support of this method: 1) Overcompensation should not be considered; otherwise, the breaching party would benefit from market fluctuations; 2) Overcompensation can be justified by arguing that the injured party has been deprived of the opportunity to profit from market fluctuations; and 3) This method is simple and avoids the complexities or uncertainties associated with the concrete method of calculating monetary damages (Bates, 1991).

7. The Relationship between “Concrete” and “Abstract” Calculation Methodologies

In various legal systems, one or both of these methods may be used in conjunction with the calculation of monetary damages. It appears that international instruments favor concrete methods by stipulating that the difference between the contract price and the current price may be claimed in the absence of a replacement transaction. In other words, the concrete method takes precedence over the abstract method, and if the aggrieved party has engaged in a replacement transaction, monetary damages must be determined using the concrete method. Despite the intention of the drafters to eradicate uncertainties, their accomplishments in this regard are highly questionable (Honnold, 2009). To address this difficulty, the relationship between these two methodologies must be investigated.

Sutton (1989) recommends that the abstract method be used when: 1) the aggrieved party has failed to make a replacement transaction; 2) the requirements of a concrete method of calculation have not been met; and 3) it has been impossible to make a replacement transaction. The relationship between the “abstract” method and the “mitigation” rule is questioned in the first two situations, but is self-evident in the third. To avoid making a reasonable replacement contract is a violation of the obligation to mitigate monetary losses. To calculate monetary damages in this instance, should an abstract method and the mitigation rule be disregarded, or should the amount of avoidable loss be deducted from the reimbursable amount? In other words, is it necessary to account for the loss that

the injured party failed to prevent or reduce reasonably? If the abstract method is used, the mitigation rule is disregarded because, under this method, the aggrieved party had no obligation to take measures to mitigate the damage or loss. Several cases decided under the CISG illustrate this difficulty by demonstrating that when the requirements of Article 75 are not met, judges and arbitrators frequently resort to Article 76 with little or no regard for the mitigation rule (Chengwei, 2003). In one instance, the recipient did not open the L/C. As the seller only resold a portion of the goods to a third party, they failed to satisfy their obligation to mitigate monetary losses. According to Article 76 of the CISG, the seller is entitled to the difference between the contract price and the market price as monetary damages.¹ The instruments are ambiguous as to whether the abstract method should be applied regardless of the mitigation rule or whether the amount of avoidable loss should be deducted from the amount payable. On the one hand, the instruments appear to permit the use of the “abstract” method when the replacement transaction has not been completed or has not been completed reasonably. In contrast, the obligation to mitigate monetary damages has been expressly indicated in the instruments. However, ignoring avoidable losses contradicts this obligation. With this premise in mind, it can be concluded that if the injured party refuses to reduce the loss, there is no other option but to use the abstract method, even though the quantity of avoidable loss must be considered. The presence of an express provision on mitigation cannot be disregarded because it may permit the aggrieved party to speculate and receive excessive compensation (Yovel, 2005).

The principles of full compensation and protection of the party’s performance interest should tip the balance in favor of the mitigation rule to prevent excessive compensation. In other words, if the application of the abstract method results in an unexpected windfall, the mitigation rule should serve as a recovery cap. However, arbitration practice is not entirely consistent with this view. Some cases reveal that arbitrators have not accorded mitigation rules a great deal of weight and have instead resorted to abstract methods to calculate monetary damages.² This attitude may derive from the fact that it is relatively easy and convenient to apply the “abstract” formula in practice, or, in part, from a desire not to place too much emphasis on the duty of mitigation.

¹. CIETAC Arbitration dated 29 September 1999.
<http://cisgw3.law.pace.edu/cases/970929c1.html>. See also arbitral award dated 1st March 1999.

². For example, see CIETAC Arbitration, award dated 29 September 1997.
<http://cisgw3.law.pace.edu/cases/970929c1.html>

8. Solution

As described previously, there is no consistent application of these methods; they have been employed indiscriminately. In other words, arbitrators for the appraisal of monetary damages do not care which of the aforementioned methods should be prioritized or what the requirements are for each. As the mitigation rule is well-established in domestic legal systems and articulated in international instruments, it can be argued that referring to the abstract method in the first instance implies ignoring the mitigation rule. The concrete method of calculation has precedence over the abstract method, and it is fully compliant with the international instruments discussed in this article. Therefore, if the aggrieved party fails to take any measures to mitigate the loss, the concrete method cannot be applied; however, the quantity of avoidable loss must be accounted for when calculating monetary damages. However, since the burden of invoking and proving the mitigation rule (replacement transaction) rests with the defendant, if they fail to invoke mitigation or are unable to prove that the claimant took no steps to avoid or reduce the monetary damage or that the claimant's actions were unreasonable, then the tribunal should employ the abstract method. When making a replacement transaction is not possible -for example, when monetary resources are unavailable or when making a replacement transaction would be pointless- the tribunal should rely on the abstract method of calculation.

Regarding this, it is necessary to examine the position of the Iranian legal system. According to this approach, as previously explained, the difference between the contract price and the current price is regarded as monetary damages. In order to protect the aggrieved party in the event of a breach of contract, it is necessary in the first stage to propose a solution to this question. Simply stated, is the aggrieved party entitled to the profits they would have anticipated had the contract been performed, or should they be returned to the position they held before the conclusion of the contract? Due to the vast gap in Iranian law in this field, it is impossible to provide a definitive response to this question. For this reason, we must provide a response based on legal principles.

"Certainty" is one of the requirements officially recognized by Iranian law for monetary damages. Article 520 of the Civil Procedure Act stipulates in this regard that "the claimant shall prove the loss sustained was directly caused by non-performance or delay in performance... ." This principle conveys the notion of "certainty" of loss based on its adoption of limited interpretations. According to these interpretations, the promise's anticipated profits from the performance of the contract are not deemed to be certain. It means that it is sufficient compensation to

restore the innocent party to the position they held before the contract's execution and to cover the costs that have been incurred for this purpose. In a decision issued by the Iran Chamber of Commerce's Arbitration Center, a similar position was adopted.¹ In such a scenario, the seller failed to deliver the products, and the buyer filed a claim for performance interest, which is the difference between the contract price and the market price. According to Article 522 (Note 2) of the Civil Procedure Act, lost profits are inadmissible, so the arbitrator denied the claim.

However, the aforementioned arguments are not persuasive. Although the sanctions for contract breach may vary from country to country where a contract is signed, a new situation is created that is recognized and protected by the law. It can be argued that property rights are created by a contract. These property rights are part of the contracting party's possessions. A breach of contract is a negative action that impairs the legal situation. Therefore, to receive complete compensation, the aggrieved party must be placed in the position they would have occupied if the contract had been performed and its rights realized (Katouziyan, 2008). In a case heard by the Iran Chamber of Commerce's Arbitration Center, the tribunal reached this conclusion². Arbitrators reasoned that the aggrieved party must be placed in the position they would have occupied had the contract been honored.

In brief, the prevailing view is that lost profits that are reasonably certain and would have been earned had the contract been executed can be claimed as monetary damages. In contrast, likely profits will not be classified as losses and will bear no liability.

Thus, according to what was stated, the Iranian legal system permits only the abstract method for calculating monetary damages. To calculate damages, the question arises as to whether the current price at the time of breach or the price at the time of award or judgment must be used. Some law commentators have argued that determining the time for calculation as opposed to the case in civil liability is unimportant; it should be made clear, however, that contrary to the prevalent view that introduces the time of harm occurrence for calculation, the time of issuing the award or judgment must be relied upon for two reasons. 1) Before a judgment is rendered, the party in breach is liable for monetary damages. This legal obligation is materialized in the form of monetary damages by the judgment. Therefore, it is prudent to consider monetary damages when rendering a verdict. 2) Only in this

¹. Award No. 36/85/47/146

². Award No. 36/85/36/192; see also Award No. 36/82/5/171.

case is the loss resulting from non-performance entirely compensated, and the aggrieved party placed in the position they would have occupied if the contract had been performed (Katouziyan, 2008). It is important to note, however, that the assessment of monetary damages at the time of judgment may in some instances best compensate the injured party, whereas in other cases the opposite is true. Take the price of luxury goods, for example which will fall as the supply of newer products increases. Using the price at the time of judgment would not serve the interests of the injured party in this situation. Nevertheless, in accordance with the general principles of the Iranian legal system, the more favorable view is the price at the time of performance, as it is presumed that if the promisor had performed the contract, the promise would have realized the profits they had anticipated under the contract. Though this viewpoint may serve the interests of the aggrieved party in some instances, as devaluation is not recognized and protected under Iranian law, the aggrieved party will likely remain uncompensated for a portion of the loss they have suffered in the majority of cases. Nonetheless, this lacuna in the Iranian legal system appears advantageous, as the adjudicator has greater latitude to adopt a position regarding the particulars of each case that best compensates the aggrieved party. Consequently, this strategy appears to be more consistent with the essence of justice and more acceptable to common sense.

9. Conclusion

If the party in breach is held liable for non-performance, the tribunal must determine the amount of loss. Nonetheless, the method of calculation may have a substantial effect on the amount of monetary damages. Not all legal systems employ a singular strategy for this purpose. Under the CISG, UPICC, and PECL, both “concrete” and “abstract” methods are defined. Article 75 of the CISG defines the concrete method as the difference between the price of the contract and the price of the replacement transaction. Monetary damages can be claimed only if the price of the replacement contract was higher.

The alternative technique of calculation is the so-called abstract method outlined in Article 76 of the CISG. According to this method, if no replacement transaction has been executed, the amount of monetary damages equals the difference between the contract price and the price at the time of the transgression. Numerous discrepancies have surfaced as a result of the convention’s adoption of these two methods without elucidation of their respective application requirements.

When calculating monetary damages, the arbitrator considers whether a replacement transaction has been executed. If so, the concrete method (Article 75) is utilized; otherwise, the abstract method (Article 76) is utilized. Nonetheless, this comprehension is a superficial and incorrect interpretation of these Articles, which can even be found in case law, as it disregards the obligation to mitigate monetary damages that has been expressly stipulated by the convention. The CISG requires the aggrieved party to engage in a replacement transaction for the purpose of avoiding or minimizing the loss; otherwise, their inaction will be to their detriment, as they cannot claim avoidable losses.

In the absence of an alternative transaction, a direct reference to the abstract method is equivalent to disregarding the mitigation obligation. This is why, at first glimpse, the language of the CISG appears contradictory, since on the one hand it requires the injured party to mitigate monetary damages or else bear the consequences (Article 77). Alternatively, if a replacement transaction has not been executed, Article 76 states that the difference between the contract price and the current price will be the amount of monetary damages; an approach that disregards the sanction of mitigation duty. To resolve this conflict, it is possible to argue that if reasonable measures have not been taken to reduce the loss, the judge or arbitrator will rely on the abstract method, but the quantity of avoidable loss must be considered.

As the focus of this article, even though the CISG, UPICC, and PECL make no explicit reference in this regard, it can be inferred that the concrete method of calculation has precedence over the abstract method because it is in line with and in harmony with the mitigation duty expressly provided for under the instruments. In situations where a replacement transaction is not possible, the defendant does not invoke it, or cannot demonstrate that the measures taken were not reasonable, the tribunal should rely on the abstract method directly.

Methods of calculating monetary damages have not been spelled out in Iranian statutes; consequently, there is a lacuna in this area. Nonetheless, a solution can be proposed by utilizing legal principles and logic. It must be acknowledged that recourse to the concrete method is not permitted, as a replacement transaction is required for its application, whereas this concept is rooted in common law and has no position in the Iranian legal system. In contrast, a replacement transaction conflicts with specific performance as the primary remedy for breach of contract. Therefore, the only method that can be applied is the abstract method because the price to be relied on (price at the time of breach or price at the time of judgment) is questionable. Some commentators have argued that the price at the time of

judgment must be considered because it best compensates the aggrieved party. However, one should not be oblivious to the fact that reliance on the price at the time of breach does not always fulfill the purpose of contractual liability. Therefore, it is the responsibility of the judge or arbitrator in each instance to consider the specifics of the dispute and to award the party who has been wronged the amount that is most equitable and adequate compensation.

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The Impact of Economic Growth on Financial Performance in GCC Countries

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Abstract

This study presents empirical findings on the relationship between financial performance and economic growth for Gulf Cooperation countries panel generalized method of moments (GMM) between 2000 and 2019. The results show that banking performance, human capital, investment, trade openness, and inflation have significant positive impacts on economic growth. Robustness tests support the main findings. The relationship between banking performance and trade openness also contributes to economic growth. The study emphasizes the importance of effective banking performance, human capital, investment, and trade openness for long-term economic growth. The findings are relevant for policymakers and practitioners in the Gulf Cooperation Council countries.

Keywords: Banking Performance, Economic Growth, Financial Development.

JEL Classification: F43, F63, P47.

1. Introduction

The correlation between economic growth and financial development has been a well-established topic in the literature. According to Schumpeter (1911), financial resources are essential for entrepreneurs to fund both new and existing ventures, and finance has played a vital role in establishing and maintaining global businesses. A proficient financial system is expected to direct financial resources towards the most viable and productive business proposals. Robinson (1952), however, challenged the demand-following hypothesis by suggesting that financial development does not stimulate economic growth, but rather responds to the need for additional financial services due to significant economic progress. Conversely, the supply-leading hypothesis highlights the importance of developing more financial institutions, products, and services, which could ultimately enhance the overall financial system. Banks are viewed as the primary catalysts for financial

intermediation between economic sectors with inadequate funds and those with surpluses, a process that fosters economic development.

The backbone of financial sector development across the globe is a stable and efficient banking system. Numerous studies have explored the link between financial development and economic growth, including works by Beck et al. (2006), Cojocaru et al. (2016), Ehigiamusoe and Lean (2018), Jiang et al. (2013), Kamau (2011), Park and Shin (2017), Shen et al. (2018), and Soedarmono et al. (2011). These studies suggest that a well-established financial market is conducive to growth. For example, Bencivenga and Smith (1991) developed an endogenous growth model that incorporates financial intermediation to study its impact on growth. Their findings indicate that financial intermediation leads to capital accumulation, making it growth-driven. Furthermore, financial intermediaries prevent unnecessary capital liquidation, which results in further growth. Demirgüç-Kunt et al. (2011) assessed the significance of banks and securities markets in economic development, concluding that economic growth leads to more demand for financial securities than what banks can provide, gradually making securities markets more important for future economic growth. Beck and Levine (2004) analyzed the effect of stock markets and banks on long-run economic growth based on panel data and found that they contribute to economic growth. In recent years, the focus of the literature has shifted from examining the link between financial systems and economic growth to scrutinizing the determinants of the banking system. However, the global financial crisis and recession of 2007-2008 prompted a re-examination of prior research and conclusions by scholars and policymakers. The crisis demonstrated that a failure of the financial system can have a direct and indirect impact on resource scarcity, loss of confidence in savings, increased speculation, reduced investment, and misallocation of resources, leading to stagnation, unemployment, and poverty. The banking system's inability or failure to lend to the real economy due to financial instability was a major factor in the drastic decline in the real sector during the crisis. This has prompted economists and policymakers to question the optimal size of the financial system for stable economic growth. While banking performance plays a crucial role in promoting growth, does an excessively large banking system become a drag on the rest of the economy? Some researchers suggest that the relationship between financial development and economic growth is nonlinear for developed countries but linear for emerging economies. In this paper, we investigate the linear relationship between banking performance and economic growth in emerging economies.

The banking sector and stock market are crucial components of a well-functioning financial system that contribute to economic growth, according to several studies (Mustafa, 2023; Seelanatha, 2010; Danish, 2023). In particular, stability in the banking sector is important for firms to secure the necessary funding for existing and new investments. This study aims to investigate the dynamic relationship between banking performance and economic growth in GCC countries. The analysis considers several factors that moderate this relationship, including human capital, institutional quality, trade openness, investment, and government expenditure. While many previous studies have examined the impact of financial development on economic growth, few have adequately estimated the impact of banking performance on economic growth in this region. The study uses the generalized method of moments (GMM), a panel data technique that accounts for endogeneity issues, time-invariant effects, and lagged dependent variables. By investigating the impact of banking sector performance on economic growth in GCC countries, this study addresses an important gap in the literature.

The study reveals several significant relationships that contribute to the understanding of economic growth in Gulf Cooperation countries. Firstly, the study highlights the positive and significant impact of banking performance, measured by return on equity (ROE), on economic growth. This finding emphasizes the crucial role of an effective banking sector in driving economic growth in these countries. Secondly, the study identifies the importance of human capital, investment, trade openness, and inflation in fostering economic growth. These variables exhibit significant positive relationships with economic growth, providing valuable insights into the drivers of economic expansion in the Gulf Cooperation countries. Additionally, the study acknowledges the negative impact of the global financial crisis in 2007-2008 on economic growth across the sample countries. This recognition underscores the relevance of external shocks and their influence on economic performance. Furthermore, the robustness tests conducted in the study strengthen the reliability and validity of the findings. By utilizing different measures of banking performance and excluding advanced economies from the sample, the study verifies the consistency and resilience of the main results.

The paper is organized as follows: In section 2, a literature review is provided, first in general and then specifically focusing on the countries that are being studied. Section 3 describes the econometric methodology used, including the approach, model, and variable specification. In section 4, the data used in the

study are discussed, including their sources and limitations. Section 5 presents the empirical findings. Finally, the last section concludes the paper.

2. Literature Review

The banking system is an essential component of the economy, and its performance can impact other sectors by creating structural distortions in the economic system. Various studies have examined the relationship between banking performance and economic growth across different countries, regions, and economic unions. However, due to variations in the geographic scope, econometric methods employed, and data sources utilized, the findings of these studies differ, especially after the global financial crisis in 2007-2008.

Law and Singh (2014) used a dynamic panel threshold approach to study the relationship between finance and economic growth in 87 advanced and less developed countries, and found that the finance-growth nexus is conditional, where the level of financial development contributes positively to economic growth only up to a certain point. Further development of finance beyond this level tends to have a negative effect on economic growth. Beck et al. (2014) investigated the relationship between financial system size, financial intermediation, GDP per-capita growth, and volatility growth in 77 sample countries between 1980 and 2007. Their findings suggest that financial intermediation enhances growth and reduces volatility in the long-run. However, in the short-run, a large financial sector encourages growth despite the higher volatility cost in high-income countries. Samargandi et al. (2014) used pooled mean group estimation to examine the dynamic impact of financial development on economic growth across 52 middle-income countries from 1980 to 2008, and found an inverted U-shaped relationship between finance and growth in the long-run. They also found that the relationship between finance and growth was insignificant in the short-run, suggesting that too much finance can have a negative effect on growth in the countries studied.

Rasoulinezhad and Mostaghimi Ghomi (2022) examine the relationship between financial development and sustainable economic development in selected Asian countries from 1993 to 2018. Using advanced estimation methods, they find a positive and significant long-term association between financial depth, financial inclusion, economic growth, urban growth, energy intensity, and sustainable development. However, they observe an inverse relationship between money supply and sustainable development. The study suggests policy measures such as improving financial market efficiency, strengthening the role of the financial sector

in national production, and regulating the finance-industry relationship to promote sustainable economic development in the analyzed Asian countries.

The relationship between financial development and economic growth has been explored in relation to the regulatory framework and institutional quality by some scholars. Beck et al. (2006) studied the impact of banking regulations, bank concentration, and domestic institutions on the probability of a country experiencing systemic banking crises, using data from 69 countries from 1980 to 1997. The study found that focused banking systems were less vulnerable to banking crises, despite controlling for variations in regulatory policies, domestic institutions affecting competition, macroeconomic situations, and economic shocks. Additionally, domestic institutions and regulatory policies that impeded competition were linked to higher banking system instability.

In a study by Law and Azman-Saini (2012), a dynamic model of Generalized Method of Moments (GMM) was used to investigate the effect of institutional quality on stock market and banking indicators in developed and developing countries between 1996 and 2004. Institutional quality was found to be a significant determinant of financial development in the sample countries when the banking sector indicator was used to represent financial development.

Muhammad et al. (2022) developed a model to analyze the relationship between financial development and economic growth in the top 10 financially developed countries. They found threshold effects, where financial development had positive or negative impacts on economic growth depending on the country and regime. Trade openness positively influenced economic growth in multiple countries, while capital formation and labor also played roles in sustaining economic growth in specific countries. The study's dynamic multipliers highlighted the varied responses of economic growth to financial development shocks in different regimes. Laeven and Levine (2009) have researched the relationship between risk-taking behavior in the banking sector and the power of shareholders within the corporate governance structure of banks. The study found that the level of risk-taking in banks was positively correlated with the relative power of shareholders. Additionally, the study showed that the impact of capital regulations, deposit insurance policies, and restrictions on bank activities were dependent on the ownership structure of each bank, meaning that the effects of these policies on risk-taking behavior varied depending on the bank's corporate governance structure. The study concluded that a one-size-fits-all regulatory approach is not suitable for the diverse range of banks in terms of their corporate governance structures. Baltagi, Demetriades, and Law (2009) used the GMM panel

data technique to examine the relationship between financial openness and the development of the financial sector in both developing and industrialized countries. The study found that the marginal effects of trade and financial openness were inversely related to the degree of financial and trade openness. Closed economies tended to utilize trade and financial sector openness more than open economies. Thus, more closed economies could benefit from opening their trade and capital accounts, which could also lead to gains in the development of their banking sector.

In their study, Rousseau and Wachtel (2009) investigate whether a high level of financial development can hinder economic growth. They observe that financial crises tend to occur when there is a decreasing reliance on financial development to drive growth. They also find that excessive reliance on credit and financial intermediation can lead to inflation, which weakens banking systems and ultimately leads to growth-inhibiting financial crises. In addition, they argue that excessive dependence on the financial sector could have contributed to the prevalence of financial liberalization in economies with weak legal and regulatory infrastructures in the late 1980s and early 1990s. In contrast to the findings of Baltagi et al. (2009), Rousseau and Wachtel find that financial liberalization has a negative impact on financial development.

The relationship between finance and economic growth operates through various channels, including the conversion of savings into investment projects, which promote productivity and investment growth (Greenwood & Jovanovic, 1990). However, the impact of financial development on productivity growth varies depending on the level of development of the country. For example, Cecchetti and Kharroubi (2012) reveal that financial development enhances productivity growth up to a certain level, and this effect is more significant in developed countries than in developing ones. In contrast, too much finance can have an adverse effect on productivity growth, as argued by Cecchetti and Kharroubi (2015). They suggest that an excessive growth rate in the financial sector could result in financing being directed towards low-productivity projects with high collateral requirements, leading to a decline in overall factor productivity. Pagano (2012) also warns that excessive finance can endanger the solvency of banks and systemic stability, which could negatively impact economic growth.

The study conducted by Nguyen et al. (2022) utilizes advanced statistical techniques to analyze the relationship between financial development and economic growth in 22 emerging markets from 1980 to 2020. Unlike previous

studies using static panel data models, their findings support a positive and linear relationship between financial development and economic growth. They also find bidirectional causality between financial development and economic growth across different measures of financial development. These results provide robust evidence of the significant impact and interplay between financial development and economic growth in the examined emerging markets. Arcand, Berkes, and Panizza (2015) investigate whether there is a point at which additional financing no longer has a significant impact on the overall productivity of an economy. Their findings suggest that the level of financial depth becomes negative when the private sector reaches its peak, i.e., 100% of GDP. This indicates that when private sector credit reaches 100%, its effect on overall growth becomes negative and does not contribute to GDP growth. Ro, Kim, and Kim (2017) argue that financial development reduces firms' financial restrictions, allowing them to access additional external financing, which promotes investment and, in turn, economic growth. However, the effects of financial development on reducing a firm's financial restrictions depend on the industry sector and the size of the firm.

Recent studies have provided mixed findings regarding the relationship between banking sector development and economic growth. While earlier studies have confirmed the positive impact of the banking sector on overall economic growth, more recent studies have produced varied results. For example, Tongurai and Vithessonthi (2018) found a negative impact of banking sector development on agricultural sector development, especially in countries with high degrees of banking sector development, but no effect on industrial sector development. Jayakumar et al. (2018) studied 32 European countries over 1996-2014 and found that banking competition and stability are significant long-term drivers of economic growth. Caporale et al. (2017) found that during the crisis, domestic and foreign banks in the Middle East and North Africa region had different levels of profitability. Inekwe et al. (2018) used firm-level data from 45 countries to find that ex-ante financial distress negatively affects real GDP in the long run. Neanidis (2019) found that banking supervision promotes economic growth and is one of the key aspects of economic growth in relation to banking performance.

The relationship between financial development and economic growth has been investigated by various studies. Cojocaru et al. (2016) focused on the former Communist countries of Central and Eastern Europe and the Commonwealth of Independent States and found that financial market efficiency and competitiveness have a greater impact on economic growth than the size of the market. On the other hand, Ehigiamusoe and Lean (2018) analyzed West Africa and found a positive

impact of financial development on economic growth, although this did not hold for every country in the region when taking a disaggregated approach. Shen et al. (2018) examined the impact of outliers on the causal relationship between financial development and economic growth in 48 countries and found that while estimations without accounting for outliers showed a negative effect of banking sector development on economic growth, once outliers were accounted for, a positive effect was observed.

The impact of financial performance on economic growth in post-communist countries, which were relevant to eleven out of thirteen countries in the current study (excluding only Greece and Turkey), has varied as a result of the global financial crisis, both as a block and for individual countries. While the methods used to examine the relationship between banking performance and economic growth differ from those used in this study, it is worthwhile to explore some related findings and to what extent they match those presented in this study. Efthyvoulou and Yildirim's (2014) study on the scope and impact of the financial crisis in Central and Eastern Europe (CEE) found three main findings related to banking markets, including convergence across countries coming to a halt on the eve of the global financial crisis, a variation in bank-level ownership characteristics, and different margins in asset quality and capitalization before and after the crisis. Temesvary and Banai (2017) analyzed the role of Western European banks' subsidiaries or foreign banks in CEE from 2002 to 2013 and found that, during and after the crisis, subsidiaries lowered lending in the CEE countries. This lowering of lending was caused by the better cost efficiency of the parent banks in the EU than their subsidiaries and the financial system in general of the CEE countries, as Nurboja and Kořak (2017) demonstrated. Bhaumik, Owolabi, and Pal (2018) argue that multinational banks can overcome informational disadvantage in host countries such as the CEE through cross-border acquisitions in financial intermediation, but the cost of verification makes this unattractive. These and many other studies dealing with the segments of banking performance and financial intermediation contribute to the overall picture of how the banking sector can affect economic growth, which is the main focus of this study.

In addition to banking, there are other channels through which finance can directly and indirectly affect economic growth, such as the availability of pension funds (Alda, 2017; Kaushal, 2014) and capital market capitalization (Converse, 2018), trade and openness (Hagemejer, 2018), and social trust (Cui, 2017).

3. Empirical Model and Methodology

The study uses the Arellano and Bond (1991) difference-GMM and the Arellano and Bover (1995) system-GMM methods for dynamic panel GMM estimation techniques. These methods control for endogeneity among the series by taking the first difference and maintaining the same slope for all variables, which directly addresses endogeneity issues and time-invariant effects. Lagged dependent variables are also included in the GMM estimator. The Arellano and Bond (1991) method is a two-step procedure that calculates the first difference from the dynamic panel data model, with the lags of the right-hand side variables serving as instruments. If predetermined endogenous variables are present, their lagged levels are also used as instruments. However, if the dependent variable is persistent, the difference-GMM estimator may not be efficient. To overcome this issue, the Blundell and Bond (1998) method extends the difference-GMM estimator by incorporating a system with variables in both levels and first differences. The difference-GMM and system-GMM models are considered robust only if the restrictions create a system in which the results of both models are valid and there is no second-order serial correlation.

To ensure partial adjustment, the empirical model consists of both time series and cross-country dimensions in the annual dataset. The specification is made for a dynamic log-linear equation for economic growth, which includes a lagged dependent variable as an explanatory variable. Therefore, the equation for economic growth is represented as a dynamic log-linear equation:

$$Y_{it} = \beta_0 + \beta_1 Y_{it-1} + \beta_2 BP_{it} + \beta_3 HC_{it} + \beta_4 X_{it} + \varepsilon_{it} \quad (1)$$

where Y_{it} is economic growth, Y_{it-1} is the lagged dependent variable of economic growth, BP_{it} is banking performance, HC_{it} is the logarithm of human capital, and X_{it} is a vector that contains other control variables.

When the variables are transformed into natural logarithms, the model is then specified as follows:

$$\ln Y_{it} = \beta_0 + \beta_1 \ln Y_{it-1} + \beta_2 \ln BP_{it} + \beta_3 \ln HC_{it} + \beta_4 \ln X_{it} + \varepsilon_{it} \quad (2)$$

where variables in Equation (2) that are preceded by $\ln$ are the logarithms of their counterparts defined in Equation (1). Moreover, some variables have interactions with each other, this is shown in Model 3:

$$\begin{aligned} \ln Y_{it} = & \beta_0 + \beta_1 \ln Y_{it-1} + \beta_2 \ln BP_{it} + \beta_3 \ln HC_{it} + \beta_4 \ln TO_{it} \\ & + \beta_4 \ln INQ_{it} + \beta_4 \ln INF_{it} + \beta_4 \ln GEX_{it} + \beta_4 \ln INV_{it} + \varepsilon_{it} \end{aligned} \quad (3)$$

where $\ln TO_{it}$ is the log of trade openness, $\ln INQ_{it}$ is the log of institutional quality, which is measured by government effectiveness; $\ln INF_{it}$ is the rate of

inflation without log because it is in the form of a rate, $LnGEX_{it}$ is the log of government expenditures, $LnINV_{it}$ is the log of gross fixed capital investment.

4. Data

Data from various sources were used to gather information on six Gulf Cooperation countries between 2000 and 2019. The research did not use data from before 2000 due to political and economic turbulence in some of the countries. An unbalanced panel data type was utilized due to some missing data for certain countries. The data for banking performance, including return on assets (ROA) and return on equity (ROE), was obtained from the Financial Development and Structure Dataset (updated in September 2015), while financial development and structure data came from the World Bank. Economic growth was measured using the changes in real gross domestic product (GDP) per capita, and human capital was represented by secondary school enrollment as a share of total enrollment of students. The sum of exports and imports as a percentage of GDP was used as a proxy for trade openness, gross capital formation for investment, growth rate of the consumer price index for inflation, and final government consumption expenditure for government expenditure. The data for these variables were obtained from the World Development Indicators (WDI) of the World Bank database. Finally, government effectiveness was used to measure institutional quality, and the data were obtained from the World Governance Indicators.

5. Empirical Finding

In this section, statistical information about the variables is presented in Table 1. The table lists the number of observations, mean, standard deviation, minimum, and maximum values for each variable, along with the unit of measurement.

The coefficient of variance is used to assess the variability of each variable. Bank performance exhibits the highest coefficient of variance, indicating that it is the most volatile variable, followed by inflation and institutional quality. On the other hand, human capital has the lowest coefficient of variance.

Table 2 presents the correlation matrix of the variables, displaying the relationships between them. We observe a significant negative correlation between banking performance, human capital, institutional quality, and trade openness. Economic growth, however, shows a positive correlation only with institutional quality.

Furthermore, a strong positive correlation is found between human capital and institutional quality, as well as between human capital and government

expenditures. It is important to note that correlation does not imply causality, necessitating alternative methods to estimate the impact of these variables on economic growth.

To assess multicollinearity, a preliminary analysis using the correlation matrix coefficient was conducted. According to Gujarati & Porter (2010), multicollinearity is indicated if the partial correlation value between independent variables exceeds 0.8. However, in our case, Table 2 demonstrates that all values are below this threshold, suggesting that the model does not suffer from multicollinearity issues.

Table 1. Descriptive Statistics of the Variables

Variable	Obs	Mean	Std. Dev.	Min	Max	Measure
Y	2.259	5.0424	3.9544	-7.0758	26.1702	Real per-capita GDP
BP	1.008	22.6171	18.8931	-10	223.12	Return on equity/assets
HC	1.678	47.6728	25.8063	0.064	99.506	Ratio of secondary school enrollment
INQ	1.644	14.3062	57.9658	-100	922.22	Government effectiveness
INV	2.254	5.3359	3.36492	0.5	17.6	Gross capital formation
TO	1.174	26.6611	20.5717	-13.1	223.12	Sum of exports/imports as a percentage of GDP
INF	2.254	4.5549	5.3061	0.2	19.5	Consumer Price Index
GEX	1.834	32.2541	26.0046	-51.55	99.819	Government final consumption expenditure

Source: Research finding.

The correlation matrix in Table 2 reveals that only human capital (HC) and institutional quality (INQ) exhibit a significant correlation (0.086), while the correlation between the other variables is weak. Interestingly, the relationship between bank performance (BP), measured by return on equity (ROE), differs from that of BP measured by return on assets (ROA).

To ensure the model is free of heteroskedasticity, we conducted both the Bruesch-Pagan Lagrange Multiplier (BP-LM) test and the Green Likelihood Ratio (LR) test. Table 3 displays the results, indicating that the p-values for both tests are less than 0.05, suggesting that the panel data suffers from heteroskedasticity.

Additionally, an autocorrelation test based on the Wooldridge test was performed and reported in Table 4. The p-values are less than 0.05, indicating the presence of first-order autocorrelation in the model. Considering the evidence of heteroskedasticity and autocorrelation, we opted to use the system-GMM and difference-GMM models with robust standard errors for estimation.

Table 2. Correlation Matrix between the Variables

	Y	BP	HC	INQ	INV	TO	INF	GEX
Y	1.0000							
BP	-0.0902	1.0000						
HC	0.0171	-0.1830	1.0000					
INQ	0.0593	-0.0303	0.0866	1.0000				
INV	0.1915	-0.0916	0.0639	0.0723	1.0000			
TO	-0.0878	0.9811	-0.1347	-0.0314	-0.0866	1.0000		
INF	-0.1371	-0.1425	0.4444	-0.0118	-0.0518	-0.0065	1.0000	
GEX	-0.0500	0.8228	-0.3806	-0.1014	-0.0804	0.8201	-0.0986	1.0000

Source: Research finding.

Table 3. Heteroskedasticity Test

Breusch-Pagan Lagrange Multiplier Panel Heteroskedasticity Test
H0: Panel Homoskedasticity – Ha: Panel Heteroskedasticity
chi2(1) = 487.31
Prob > chi2 = 0.0000

Source: Research finding.

Table 4. Autocorrelation Test

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
F (1, 67) = 7.572
Prob > F = 0.0076

Source: Research finding.

The results obtained using the system GMM method indicate that banking performance has a significant and positive impact on economic growth in the sample countries, although not in all models. In other words, a 1 percent increase in banking performance leads to a 0.635 percent increase in economic growth. This key finding highlights the importance of banking performance in the overall economic growth of the Gulf Cooperation countries.

Furthermore, the results show that investment, trade openness, and inflation also have a significant and positive impact on economic growth. Specifically, a 1 percent increase in human capital, investment, trade openness, and inflation leads to an increase in economic growth by 0.094 percent, 0.090 percent, 0.075 percent, and 0.098 percent, respectively. These findings suggest that human capital is slightly more important for economic growth compared to the other variables.

The analysis after the initial estimation aligns with the theoretical requirements, which means that the null hypothesis (based on the p-values) of the Hansen and Sargan tests cannot be rejected. This indicates that the instruments used in the difference and system-GMM methods are appropriate, and the issue of over-identification restrictions in the model has been resolved. Additionally, the problem of serial autocorrelation in the models has also been addressed, as AR(2) is applied to check AR(1), and the p-values of AR(2) meet the theoretical requirements.

Table 5. The Impact of Banking Sector Performance on Economic Growth: Dynamic Panel GMM Model Robustness Checks

	(1)	(2)
	Two-step Sys. GMM	One-step Sys. GMM
L.Y	0.246***	0.247***
	(93.55)	(8.39)
BP	0.224***	0.221**
	(-22.92)	(-2.36)
HC	0.0776***	0.0766***
	(19.14)	(3.18)
INQ	0.000714	0.000592
	(0.94)	(0.16)
INV	0.214***	0.218***
	(25.91)	(4.78)
TO	0.181***	0.177**
	(16.90)	(2.12)
INF	-0.301***	-0.312***
	(-33.53)	(-4.30)
GEX	0.0486***	0.0429
	(5.02)	(0.89)
Sargan test	1.0000	0.0000
AR(2)	0.3090	0.3090
_cons	-0.506	-0.276
	(-1.48)	(-0.17)
N	901	901

Source: Research finding.

To confirm the primary discovery of the study and assess its resilience, a different measure of banking performance (ROA) is utilized. The outcomes in Table 5 support the primary finding that banking performance has a favorable and significant effect on economic growth in the Gulf Cooperation nations.

Specifically, a 1 percent increase in banking performance leads to a 0.012 percent rise in economic growth.

However, the economic importance of the estimated coefficients for the banking sector decreases significantly when robustness tests are conducted. For example, the results in Table 5 demonstrate that a 1 percent increase in banking performance positively impacts economic growth by 0.012 percent, which is a significant drop from the previously reported 0.635 percent. These outcomes indicate that the economic importance of banking sector performance on economic growth is dependent on the alternative indicators of banking performance used.

According to the results, human capital, investment, and trade openness have a more favorable and significant impact on economic growth. Specifically, a 1 percent increase in human capital, investment, and trade openness leads to a positive influence on economic growth by 0.309 percent, 0.097 percent, and 0.819 percent, respectively. The robustness tests support the notion that trade openness and human capital are comparatively more important for economic growth in these nations.

Additionally, the post-estimation analysis of the model meets the theoretical requirements, as evidenced by the fact that the null hypothesis of both the Sargan and Hansen tests cannot be rejected. This implies that the instruments used in the model are valid, and the issue of over-identification restrictions has been resolved. Furthermore, the problem of serial autocorrelation in the model has been addressed since AR(2) is employed to check AR(1), and the p-values of AR(2) satisfy the theoretical requirements. Thus, the model is free of autocorrelation problems.

To investigate the indirect effect of banking performance and trade openness on economic growth, the two variables were interacted with bank performance. The main finding in Table 5 indicates that banking performance has a positive and significant influence on economic growth, which is consistent with the findings of other models. Based on both the system and difference GMM approaches, the marginal effect of banking performance and trade openness on economic growth is positive and significant. A trade sector that is open promotes banking sector performance and has a favorable effect on long-term economic growth.

The marginal effect of banking performance and investment on economic growth is also positive and significant based on both system and difference GMM. This implies that effective banking performance encourages investment and positively impacts long-term economic growth.

6. Conclusion and Limitations of the Study

This research aimed to investigate the impact of banking performance on economic growth in six Gulf Cooperation countries between 2000 and 2019, while considering other relevant control variables. Dynamic panel GMM models were utilized for the analysis. The primary empirical result reveals a positive and statistically significant relationship between banking sector performance and economic growth in these countries. This finding emphasizes the significance of a sound and effective banking sector as a vital determinant of economic growth in the sample countries.

To support this main finding, an alternative indicator of banking efficiency (ROA) was used, demonstrating the robustness of the main results, even though the economic significance of banking performance decreased when the ROA was employed.

In addition to the positive and statistically significant relationship between banking performance and economic growth in Gulf Cooperation countries, the study also found that human capital, investment, and trade openness have a positive impact on economic growth in some, but not all, models. Based on these findings, the study suggests that policymakers in these countries should focus on maintaining or improving the efficiency of their banking systems and consider regional policy integration to measure and enhance banking efficiency through a proper legislative framework.

The study is limited by significant differences and inconsistencies within the contiguous geographical region, creating endogeneity problems. Despite having a similar geographical size and number of countries, the region is economically and financially heterogeneous. Only six countries are included in the study, while the remaining countries are successor states of former countries with a mixed economic system involving state plans and the market. These differences raise skepticism among scholars and researchers about conducting a joint study for all countries due to the endogeneity problem.

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The Effect of Consumer Perception toward Home Financing Moderated by Religious Belief

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Abstract

The effect of consumer perception toward home financing can be influenced by various factors, and one potential moderating factor is religious belief. Religious beliefs and values can significantly shape individuals' perceptions, attitudes, and behaviours, including their approach to financial matters such as home financing. This study objective to empirically test the role of religious believe for home financing selection. It also aims to investigate the effect of consumer perceptions (price, location, and service) toward home financing selection with sharia scheme moderated religious belief. The research method used is a questionnaire survey and structural equation modelling with moderation analysis by using software, namely SmartPLS03 in order to run the data about 325 respondents from consumer who buy house and used sharia scheme developer financing and Islamic banking. The result of the study reveals that price and location affect the home financing selection with sharia scheme, while service and religious belief are not significant or have no direct effect. Other finding also reveals that religious belief can strengthen the effect of price toward home financing selection with sharia scheme. It is also found that the key findings of religious belief has an effect toward the home financing selection with sharia scheme not direct effect but with indirect effect through strengthen price influenced, thus, a comprehensive view of the relationship between price, location, religious belief, and the home financing selection with sharia scheme is presented and become the baseline study for introducing essential factors of religious belief to ensure the growth of Islamic Banking financing.

Keywords: Consumer Perception, Home Financing, Location, Religious Belief, Sharia.

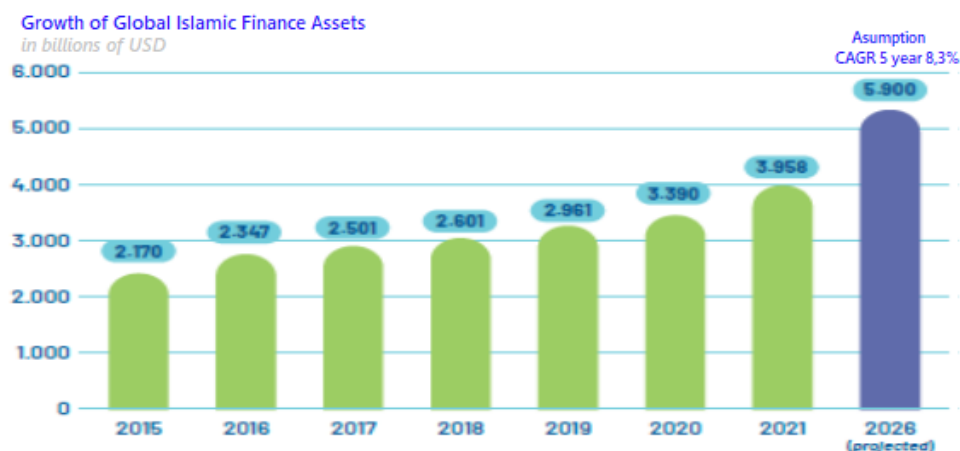
JEL Classification: C83, D01, D12, D45, G41.

1. Introduction

In Indonesia, owning a house is a top priority for most people, they are willing to pay and using debt to be able to buy a house. To achieve this goal, the community builds houses from scratch, buys existing houses, and even rents their houses first.

The trend of rising house prices has caused people to rarely be able to buy houses with cash. The solution is home buyers can buy a house through a financial institution. Indonesia offers two banking systems in home financing methods which are conventional home ownership loans and sharia home financing (Islamic mortgages) (Harefa, 2021; Sayuti and Amin, 2019; Syam et al., 2020). The concept of sharia mortgage financing is different from mortgage financing. Sharia mortgages are based on Islamic financing principles and prohibit the element of interest (Sayuti and Amin, 2022; Shaikh et al., 2022). Unlike conventional home financing, Islamic financing is based on a flat rate or profit rate (Razak and Tazwar, 2018; Wahyuni, 2018).

With the development of Islamic financial assets, which have an increasing trend with predictions of an increase reaching 8.3% (figure 1.), and the growth of Islamic banking financing that is above conventional banking, this indicates an ample opportunity in Islamic banking to increase market share to a greater extent than conventional banks. Meanwhile, one of the challenges in the development of Islamic economics is not external, it comes from internal Muslims. Ishak (2019) and Bukhari and Isa (2019) explain that religiosity plays a role in consumer decision making so that, based on the information received by consumers, this information is converted into religious belief to make a decision to use halal products. With the MUI (Indonesian Ulema Council) have issued a haram fatwa in 2000 for bank interest which includes usury, all financing carried out by Muslim consumers should after two decades of the fatwa come out to have switched to Sharia financing. In reality, the growth of sharia financing is growing, but it is still far below the market share of conventional banks (Hanif, 2019).



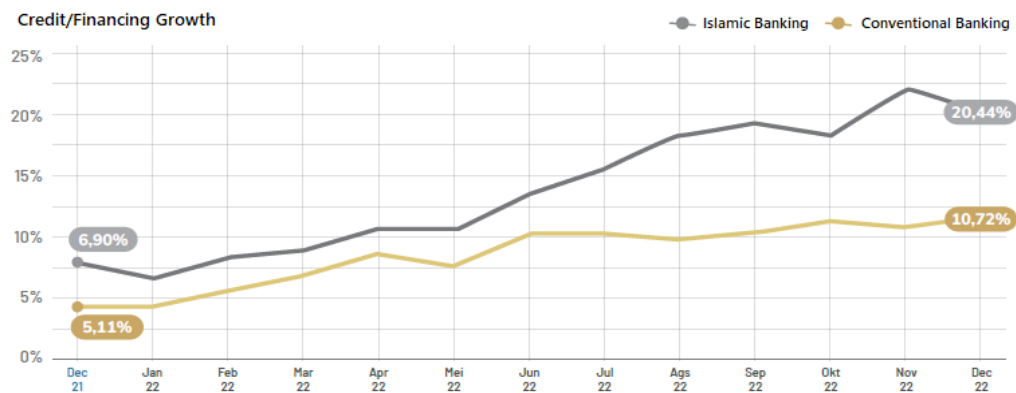


Figure 1. The Growth of Global Islamic Finance Assets and Islamic Banking Financing in Indonesia

Source: Research finding.

The development of Islamic banking financing is an exciting matter to study, with developments that are higher than conventional banks. There is a question mark, whether is it possible for the market to Islamic banking to be more than conventional banking? Hence, the outcome of this study is significant for the future growth of Islamic banking. Based on the results of the search and knowledge, the discussion of home financing with sharia schemes, in both banks and in particular non-banks, has not been studied as widely as home financing in general or conventional. The sharia scheme research that has ever been conducted by (Firmansyah and Gunardi, 2018; Wahyuni, 2018; Wulandari et al., 2016); in Malaysia by (Ismail et al., 2014; Razak and Tazwar, 2018); in Pakistan by (Ali et al., 2017; Chhapra et al., 2018; Raza, 2015); and research related to Islamic home financing and in Nigeria is conducted by (Ajetunmobi and Ibrahim, 2016; Hamza, 2016).

In an increasingly competitive environment, banks are forced to innovate to expand and ensure that home loan products are offered. Most Indonesian banks offer sharia financing products. Besides, bank-less sharia financing products make consumers have alternative financing choices between various types of financing or home loans. However, to our knowledge, there is still a lack of research on the determinants of the selection criteria for Islamic home financing in Indonesia, and this creates a gap in the development of sharia financing, hence, the purpose of this study is to fill this gap by analyzing the important factors that strengthen consumer perceptions in choosing home financing with sharia schemes and also how religious belief strengthens consumer perceptions to choose home financing with sharia schemes. According to a study on how religious beliefs affect consumer perceptions of home financing, it can be seen that religious belief is a crucial determinate in accelerating the growth of Islamic home financing users.

2. Literature Review

The research is applied based on the theory of planned behavior. One of the common theories that helps to understand consumer attitudes and purchasing intentions, is theory of planned behavior (TPB). This model was developed by Ajzen (1985). Bosnjak et al. (2020) define the theory of planned behavior as reflecting the relationship between attitudes, subjective norms and perceived behavior towards the intention to buy sustainable products. According to this concept, a person's behavior is dictated by their goals, which are consequently impacted by their perspective on their behavior, personal norms, and their perception of their level of behavioral control (Amin et al., 2014). Obviously, in consumer studies, perceived behavioral control has been shown to be a predictor in predicting a person's behavioral intention (Teo and Beng Lee, 2010). People often have some influence over making decisions or not making decisions, which emphasizes the need of respecting one's control in a decision-making process. Research conducted by Alam and Sayuti (2011), explores that the purchase of halal food has provided proof that the hypothesis of planned behavior (TPB) is accurate. Moreover, attitude refers to the individual's perception of a particular behavior while subjective norms lead to individual subjective judgments about the preferences of others and support (Kaakeh et al., 2019). Norms represent the decision-maker's perceptions of what important persons (such friends or relatives) expect of them while deciding whether to act out or not. Ajzen (2020) states that individuals' elaborative thinking about subjective norms is the perception of whether they are expected by friends, family, and society to perform the recommended behavior. Depending on the decision-maker's perception of the existence of behavior-limiting circumstances, the perceived ease or difficulty of carrying out a behavior is referred to as behavioral control (Balushi et al., 2018).

Further, every attempt to promote Islamic home finance options would be heavily reliant on the cooperation and attitude of bank clients. The perceptions of bank clients' attitudes of the value of Islamic home financing options, whether favorable or unfavorable, are influenced by such perceptions (Amin et al., 2014). In addition to mindset, personal norms might influence the intention to use. The significance of this concept in research has been proven by several investigations. Hansen et al. (2004) investigate the intention of purchasing goods online for groceries and discovers a strong correlation between the intention and the personal norm. Gopi and Ramayah (2007) reveal that identifying the aim of an online purchase requires the use of a personal norm. They also argued that a person's impression of the possibility that an anticipated comparable group or individual will accept or disapprove of participating in a certain behavior is referred to as a norm that is subjective. Overall, the theory of planned behavior (TPB) identifies

subjective norms and attitude as factors that directly influences the behavioral intention.

2.1 The Relationship between Consumer Perception and the Selection of Sharia Home Financing Schemes

Financing often entails the transfer of funds from wealth creators to entities that produce or consume deficits. Financing is encouraged among those who believe from an Islamic perspective to support the socioeconomic growth of the "community" (Amin et al., 2014). Islamic funding has two primary goals. Firstly, Islamic finance is created to direct funds from investors to entities that produce deficits or use large amounts of money. Secondly, the primary goal of Islamic finance is to fulfill people's desire to increase their wealth (Kahf and Khan, 1992). Hence, Islamic banks act as financial intermediary firms, taking deposits from consumers and using the accumulated funds for lending others. In our study, Islamic banks are predicted to provide a variety of financing options, and Islamic home financing can be considered as one of them. However, the provision of Islamic home finance options satisfies the demands of house purchasers who seek to adhere to Shariah guidelines in their financial assets. From the previous literature, Ali et al. (2017), Islam et al. (2022), and Nayeem et al. (2009) have found a positive association between consumer perception and the selection of sharia home financing schemes.

2.2 The Relationship between Consumer Perception, Religious Belief, and the Selection of Sharia Home Financing Schemes

In a religious perspective, the human conception of reality is based entirely on knowledge, but, it is also founded on the basis of belief originating from the transcendental authority of divinity (Junaidi et al., 2022; Salam et al., 2019). The form of this conception is certainly different from one religion to another. For example, in monotheistic religion that authority is God who is called Allah and everything that comes from Him. In contrast to primitive religion which understands authority is in the form of spirit and magic (Junaidi, 2021). These conceptions then determine the social structure, behavior, and even interactions expressed by religious adherents. In contrast to later with religion as a model of reality, it deals directly with the representation of the object. More concrete, and displayed in harmony with the object of dogma, and norms. Simply, religion as a model of reality is a belief that is expressed based on space, time, and culture where religion is accepted as a conception (Dawami, 2020; Wahyoedi et al., 2021). Religion in this model then underlies the strengthening of the criteria for choosing home financing with a sharia scheme.

There are five important factors that are usually considered by consumers in choosing Islamic home financing; these five things are sharia principles, fast

service and location, price, then the reputation of the bank that provides financing as well as the terms and flexibility of the product (Saptasari & Aji, 2020). Apart from these five factors, there are other factors that influence, however, it may not be important, such as trends, lifestyle, advertising and promotions, advice from banks, and advice from housing developers. These factors are usually used by consumers in choosing a home financing provider (Biancone et al., 2020; Hamid and Masood, 2011). In this study, the five factors are classified into three variables of price, location and service while still including other factors into the dimensions of the indicators of the three variables.

In a banking selection survey conducted in Jakarta and Peninsular Malaysia where the sample centers are in Kelentang, Penang, Johor and Kuala Lumpur, it is found that reputation is a key factor that influence bank consumers in choosing a bank (Biancone et al., 2020; Dusuki and Abdullah, 2007; Aldarabseh, 2019). In addition to reputation when viewed from the perception and knowledge of Islamic financial products, the religious factor is the most important factor considered by consumers, prices, bank reputation, and service quality become further considerations (Razak and Tazwar, 2018).

A study on the relationship between service quality and customer satisfaction among Islamic banks in Malaysia showed that most of the bank's consumers who transacted with Islamic banks were satisfied with the quality of services provided by these Islamic banks (Amin, 2008; Fauzi and Suryani, 2019; Hosen et al., 2021). In Greece, from 200 surveyed consumer banks stated that the influence of media advertising, flexibility, and low payment penalties are the main factors that become the criteria in making decisions (Mylonakis, 2007). Another opinion states that the use of media can influence adults more than adolescents in making decisions (Ismail et al., 2014).

Adu-Gyamfi (2020) homeownership enhances religious practices while rental status is seen to stifle the performance of certain religious practices. In that way, religious considerations are made in the pursuance of the transition from rental status to homeownership. One of the banking studies found that the influence of people, marketing promotions, and financial benefits are important factors of consumer choice criteria in choosing a bank (Hosen et al., 2021; Syed and Hanif, 2010). On the other hand, sharia bank does not have direct access to marketing and promotion, it is because the marketing unit of Islamic banks handles conventionally where promotions are carried out by bank branch offices by bank branch office managers (Fauzi and Suryani, 2019). There are several factors that influence consumer choice in determining the provider of Islamic housing finance in Sabah, Malaysia. Other, there are seven discovery factors such as service availability, is also related to the influence of others (Hosen et al., 2021), where for married consumers, the decisive factor in making decisions is their partner

(Ismail et al., 2014). Based on theory and the above explanations, including research development and empirical evidence, the study models are described in Figure 2 below.

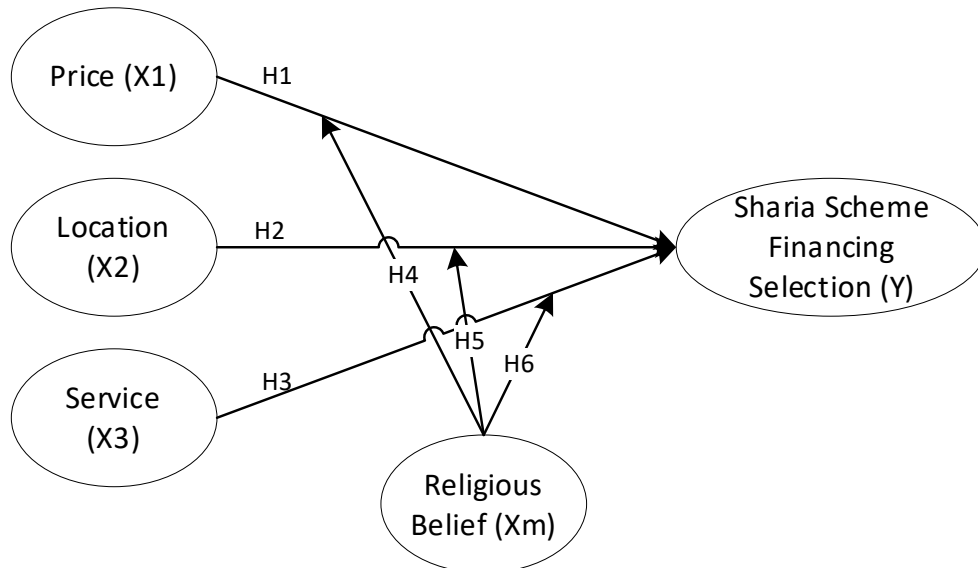


Figure 2. Research Model

3. Research Methodology

Quantitative research with a structural equation modeling (SEM) approach uses a questionnaire sample with purposive sampling and the object in the study uses the criteria of the object of the study of Muslim respondents who have made a home purchase. The research object areas in Indonesia which have 2 variations in the sharia scheme, namely the non-bank sharia scheme and the sharia scheme through Islamic banks and these areas are the areas with the highest home sales. After the data is obtained, it is analyzed by the research model using the structural equation modeling SmartPLS03.

The questionnaire uses a Likert Scale of 1 to 5 and the number of samples or respondents taken for research using the Structural Equation Modeling (SEM) method. Determination of the sample or respondents is carried out with respondents who have purchased houses in the last 2 years to ensure that the information held by respondents does not have a large gap that could cause bias in the study. According to (Loehlin and Beaujean, 2016), a good sample is the sample that reflects the population and believes the minimum sample size needed to reduce bias in all types of SEM estimates using G*power (effect size, 0,2; α , 0,05; power(1- β),0,95) 319 samples. Therefore, the total number of questionnaires distributed in this study is 325 questionnaires.

The main data collection in this study is by distributing questionnaires to home buyers in the last two years by submitting a closed questionnaire. In the

initial stage, a small number of respondents (30 samples) are selected to test the validity and reliability of the questionnaire questions. After that, if the Questionnaire questions have met the validity and reliability rules, the questionnaire will be distributed to the entire sample. The questionnaire uses a Likert scale with an ordinal scale. Before testing the hypothesis with SmartPLS03 structural equation modeling with moderation analysis, this study used the average variance extracted (AVE) indicator as a validity test. The reliability test used outer loading, Cronbach's alphas, and composite reliability indicators, and furthermore used discriminant validity to differentiate one construct from another.

Table 1. Variable Operations

No	Variable	Concept	Indicator	Scale
1	Price (Consumers' Perception)	Consumer perception that reflects the appropriate price according to cost incurred with those obtained to obtain goods. Item questions: - The price of the house I bought with the sharia scheme is according to my ability (P1) - The price of the house I bought with the sharia scheme reflects my daily lifestyle (P2) - The price of houses in Islamic housing or housing that implements the sharia scheme is guaranteed quality (P3) - The price level of houses in Islamic housing is more affordable compared to other housing prices (P4)	Purchasing Power (P1) Lifestyle (P2) Benefit (P3)	Ordinal
			Competitor's Price (P4)	Ordinal
2	Location (Consumers' Perception)	Location is the area or place where something is located. In this study, the location variable refers to consumer preferences for housing location and accessibility. Item questions: - Islamic housing or housing that implements the sharia scheme that you know is located in a strategic location (L1) - Islamic housing or housing that implements the sharia scheme that you know is located not far from the main road and has access to public transportation (L2)	Location Strategy Access (L1) Vehicle Access (L2)	Ordinal
3	Service (Consumers' Perception)	Service is all facilities given to consumers to convince them buying a product. Item questions:	Infrastructure (S1)	Ordinal

No	Variable	Concept	Indicator	Scale
4	Religious Belief	- Islamic housing or housing that implements the sharia scheme that you know has complete public facilities (S1)	Environment (S2)	Ordinal
		- Islamic housing or housing that implements sharia schemes that you know have a more comfortable environment (S2)	Business Reputation (S3)	
		- Islamic housing or housing that implements sharia schemes that you know always provide services that don't disappoint (S3)		
6	House Financing with Sharia Scheme	Religious belief is Muslim consumers believe in living their religion both in worship and in daily life, including in doing business. Item questions: - Financing with sharia schemes is financing that operates in accordance with sharia principles (R1)	External Beliefs (R1)	Ordinal
		- I know that the MUI issued a fatwa forbidding bank interest because it is considered usury (R1)	Internal Beliefs (R2)	
		- I am a person who practices religious teachings by helping others, especially those who are in trouble (R2) - I often donate wealth for the benefit of others (R2)		
		Consumer selection for home financing with sharia schemes, both cash in stages and installments to sharia developers. Item questions: - Home Financing Margins with the Sharia Scheme are not burdensome and affordable (F1)	Affordable (F1)	Ordinal
		- I am interested in financing the sharia scheme because it is considered very suitable for the needs (F2)	According to needs (F2)	

Source: Research finding.

Hypothesis testing in the PLS SEM reflective model in the discussion will be separated into two parts; the first part is the effect of the independent variable on the dependent variable and the second part the moderator variable strengthens or weakens the influence of the independent variable on the dependent variable, the significance level of both uses the t-value (t_0) compared with the value of t-table (t_α).

a. Hypothesis test part one

$$\text{Hypothesis test } Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + e$$

Where:

X_1 = Price

X_2 = Location

X_3 = Service

Y = Sharia home scheme financing selection

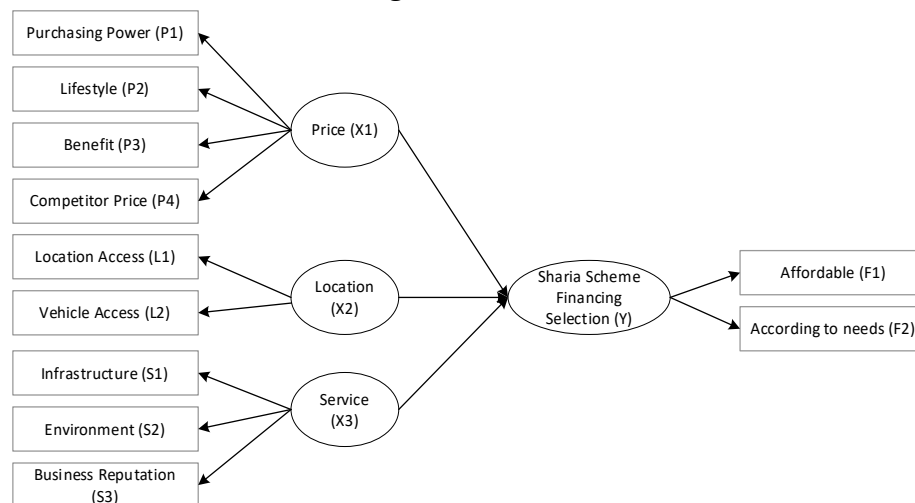


Figure 3. Specification of Research Model Part One

Source: Research finding.

Therefore, the hypotheses are:

H_0 : Price does not have a positive effect on the selection of sharia home financing schemes.

H_1 : Price has a positive effect on the selection of sharia home financing schemes.

H_0 : Location does not have a positive effect on the selection of sharia home financing schemes.

H_2 : Location has a positive effect on the selection of sharia house financing.

H_0 : Service does not have a positive effect on the selection of sharia home financing schemes.

H_3 : Service has a positive effect on the selection of sharia house financing.

- If the value of $t_0 > t_{\alpha}$, then H_0 is rejected and $H_{1,2,3}$ is accepted.
- If the value of $t_0 < t_{\alpha}$, then H_0 is accepted and $H_{1,2,3}$ is rejected.

Or

- If the significance value is $< \text{from} = 0.05$, then H_0 is rejected and $H_{1,2,3}$ is accepted
- If the significance value is $> \text{from} = 0.05$, then H_0 is accepted and $H_{1,2,3}$ is rejected

b. Hypothesis test part two

Hypothesis test

$$Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_1 x_4 + \beta_6 x_2 x_4 + \beta_7 x_3 x_4 + e$$

X_1 = Price

X_2 = Location

X_3 = Service

X_m = Religious belief

$X_1 * X_m$ = Moderation of 1 religious' belief with price

$X_2 * X_m$ = Moderation of 2 religious' belief by location

$X_3 * X_m$ = Moderation of 3 religious' belief with service

Y = Sharia scheme home financing options

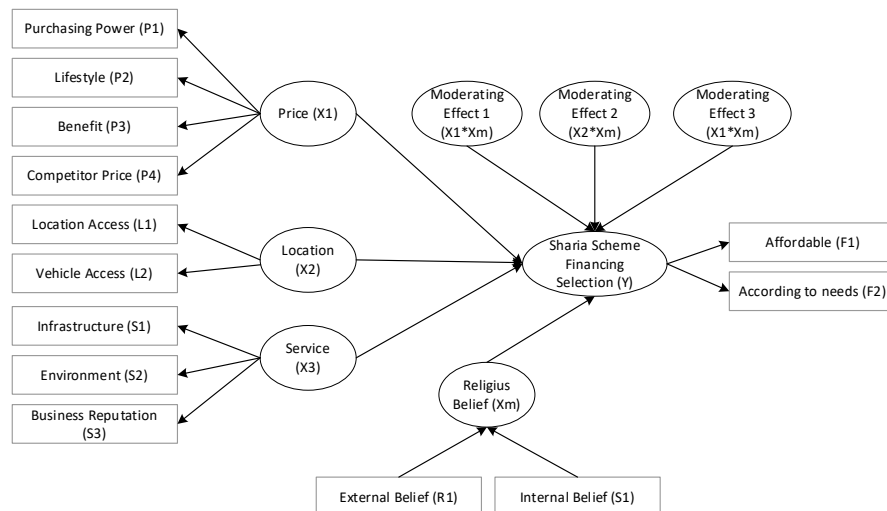


Figure 4. The Specification of Research Model Part Two

Source: Research finding.

Therefore, the hypotheses are:

H_0 : Religious beliefs do not positively moderate the price in influencing the selection of sharia home financing schemes.

H_4 : Religious beliefs positively moderate prices in influencing the choice of sharia home financing.

H₀: Religious beliefs do not positively moderate location in influencing the selection of sharia home financing schemes.

H₅: Religious beliefs positively moderate location in influencing the selection of sharia home financing schemes.

H₀: Religious beliefs do not positively moderate the service in influencing the selection of sharia home financing schemes.

H₆: Religious beliefs positively moderate the service in influencing the selection of sharia home financing schemes.

5. Results

5.1 Profile Respondent

The composition of the research respondents re based on aspects of gender can be seen in Figure 5. Based on Figure 5, the distribution of respondents is dominated by gender 71% male and 29% female. This distribution of respondents indicates that in buying a house or financing a home purchase, men are more dominant in decision making.

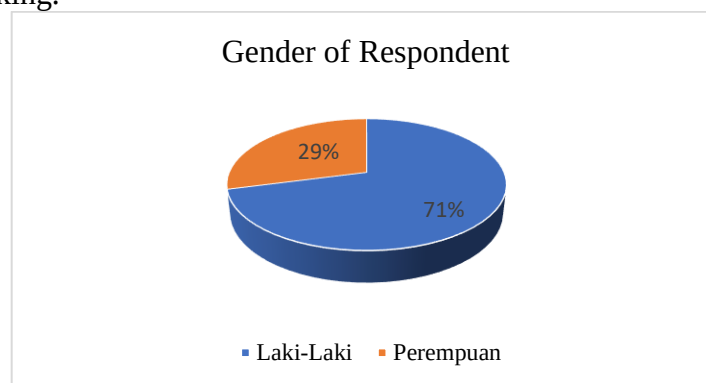


Figure 5. Respondents' Gender

Source: Research finding.

This study has a composition of respondents according to income levels which can be described in Figure 6 as follows.

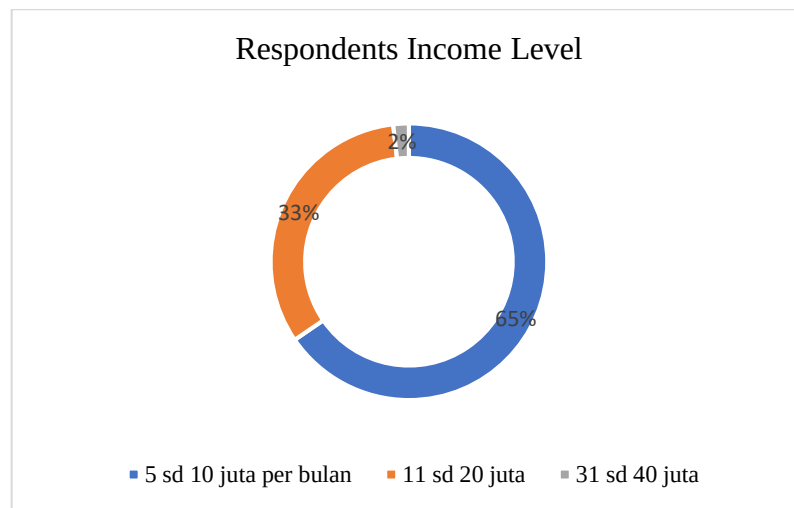


Figure 6. Respondents' Income Level

Source: Research finding.

Respondents' income categories are divided into 4 categories, but in home financing that offers a Sharia scheme, according to Figure 6, the most respondents are those who have an income of 5 to 10 million per month by 65%, and an income of 11 to 20 million per month by 33% and an income of 31 to 40 million per month by 2%. In the last 2 years, based on interviews with Islamic housing marketers, there has been a decrease in housing sales transactions and tend to purchase houses that offer Sharia schemes that are more in demand by first time home buyers.

5.2 Validity Test

PLS SEM provides two validity tests. Namely, convergent validity and discriminant validity. This study uses convergent validity because it means that a set of indicators represents one latent variable and that underlies the latent variable, the representation can be demonstrated through un-dimensionality which can be expressed through using the average value of the extracted variance (Average Variance Extracted/AVE), the test result validity in this study can be seen in Table2.

Table 2. Validity Test

Research Variable	Average Variance Extracted (AVE)
Consumers' Price Perception	0,649
Consumers' Service Perception	0,686
Consumers' Location Perception	0,746
Moderating Effect 1 (Price-Religious Belief)	1,000
Moderating Effect 2 (Location-Religious Belief)	1,000
Moderating Effect 3 (Service-Religious Belief)	1,000
Sharia Scheme Financing	0,560
Religious Belief	0,595

Source: Research finding.

From the result of Table 2, all AVE values are above 0.5, thus, it can be said that the research variables have measurements that can be used. The next step was assessing metric discriminant validity. Different metrics can confirm that each construct is distinct from other constructs. (Henseler et al., 2015) suggested the heterotrait-monotrait ratio (HTMT) to test the discriminant validity, with a threshold value is 0.8 for a precise result. Table 3 shows that all HTMT scores were below 0.8. Therefore, if the research has passed the validity test, then the reliability test will be carried out afterwards.

Table 3. Discriminant Validity Heterotrait-Monotrait (HTMT) Values

	Price	Service	Location	SSF	RB
Consumers' Price Perception					
Consumers' Service Perception	0.364				
Consumers' Location Perception	0.458	0.798			
Sharia Scheme Financing	0.442	0.636	0.726		
Religious Belief	0.734	0.576	0.408	0.530	

Source: Research finding.

5.3 Reliability Test

The reliability test in this study uses the Cronbach alpha value and the composite reliability value, the minimum value is 0.7, although the ideal value of these two values is greater than 0.9 in this study. The result of reliability testing in this study can be seen in Table 4.

From the result of table 4, all Cronbach's Alpha values are above 0.7, thus, it can be said that the research variables have consistency in testing; the result of Cronbach's alpha are supported by the composite reliability value which has a value above 0.9 and states that the data and research variables are reliable for testing.

5.4 Hypothesis Testing and Discussion

The result of the study in table 5 shows that the adjusted R^2 value of 0.723 can be categorized as strong, which means the ability of the independent variable to explain the dependent variable is 72.3%, the other 27.7% is explained by other factors that are not included in this research model. After seeing the value of R^2 in the PLS analysis, look at the estimated value of the path coefficient which is described in Table 6.

Table 4. Reliability Test

Construct	Outer Loadings	Cronbach's Alpha's	Composite Reliability	Average Variance Extracted (AVE)
Consumers' Price Perception		0.769	0.896	0.812
P1	0.911			
P2	0.899			
P3	0.786			
P4	0.892			
Consumers' Location Perception		0.782	0.873	0.696
L1	0.841			
L2	0.806			
Consumers' Service Perception		0.755	0.859	0.67
S1	0.823			
S2	0.843			
S3	0.787			
Religious Belief		0.777	0.871	0.692
R1	0.819			
R2	0.859			
Sharia Scheme Financing		0.769	0.867	0.685
F1	0.797			
F2	0.869			

Source: Research finding.

Table 5. The Coefficient of Determination (R^2) Values

Sharia Home Financing Schemes	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
R^2	0,759	0,800	0,052	14,672	0,000***
R^2 -Adjusted	0,723	0,769	0,060	12,120	0,000***

Source: Research finding.

Table 6. Testing Result of Patch Coefficient Value

Research Variable	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
Consumers' Price Perception -> Sharia Scheme Financing	0,410	0,473	0,156	2,630	0,009***
Consumers' Service Perception -> Sharia Scheme Financing	0,131	0,115	0,155	0,849	0,396
Consumers' Location Perception -> Sharia Scheme Financing	0,369	0,330	0,140	2,632	0,009***
Moderating Effect 1 (Price-Religious Belief) -> Sharia Scheme Financing	0,159	0,116	0,409	2,578	0,037**
Moderating Effect 2 (Location-Religious Belief) -> Sharia Scheme Financing	-0,060	-0,019	0,185	0,326	0,745
Moderating Effect 3 (Service-Religious Belief) -> Sharia Scheme Financing	-0,064	-0,079	0,188	0,338	0,735
Religious Belief -> Sharia Scheme Financing	0,068	0,078	0,086	0,796	0,426

Source: Research finding.

The result of the study in Table 6 shows significant result that have a P-Value less than 5% or 0.05, namely the price variable with a P-value of 0.009 (0.00852) and location with a P-value of 0.009 (0.00859), as well as the religious belief variable which moderates the significant price with a P-value of 0.037. While other variables, namely service variables, religious belief moderating variables on location and religious belief moderating variables on services are not significant which means the price variables and location variables affect the financing of sharia schemes, and religious belief strengthens the influence of price in influencing sharia financing schemes. However, the service variable does not affect the financing of the sharia scheme and religious belief cannot moderate the location and service in improving consumer decisions in choosing home financing for the sharia scheme.

The first part of the research model will explain the direct effect of price, location, and service variables (consumer perceptions) on the decision to choose Islamic financing schemes and the second part will explain the role of religious belief, in which the first part can be described in Figure 7 below.

Based on Table 6 and Figure 7, the hypothesis in the first part can be explained in the following.

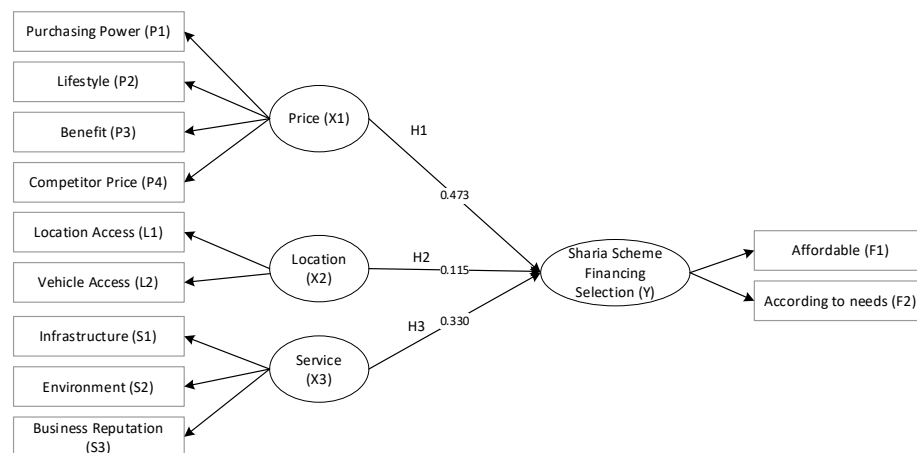


Figure 7. Testing Result of Price, Location, and Service toward Financing Selection with Sharia Scheme

Source: Research finding.

Based on Table 6 and Figure 7, the hypothesis in the first part can be explained, namely:

First Hypothesis

H₀: Price does not have a positive effect on the selection of sharia home financing schemes.

H₁: Price has a positive effect on the selection of sharia home financing schemes.

In the first hypothesis, H_0 is rejected and H_1 is accepted, this means that the price (consumer perception) has a positive effect on the selection of Islamic home financing. So that the higher the positive perception of prices, the greater the choice of Sharia home financing. The price variable explains the dimensions of purchasing power, lifestyle, benefits and competitor prices, this is the main consideration for consumer perceptions in choosing Sharia home financing, for example, if the purchasing power of the community is high, consumers will choose Sharia home financing due to the certainty of Sharia financing schemes. Having fixed installments makes the main choice compared to non-Sharia financing schemes which tend to have low interest at the beginning but after running it will be adjusted to floating interest rates which can cause an indeterminate increase in financing installments.

Second Hypothesis

H_0 : Location does not have a positive effect on the selection of sharia home financing schemes.

H_2 : Location has a positive effect on the selection of Sharia house financing.

The second hypothesis in table 6 and figure 7 shows that H_0 is rejected and H_2 is accepted. This means that location (consumer perception) has a positive effect on the selection of sharia house financing, in the location variable, there are dimensions of strategic access and vehicle access, in one of the strategic access indicators here it also emphasizes to the distance of housing from school, distance to activity center and distance for places of worship, because this is one of the important factors if housing is in the form of a cluster or in which there is no mosque so that consumers place more emphasis on strategic access to these three indicators.

Third Hypothesis

H_0 : Service does not have a positive effect on the selection of sharia home financing schemes.

H_3 : Service has a positive effect on the selection of sharia house financing.

The third hypothesis in Table 6 and Figure 7 show that H_3 is rejected and H_0 is accepted. This means that the service (consumer perception) has no effect on the choice of sharia home financing, where in the service variable there are two dimensions, namely, the dimensions of business ethics and facilities & infrastructure. However, consumers still think that this variable is not a variable that affects the selection of sharia financing schemes, based on discussions with one of the developers, this is because the offerings of facilities and infrastructure provided by developers tend to be the same and do not differ, so that consumers

do not perceive that there is one special difference that makes them different in choosing sharia financing schemes, while this business ethic is related to consumers who buy more houses for their first purchases so they do not know in depth the business ethics or services of one developer to another.

Based on Table 6 and Figure 7 explanation of part one, it can be concluded that the variables that directly affect the selection of financing for the sharia scheme are price and location variables. After discussing the findings of the first part, we will discuss the second part, namely the role of religious belief in moderating the influence of price, location, and service on the selection of Sharia financing schemes which are depicted in Figure 5 below:

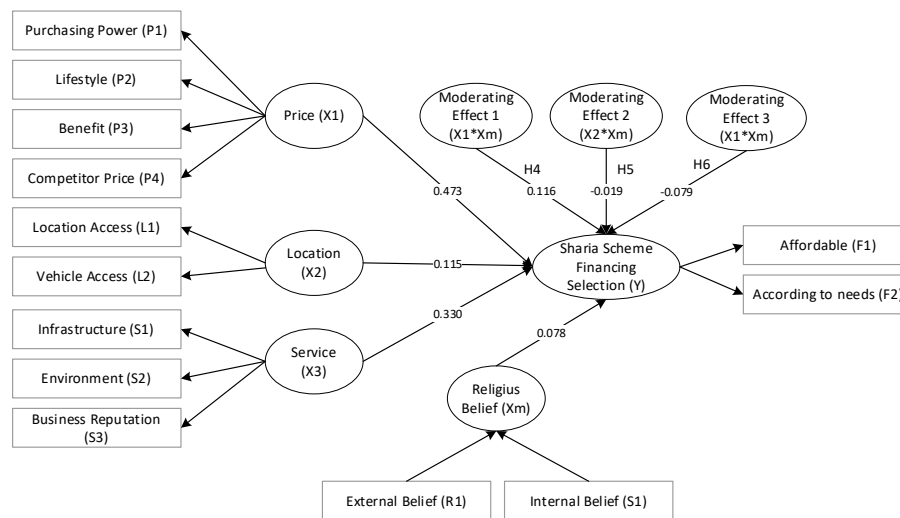


Figure 8. Testing Result of Religious Belief Moderated by Price, Location, and Service Effects toward Financing Selection with Sharia Scheme

Source: Research Finding.

Based on Table 5 and Figure 5, the hypothesis in the second part can be explained in the following.

Fourth Hypothesis

H₀: Religious Beliefs do not positively moderate the price in influencing the selection of sharia home financing schemes.

H₄: Religious Beliefs positively moderate prices in influencing the choice of sharia home financing.

The fourth hypothesis in table 6 and figure 8 show that H₀ is rejected and H₄ is accepted. It means that religious beliefs moderate the price positively in influencing the choice of sharia home financing. The stronger the consumer's religious beliefs, the more influence the price variable (consumer perception) will

have on the selection of Islamic financing schemes. Consumers who have strong religious beliefs will solidify their choices in choosing sharia financing schemes, although in practice, based on the responses of research respondents, some state that sharia financing schemes are not more flexible and more expensive than conventional or non-sharia financing schemes.

Fifth Hypothesis

H₀: Religious Beliefs do not positively moderate location in influencing the selection of sharia home financing schemes.

H₅: Religious Beliefs positively moderate location in influencing the selection of sharia home financing schemes.

The fifth hypothesis in table 6 and figure 8 shows that H₅ is rejected and H₀ is accepted, this means that religious beliefs do not positively moderate the location in influencing the choice of sharia home financing. This not significant moderation is reinforced by the response of respondents which explains that the value of the high response is not dominant, none of which exceeds 70%. It indicates that religious belief has not been able to strengthen consumer perceptions in this case location in influencing the choice of sharia home financing, although in the second hypothesis the location directly influences the selection of sharia home financing schemes.

Sixth hypothesis

H₀: Religious Beliefs do not positively moderate the service in influencing the selection of sharia home financing schemes.

H₆: Religious Beliefs positively moderate the service in influencing the selection of sharia home financing schemes.

The sixth hypothesis in table 6 and figure 8 show that H₆ is rejected and H₀ is accepted. It means that religious beliefs do not positively moderate the service in affecting the selection of sharia home financing. This moderation insignificance is reinforced by the third hypothesis which shows that it is not significant, the influence of services on the selection of houses for the sharia scheme, and based on discussions with developer resource persons, consumers prioritize the price factor over the services provided, especially with the concept of developers who rarely integrate the construction of religious facilities into The public facilities development agenda is first, but the developer prefers to provide public facilities for worship facilities for the construction to be handed back to the housing community to build it after occupying it, however, the developer still proposes a design based on the concept of the housing it sells. From the sources, it can be seen that service is not the main factor in determining the selection of a house with a Sharia scheme.

6. Discussion

From the findings, three things become highlighted in this study: First, price (consumer perception) affects the choice of Sharia home financing, and second, location (consumer perception) affects the choice of Sharia home financing. Thirdly, religious belief can increase the influence of price (consumer perception) in the choice of Sharia home financing. An in-depth discussion will focus on these three things, starting with looking at the similarities with similar research to apply the findings in order to the benefits and make policies to be produced.

The first discussion of price (consumer perception) affects the choice of financing for this Sharia scheme. Following research states that in choosing Islamic financing or conventional financing, the most important factor is the price of competitors' because consumers will compare which one is more profitable for consumers. (Firmansyah and Gunardi, 2018; Hamid and Masood, 2011; Razinah et al., 2019). In this study, the price variable (consumer perception), four dimensions are included in the indicators of the price variable, which is; purchasing power, benefits, competitor prices, and lifestyle. The dimensions indicators become the main elements in determining the price variable (consumer perception) affecting the selection of sharia financing schemes. Purchasing power will affect the selection of sharia home financing schemes in the focus group. The discussion conducted by consumers will prioritize the appropriate purchasing power to choose home financing. Consumers are more likely first to ask about the sharia scheme of home financing. If the consumer turns out to be unable to fulfil it due to lower purchasing power than the appraisal of Islamic banks, the consumer will look for another affordable financing. Maybe other financings to conventional financing options or conventional banks. In addition to the purchasing power of the benefits of influencing the choice of sharia home financing, this benefit is based on how well the selection of sharia home financing is with the benefits received by consumers. This development is based on the differences in the instalment pattern of Islamic banks and conventional banks, for example; before there was a sharia BTN, consumers always had the perception that BTN was the only bank that had home financing with a fixed instalment scheme, but with its development, BTN changed its financing concept to equate it with the conventional concept of floating rate or instalments based on floating interest rates and the fixed instalment scheme was submitted to BTN sharia. Hence, the difference in benefits between Islamic and conventional banks can be seen clearly (Firmansyah & Gunardi, 2018). Based on the description that has been disclosed, price (consumer perception) remains the main factor in consumers choosing sharia home financing schemes.

The second discussion, locations (consumer perceptions) affect the choice of home financing for this Sharia scheme. According to research conducted by (Hamza, 2016; Razak and Tazwar, 2018), location is an essential factor in house

selection. Islamic banks will provide appraisal more based on strategic access to activity centers and road access that can enter cars. In the location variable of this study, two main dimensions are indicators of the location variable, namely, strategic location access and vehicle access. In focus group discussions, strategic location access is developers' main concern in developing their housing. The closer the location to the center of activity, the more consumers will consider the benefits of the location. Location can facilitate consumer activities and vehicle access regarding the costs of these activities so that it will affect consumer price perceptions. In addition, based on the research findings, it turns out that religious belief cannot moderate location (consumer perception) to influence the choice of sharia home financing. The selection of sharia home financing schemes is based on the psychological theory, and the idea is that religious belief is more likely to indirectly influence the selection of sharia home financing. When consumer perceptions are influenced by religious belief, religious belief can have an indirect effect or have an indirect effect on the selection of sharia home financing schemes. Strong perceptions of location on the selection of sharia home financing can create new information to develop a research model. The research model focuses on religious belief as an indirect effect on the selection of sharia home financing.

The third discussion of religious belief can strengthen the influence of price (consumer perception) on the choice of sharia home financing. The result was not different from (Hamza, 2016). The result states that when religious belief has a role in determining someone's choice. By strengthening the influence of public perception on his choice, the price variable emphasizes consumer perceptions, so it can be said that there are clear relationship. (Amin, 2008; Hamid and Masood, 2011) findings explain; "although not explicitly related to the choice of home financing, the results of this study explain how prices (consumer perceptions) can affect the choice of home financing by taking into account the level of consumer confidence in the fatwa or sharia regulations".

Price and location have a significant impact on home financing selection with a Sharia scheme because the growth of house prices is higher than the growth in customer income; because of that, customers want to buy houses with affordable prices and strategic location; strategic location can reduce the burden to pay financing instalments. Meanwhile, the finding of this research aligns with Khan et al. (2021) in their research that service does not affect Islamic home financing; henceforth, religious belief supports Sharia compliance and affects Islamic home financing selection. This happens because, in considering Islamic home financing, the most substantial factor is affordable prices; religiosity can increase the effect of prices on Islamic home financing if there are two price options for determining to buy a house between the Islamic and conventional financing systems, even though the Islamic financing system costs higher than conventional, then with a

religious level firm belief will choose to buy a house with an Islamic system. Although, religious belief can increase the price effect for Islamic home selection, but affordable prices are becoming critical. The limitations of the study are to address only consumer perception. Future research can add expert experience to confirm the results and become more robust.

This study in formulating the religious belief variable uses two dimensions that are used as indicators, namely, the dimensions of external belief and internal belief; external belief is related to how respondents understand all rules related to Muamalah, which emphasizes more information on MUI fatwas related to usury and other things that distinguish between sharia financing schemes with non-sharia or conventional schemes. While the internal belief is more about the respondent's self-assessment of the worship performed, these two dimensions will complement each other to measure the religious belief variable. In the analysis of respondents' opinions there is a high response 100% related to external belief, namely knowing that the MUI is an institution that is believed to make fatwas for Muslims in Indonesia, so that the MUI fatwa is a rule that must be followed, and the existence of an MUI fatwa and the argument that forbids usury, but even though respondents already consciously know this, but in the respondent's perception there are still things that weaken this belief with the consideration that if the financing of the sharia scheme is not 100% carried out by a sharia institution which can be burdensome for the respondent to choose it and also when the respondent has chosen to finance with a sharia scheme with high power. Limited purchases, it turns out that when appraisals do not meet, so if consumers want to use home financing with a sharia scheme, consumers have to add the initial capital to buy a house (in practical terms, it is called a lower ceiling because the calculation of financing guarantees or financing requirements is not fulfilled). In contrast, in the financing, non-sharia scheme respondents get financing according to the purchasing power respondents.

7. Conclusion

Studies conducted on price, location, and service (consumer perceptions) of the selection of sharia home financing, as well as religious belief as a moderator variable and developed have an indirect influence on the selection of sharia home financing in Indonesia which were analyzed through descriptive, explanative, and empirical research, can be concluded as follows:

Price (consumer perception) affects the choice of financing for the Sharia scheme. In this study, the price variable (consumer perception) in which there are four dimensions that are included in the indicators of the price variable, namely; purchasing power, benefits, competitor prices and lifestyle, based on the dimensions entered, these indicators become the main elements in determining the

price variable (consumer perception) affecting the selection of sharia financing schemes, purchasing power will affect the selection of sharia home financing schemes, thus, consumers will give more attention to the appropriate purchasing power for selecting the best home financing. In addition to the purchasing power of the benefits that influence the selection of sharia home financing, this benefit is based on how well the selection of sharia home financing is with the benefits received by consumers.

Location (consumer perception) affects the selection of home financing, location is an important factor in house selection, and Islamic banks will provide more appraisals based on strategic access to activity centers and road access that can enter cars. In the location variable of this study, there are two main dimensions that are indicators of the location variable, namely, strategic location access and vehicle access, in FGD strategic location access is the main concern of developers in developing their housing, the closer the location is to the center of activity, the consumers will consider the benefits of the location in facilitating consumer activities and vehicle access regarding the costs of these activities.

Religious belief strengthens the effect of price (consumer perception) on the choice of sharia home financing. This study in formulating the variable of religious belief uses two dimensions that are used as indicators, namely, the dimensions of external belief and internal belief, external belief related to how respondents understand all the rules that related to Muamalah, which emphasizes more information on MUI fatwas that related to usury and other matters that distinguish between sharia financing schemes and non-sharia or conventional schemes. However, the internal belief is more about the respondent's self-assessment of the worship performed by the respondent, these two dimensions will complement each other to measure the religious belief variable. The limitation for this research does not include the perception of all stake holders, so that in future research it can be added from the point of view of the stake holders offering this scheme and willingness to pay customers.

Statements and Declarations

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- Conflict of interest: The authors declare that there is no conflict of interest.

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An OOHB-DC Survey for Estimating Willingness to Pay of Residual Consumers to Avoid Power Outage by Using PSO

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Abstract

In the face of insufficient energy production in power systems, load shedding in residential areas has become unavoidable. This study evaluates the willingness to pay (WTP) among households in Kerman, Iran, to prevent power outages. A survey of 800 households was conducted in May 2021 using a one-and-one-half-bound dichotomous choice (OOHB-DC) approach, integrated with a spike model to address zero WTP responses. The questionnaire was designed to clearly communicate the study's purpose, ensuring meaningful responses. Particle swarm optimization (PSO) was employed to estimate model parameters. Findings indicate that the average monthly WTP per household is 92,886 Rials (USD 0.37), with an annual aggregate value of 972 billion Rials (USD 3.89 million). These results, which are statistically significant, suggest that substantial investments are needed by utility providers to maintain reliable power supply in residential areas.

Keywords: OOHB-DC Survey, Particle Swarm Optimization, Residual Consumers, Willingness to Pay.

JEL Classification: C51, G53, R21.

1. Introduction

Electricity is an essential component of modern life, underpinning critical services such as healthcare, transportation, and communication infrastructure. Power outages disrupt these services, affecting societal well-being. Due to limited energy generation, load shedding is often necessary to protect equipment and stabilize grid voltage. To minimize disruption, utility companies must prioritize outages for customers with lower willingness to pay (WTP), thereby reducing economic and

social impacts. Understanding consumer preferences and behaviors is therefore critical for effective power management.

Two primary methods for assessing WTP are the choice experiment (CE) and contingent valuation method (CVM). In CE, goods or services are defined by their attributes, and respondents rank or select preferred options, allowing WTP to be inferred indirectly (Speckemeier et al., 2021). Conversely, CVM simulates a hypothetical market where respondents state their maximum WTP for non-market goods under specific conditions. CVM approaches include iterative bidding (IB), payment card (PC), dichotomous choice (DC), and open-ended (OE) formats (Tian et al., 2011).

In IB, respondents are offered an initial bid, which is adjusted based on their responses until their WTP is determined (Randall et al., 1974). The PC method, introduced by Carson et al. (1984), asks respondents to select their maximum WTP from a list of values (Venkatachalam, 2004). OE formats allow respondents to freely state their WTP without guidance. DC methods include single-bounded (SB-DC), double-bounded (DB-DC), and one-and-one-half-bounded (OOHB-DC) approaches. SB-DC involves a simple yes/no response to a bid, while DB-DC uses two sequential questions to refine WTP estimates, yielding four outcomes. OOHB-DC, discussed later, generates six outcomes, offering a balance of simplicity and precision (Bateman et al., 2001; Cooper et al., 2002).

Despite their strengths, DC methods face challenges like starting point bias and inconsistency (Arrow et al., 1993). OOHB-DC mitigates some of these issues, making it a preferred choice, as endorsed by NOAA (Ready et al., 2001). Additionally, zero WTP responses can skew results, but the spike model, proposed by Kriström (1997), addresses this by incorporating zero responses into the likelihood function.

Prior research employing choice experiments (CE) has focused on ranking attributes to determine respondents' willingness to pay (WTP) for reliable electricity. For example, Hensher et al. (2014) explored household preferences for avoiding disruptions in residential power supply, using CE to identify preferences and estimate a mean WTP of USD 23 to prevent brief outages. Similarly, Morrissey et al. (2018) applied a CE approach to assess the economic impact of power cuts in northwest England, finding that households were willing to pay an average of £7.37 to avoid outages during weekdays. Carlsson and Martinsson (2008) conducted a CE survey among Swedish households, revealing that WTP for reducing outages increased with outage duration and were higher for disruptions during weekends or winter months, based on random parameter logit analysis.

In contrast, studies using contingent valuation methods (CVM) have directly estimated outage costs. Reichl et al. (2013) developed a CVM model to quantify economic losses from power interruptions, calculating an average value of lost load at €17.1 per kWh for Austrian households and non-households during a 1-hour outage on a summer workday morning. Woo et al. (2014) utilized a CVM survey with ordered logit analysis to assess residential outage costs in Hong Kong, estimating an average WTP of USD 45 for a 1-hour outage. Ozbaflı and Jenkins (2015) investigated WTP for improved electricity services in North Cyprus, using payment ladder CVM data from 350 interviews, finding households willing to pay a 13.8% increase in their monthly electricity bill to avoid outages. Kim et al. (2017) surveyed 1,000 households in South Korea with a CVM approach, determining a mean monthly WTP of KRW 1,522 (USD 1.41) to prevent power interruptions.

A study involving 871 online participants in Vietnam was carried out from April to August 2022 to assess preferences using a cross-sectional approach. A questionnaire employing a discrete choice experiment (DCE) framework was created and distributed via snowball sampling, with data analyzed conjointly on the Qualtrics platform. The study explored factors such as prior COVID-19 infection and vaccination, health conditions, willingness to vaccinate, willingness to pay, and additional variables (Bach Xuan Tran, 2022).

This study employs a contingent valuation approach utilizing a one-and-one-half-bound dichotomous choice (OOHB-DC) survey, integrated with a spike model to address zero willingness-to-pay (WTP) responses. Additionally, we apply particle swarm optimization (PSO) as a novel technique for parameter estimation in this domain. To enhance the survey's validity, the questionnaire was designed to clearly explain power outage impacts and ensure respondents understood the context, making responses reliable and meaningful. A hypothetical payment scenario was created to elicit bids from participants. The OOHB-DC spike model was used to derive WTP values. Notably, due to the COVID-19 pandemic, interviews were conducted via telephone.

2. Methodology

As highlighted in prior research, the OOHB-DC format offers notable benefits for WTP estimation. This section outlines a method combining an OOHB-DC survey with a spike model to determine the average WTP among residential consumers.

2.1 DC Survey

The OOHb-DC approach, developed by Cooper et al. (2002), employs a questionnaire with two bids: a lower bid (B_L) and a higher bid (B_H). The interviewer randomly presents B_L first to half of the participants and B_H first to the other half. If a participant accepts B_L , B_H is then offered; if B_L is rejected, no further questions are posed. Similarly, if B_H is accepted when offered first, no additional questions follow, but if B_H is rejected, B_L is proposed. This format often results in numerous zero WTP responses. To address these, Kriström (1997) introduced the spike model for the OOHb-DC framework. In this model, participants who reject B_L or both B_H and B_L are asked if they are willing to pay any amount. A positive response indicates a WTP between zero and B_L , while a negative response signifies a zero WTP. Figure 1 illustrates the structure of the WTP elicitation questions for this method.

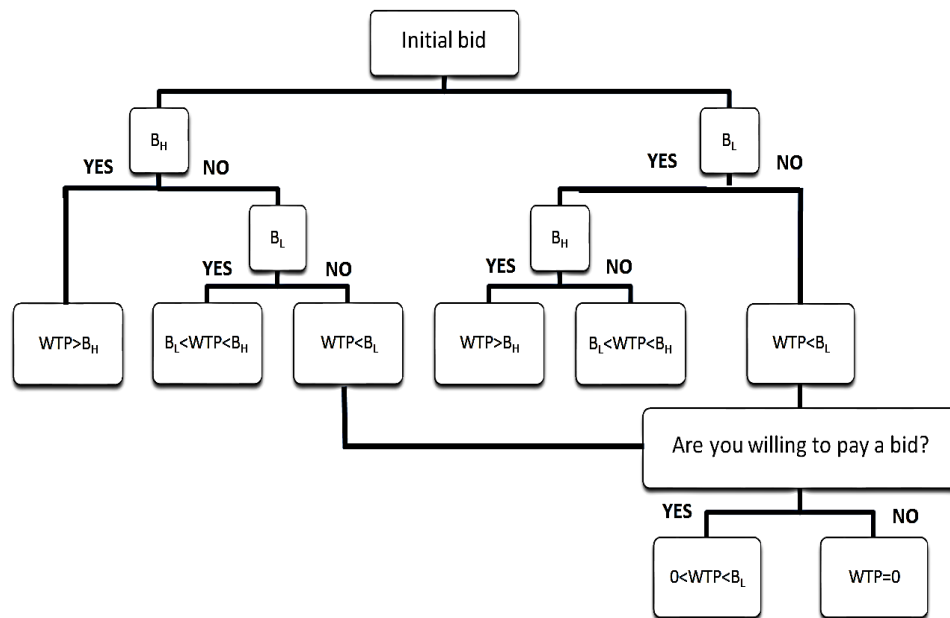


Figure1. The structure of OOHb-DC spike model to extract responder's WTP

Source: Research finding.

2.2 OOHb-DC Spike Model

Hanemann (1984) pioneered the utility difference model, offering a framework to develop Hicksian welfare measures for evaluating dichotomous survey responses

and estimating willingness to pay (WTP). This model assumes that each respondent's discrete choice reflects a process of maximizing utility. In the context of power outages, individuals are willing to pay a bid to avoid disruptions if the utility derived from this payment exceeds the utility of experiencing an outage. The indirect utility function mathematically represents this concept as follows:

$$V(Y, I - B; D) + \varepsilon_Y \geq V(N, I; D) + \varepsilon_N$$

Or

$$\Delta V = V(Y, I - B; D) - V(N, I; D) \geq \varepsilon_N - \varepsilon_Y$$

In this model, "Y" denotes the state where a power outage occurs, while "N" indicates no outage. The indirect utility function is represented by "V", with "I" signifying household income, "D" capturing socio-demographic characteristics, and "B" representing the proposed bid. The terms " ε_Y " and " ε_N " denote error components. A positive ΔV indicates that respondents will answer "yes" to the bid, leading to the following relationship:

$$Pr("Yes") = Pr(WTP \geq B) = 1 - G_{WTP}(B, \theta)$$

Here, WTP represents the customer's willingness to pay, while $G_{WTP}(B, \theta)$ denotes the cumulative distribution function of respondents at bid B . Additionally, θ is a parameter vector capturing socio-economic characteristics that influence the likelihood of responding "yes" to a proposed bid.

In the OOHb-DC Spike model, the initial questionnaire is crafted from a pilot survey with a small group of participants, establishing bid intervals as (B_{H1}, B_{L1}) , (B_{H2}, B_{L2}) , ..., (B_{Hn}, B_{Ln}) , where n denotes the number of intervals. These intervals are then evenly applied across the sample population, with an equal number of respondents first presented with either B_L or B_H bids. The interviewer proposes the bid, and the participant responds "yes" if willing to pay or "no" if unwilling.

As noted, the OOHb-DC spike model's elicitation process generates eight possible response combinations. When the lower bid (B_L) is offered first, respondents may answer "yes-yes," "yes-no," or "no." Conversely, when the higher bid (B_H) is presented initially, the responses can be "yes," "no-yes," or "no-no." Per the spike model, if a respondent answers "no-no" to B_H or "no" to B_L , they are asked an additional question about their willingness to pay any amount. A "yes" response indicates a positive WTP less than B_L , while a "no" response signifies a WTP of zero. So we have $I_i^{YY}, I_i^{YN}, I_i^{Y}, I_i^N, I_i^{NY}, I_i^{NN}, I_i^{TY}$ and I_i^{TN} as follow:

$$I_i^{YY} = 1 \text{ (ith interviewee's answer is "yes-yes")}$$

$$I_i^{YN} = 1 \text{ (ith interviewee's answer is "yes-no")}$$

$I_i^Y = 1$ (ith interviewee's answer is "yes")

$I_i^N = 1$ (ith interviewee's answer is "no")

$I_i^{NY} = 1$ (ith interviewee's answer is "no-yes")

$I_i^{NN} = 1$ (ith interviewee's answer is "no-no")

$I_i^{TY} = 1$ (ith interviewee's answer to additional question is "yes")

$I_i^{TN} = 1$ (ith interviewee's answer to additional question is "no")

Here, "I" denotes the respondent index, and $1(.)$ represents an indicator function, which takes the value 1 if its condition is true and 0 otherwise. As previously noted, each individual's observed response is assumed to reflect a utility maximization process. To estimate the parameter vector θ , the logarithmic likelihood function is maximized. The log-likelihood function for the OOHb-DC spike model is formulated as follows:

$$\ln(L) = \sum_{i=1}^R [(I_i^{YY} + I_i^Y) \times \ln(1 - G_{WTP}(B_H, \theta)) + (I_i^{YN} + I_i^{NY}) \times \ln(G_{WTP}(B_H, \theta) - G_{WTP}(B_L, \theta)) + I_i^{TY}(I_i^{NN} + I_i^N) \times \ln(G_{WTP}(B_L, \theta) - G_{WTP}(0, \theta)) + I_i^{TN}(I_i^{NN} + I_i^N) \times \ln(G_{WTP}(0, \theta))]$$

Kriström (1997) have showed assuming $\theta = (\theta_0, \theta_1)$ yields:

$$G_{WTP}(B, \theta) = \begin{cases} (1 + e^{-(\theta_0 + \theta_1 B)})^{-1} & ; \quad B > 0 \\ (1 + e^{-\theta_0})^{-1} & ; \quad B = 0 \\ 0 & ; \quad B < 0 \end{cases}$$

According to this equation the spike is defined by $(1 + e^{-(\theta_0)})^{-1}$ and the mean WTP in the spike model is defined as follows:

$$C^+ = (1/\theta_1) \times \ln(1 + \exp(\theta_0))$$

In order to analyze the effect of respondent's attitudes or socio-economic characteristics on the probability of answering "yes" to a given bid, it is necessary to include covariates in the model. If the covariates are considered, " θ_0 " is replaced by " $\theta_0 + x_i' \theta$ ", where " x_i' " is the vector of respondent's characteristics and " θ " is the parameter vector to be estimated.

2.3 Maximizing Log-Likelihood Spike Model

This study utilizes particle swarm optimization (PSO) to maximize the log-likelihood function of the OOHb-DC spike model. Introduced by Eberhart and Kennedy in 1995, PSO is a population-based stochastic search method operating in a multidimensional space. In this algorithm, each particle is assigned a fitness value determined by an objective function, with higher values indicating proximity

to the target in the search space. Particles possess velocities that guide their movement, navigating the problem space by tracking the current optimal particles. The position and velocity of each particle in the subsequent iteration are updated based on the best particle location and the leader's position, as described by the following equations:

$$v(t+1) = v(t) + C_1 * \text{rand}(t) * (P_{\text{best}}(t) - \text{pos}(t)) + C_2 * \text{rand}(t) * (L_{\text{pos}}(t) - \text{pos}(t))$$

$$\text{pos}(t+1) = \text{pos}(t) + v(t+1)$$

In the described algorithm, the current and subsequent positions of a particle are denoted by "t" and "t+1," respectively. The particle's velocity is represented by "v", and its position by "pos." The parameters "C₁" and "C₂" are fixed coefficients, while "rand" denotes a randomly generated vector applied in each iteration. The terms "Pbest" and "Lpos" refer to the particle's optimal historical position and the leader's position, respectively. If the updated objective function value surpasses the previous one, the particle relocates to the new position; otherwise, it remains stationary. The algorithm then proceeds to the next iteration, recalculating objective functions, and continues this cycle. For the maximization task, the input vector "θ" serves as the parameter set, with the log-likelihood of the OOHb-DC spike model acting as the objective function to be optimized.

2.4 Questionnaire Design

In the contingent valuation study, individuals were asked to imagine power outages occurring in different seasons and express their highest WTP to prevent them. The survey was organized into three distinct segments. The first segment introduced participants to the study's focus and objectives. The second segment collected demographic data, such as age, income, gender, education, and related personal details. The third segment included questions aimed at gathering WTP responses. The study utilized household electricity bills as the payment mechanism, chosen for its familiarity and direct relevance to the research topic. After drafting the survey and consulting with experts, a preliminary test was conducted one-on-one with researchers. This pre-test helped determine appropriate bid ranges and quantities through open-ended inquiries. Furthermore, the pre-test ensured that questions were straightforward, easily understood, and effectively elicited the required data (Brown et al., 2003).

3. Results and Discussion

The results of the study stem from analyzing 800 telephone interviews conducted in Kerman, Iran. Data collection occurred in May 2021, with telephone interviews chosen due to the ongoing COVID-19 pandemic. As previously noted, the pre-test with a focus group established the minimum and maximum bid values for the OOHB-DC survey. The bid sets applied in this research were determined based on these pre-test outcomes.

(50000;150000), (100000;200000), (150000;250000), (200000;300000), (250000;350000), (300000;400000), (350000;450000), (400000;500000), (450000;550000) and (500000;600000).

It is worth mentioning the exchange rate When the survey was implemented was USD 1 = Rials 250000.

Table 1 presents the responses to the WTP questions from the survey. Notably, 45% of participants indicated a WTP of zero. The data reveal that the proportion of “yes” responses to the proposed bid amounts generally declines as the bid value rises. For instance, as “Yes” or “Yes-Yes” responses reflect a preference for paying a higher bid, 14 participants (17%) were willing to pay more than 15,000 Rials, whereas only 3 participants (4%) were willing to pay above 45,000 Rials.

3.1 Estimation Results

Table 2 displays the outcomes of the OOHB-DC spike model estimation. The bid price coefficient is statistically significant at the 1% level and exhibits a negative value, suggesting that higher bid amounts reduce the likelihood of a “yes” response. According to Table 2, the estimated monthly household WTP to prevent power outages is 92,886 Rials (approximately USD 0.37), which is statistically significant. The p-value in this table tests the null hypothesis that all parameters are collectively zero.

Table 1. Responder's WTP to Suggested Bids

Bid amount		Higher bid is suggested first				Lower bid is suggested first				Sample size
		Yes	No Yes	No No-Yes	No No-No	Yes No	Yes Yes	No No	No Yes	
50000	150000	6 (8%)	18 (22%)	8 (10%)	8 (10%)	11 (14%)	8 (10%)	13 (16%)	8 (10%)	80 (100%)
100000	200000	3 (4%)	11 (14%)	12 (15%)	14 (17%)	13 (16%)	8 (10%)	11 (14%)	8 (10%)	80 (100%)
150000	250000	2 (3%)	10 (13%)	15 (18%)	13 (16%)	5 (6%)	6 (8%)	17 (21%)	12 (15%)	80 (100%)
200000	300000	3 (4%)	11 (14%)	16 (20%)	10 (13%)	6 (8%)	4 (5%)	21 (25%)	9 (11%)	80 (100%)
250000	350000	1 (1%)	6 (8%)	13 (16%)	20 (25%)	7 (9%)	4 (5%)	19 (23%)	10 (13%)	80 (100%)
300000	400000	2 (3%)	6 (8%)	11 (13%)	21 (25%)	3 (4%)	4 (5%)	18 (23%)	15 (19%)	80 (100%)
350000	450000	1 (1%)	1 (1%)	17 (21%)	21 (26%)	1 (1%)	2 (3%)	24 (31%)	13 (16%)	80 (100%)
400000	500000	0 (0%)	1 (1%)	19 (24%)	20 (25%)	1 (1%)	0 (0%)	26 (33%)	13 (16%)	80 (100%)
450000	550000	0 (0%)	0 (0%)	18 (23%)	22 (27%)	0 (0%)	0 (0%)	28 (35%)	12 (15%)	80 (100%)
500000	600000	0 (0%)	0 (0%)	26 (32%)	14 (18%)	1 (1%)	0 (0%)	21 (26%)	18 (23%)	80 (100%)
Total		18 (2%)	64 (8%)	155 (17%)	163 (23%)	48 (6%)	36 (5%)	198 (24%)	118 (15%)	800 (100%)

Source: Research finding.**Note:** * The unit is Rials. ** The numbers in parentheses beside the number of responses are the percentage of sample size.**Table 2.** Estimation Results of the Spike Model

Variables	Coefficient Estimation (t-value)
Constant	0.008 (-8.45)
Bid amount	-76.37 (-86.13)
Spike	0.99
Mean WTP	92886 Rials
95% confidence interval	81644 to 104127 Rials
99% confidence interval	80128 to 105643 Rials
Log-likelihood	-15237.26
Wald statistics (p-value)	341.12 (0.000)
Number of observations	800

Source: Research finding.

Table 3. Definitions and Sample Statistics of the Variables

Variables	Definitions	Mean	Standard Deviation
AGE	Dummy for the average of family age being larger than forty. (1 = Yes; 0 = No)	0.37	0.512
INCOME	Interviewee's households' income per month (unit: million Rials)	60.3	1.84
HOUSE SIZE	Dummy for the interviewee's house size being bigger than 200 m ² (1 = yes ; 0 = no)	0.72	0.48
FAMILY SIZE	Number of the interviewee's family members	3.56	1.23
EDUCATION	Dummy for average educational level of the family in years being larger than twelve (1 = Yes; 0 = No)	0.58	0.53
OUTAGE EXPERIENCE	Dummy for the interviewee's having experienced power outages (1 = yes ; 0 = no)	0.34	0.49
DAMAGE AWARENESS	Degree of the interviewee's awareness of the damage caused by power outages (from 1 to3)	1.62	0.76

Source: Research finding.

Table 4. Estimation Results of the Spike Model with Covariates

Variables	Coefficient Estimation (t-value)
Constant	-0.004 (-4.25)
Bid amount	-43.56 (-21.5)
Spike	0.85
Age	-0.0013
Income	0.145 *
House size	-0.253 *
Family size	0.057
Education	0.024 *
Outage experience	0.126
Damage awareness	0.281 *
Log-likelihood	-13568.32
Wald statistics (p-value)	326.56 (0.000)
Number of observations	800

Source: Research finding.

Note: * denotes statistical significance at the 5% level.

In Kerman, the average monthly electricity bill for households was 1,120,650 Rials (approximately USD 4.48). Consequently, the mean WTP represents 8.2% of this monthly bill. To account for uncertainty in estimating the average WTP, confidence intervals (CIs) were employed instead of point estimates. As noted, the theoretical validity of contingent valuation models can be assessed by incorporating covariates into the estimation. Table 2 outlines the definitions and descriptive statistics of the variables included in this study, which comprise the dummy variables AGE, INCOME, HOUSE SIZE, FAMILY SIZE, EDUCATION, OUTAGE EXPERIENCE, and DAMAGE AWARENESS.

Table 4 presents the outcomes of the model estimation incorporating covariates. A positive (or negative) coefficient for a given variable indicates that higher values of that variable increase (or decrease) the likelihood of a “yes” response to the proposed bid amount. For instance, greater awareness of the damages resulting from power outages positively influences the acceptance of the bid price. Additionally, the coefficient signs reveal that individuals with larger families, higher educational attainment, greater household income, or prior experience with outages are more inclined to agree to a specific bid. Conversely, those residing in larger homes are less likely to accept the bid, likely due to their already substantial electricity expenses.

The estimation results in Table 4 reveal that the coefficients for INCOME, HOUSE SIZE, EDUCATION, and DAMAGE AWARENESS are statistically significant at the 5% level, indicating their influence on the probability of agreeing to the proposed bid. In contrast, the coefficients for AGE, FAMILY SIZE, and OUTAGE EXPERIENCE are not statistically significant, suggesting these factors do not substantially affect the likelihood of a “yes” response to the bid. In 2021, Kerman was home to an estimated 872,359 households. Multiplying this number by the average monthly WTP per household (92,886 Rials, as noted earlier) and extending it over 12 months yields an annual WTP of approximately 972 billion Rials (equivalent to USD 3.89 million). This figure represents the yearly economic value of preventing power outages in Kerman’s residential sector. It should be noted that differences in study objectives, methods, and regional contexts complicate direct comparisons with other research. Nonetheless, the findings of this study appear generally consistent with earlier work. For example, Ozbaflı and Jenkins (2015) found that the average household WTP to avoid power outages was 13.8% of their monthly electricity bill, a result that aligns closely with the present study’s outcomes.

4. Conclusion

Power outages, though unavoidable, impact various sectors reliant on electricity. This study explored households' WTP to avoid such disruptions. The contingent valuation (CV) approach, commonly used for valuing non-market goods, was employed. Among CV techniques, the OOHb-DC method, known for its statistical efficiency, was selected and paired with a spike model to address zero WTP responses. The survey, conducted in May 2021, involved 800 participants in Kerman, Iran. Findings indicate that 45% of respondents expressed no WTP. The OOHb-DC spike model estimated a mean monthly WTP of 92,886 Rials (approximately USD 0.37) per household, equivalent to 8.2% of the average monthly electricity bill. Based on this, the total annual WTP for Kerman's households in 2021 was calculated at 972 billion Rials (roughly USD 3.89 million). Additionally, socioeconomic covariates were integrated into the model to examine their influence on WTP responses.

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Green Roof Valuation: Economic and Environmental Benefits Analysis

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Abstract

In the city of Tehran, factors such as the high value of land and rising prices have prevented the expansion of urban green spaces and kept green space per capita at a low level in comparison to international standards, leading to an increase in the need for citizens to have a place to rest and relax. Accordingly, creating vertical green spaces, such as walls and green roofs, plays a significant role. Therefore, introducing the functions and explaining the value of the economic and environmental benefits of developing such spaces is a necessity that can pave the way for the expansion of investment in this area. In this regard, the present study aims to assess the economic justification of green roofing in Tehran. Considering the two criteria of air pollution and green space per capita, district 2 of the municipality was selected, which is a host to a variety of social and economic classes. The discrete choice experiment (DCE) method was used to determine the economic value of green roof environmental services. In addition, the net present value (NPV), internal rate of return (IRR), and benefit–cost ratio (BCR) indices were utilized for cost–benefit analysis (CBA) of green roofing. Based on the results, citizens were willing to pay an average of 182.1 \$/m² to enjoy the aesthetic and environmental benefits of green roofs. Moreover, green roofing in the study area was economically justifiable, so that the average IRR was 44% and NPV was \$187 during 2020. However, the IRR increased by 175% to an average of 121% considering the environmental benefits of this technology, and the NPV grew by approximately 388% to \$914.

Keywords: Cost–Benefit Analysis, Discrete Choice Experiment Method, Environmental Services, Green Roof.

JEL Classification: D1, Q51, P25, P28, Q57.

1. Introduction

The environment can reduce some of the pollution produced by urban and industrial communities, including air pollution, according to its ecological

capacity. However, sometimes discharging harmful substances into the environment is such that the rate and speed of cleaning is less than the amount of pollutants and these substances, which creates dangers in densely populated or active industrial centers, leading to crises and disruption of daily life in some cases (Zhiming et al., 2018; Vang et al., 2017; Angeler et al., 2019). Thus, dealing with the pollution created and preventing the creation of new sources of pollution is among the necessities for the continuation of human life. In recent years, various solutions have been proposed, including the green economy. According to the definition of the [United Nations](#), the green economy is among the methods to improve the equality of human well-being and social justice, along with a significant reduction in environmental risks and ecological scarcity. The green economy includes all economic sectors of a country and provides frameworks for human activities. Meanwhile, the need to achieve green economy objectives in the field of human capital development, the attraction of sustainable living standards, and concerns about the planet has led to urban planners' tendency toward sustainable cities that pursue objectives such as developing human capital, improving energy conservation and efficiency, water security, construction standards, food waste management, and economic and social justice (Sodiq et al., 2019). Construction is among the most important dimensions of a sustainable city, which is called green building. Green buildings help reduce environmental pollution, especially air pollution, with various components, the most important of which is the green roof or using unused spaces in urban buildings to create a green landscape, which improves and softens the air, reduces air pollution, decreases energy consumption, prevents ultraviolet radiation to buildings, reduces the temperature and the heat island phenomenon, and so on, resulting in improving the environment of city residents (Shafique et al., 2018; Williams et al., 2019). Green roofs usually include several layers, are planted with design and purpose, do not interfere with other urban uses of the roof, and are implemented easily in current and new buildings (Vanstockem et al., 2018).

Based on some studies, 67.9% of the area in Tehran (730 km²) includes roofed lands with different uses, and the rest is related to passages and open spaces. Based on the statistics of Tehran Municipality, the green space area of Tehran is approximately 480,000 hectares, and the average per capita green space, including private gardens, is approximately 15 m² (Taghavi, 2013), which is significantly far from the standard announced by the United Nations (UNEP), which is equal to 20 to 25 m² per person. Using green roof technology in Tehran seems to be a good option due to the improvement and stability of urban environments, along with the

high added value of the land and the low area of green space (Khosravi and Ghobadi, 2014). Some studies indicate that at least approximately one-fifth of the area in Tehran can be turned into green space, and air pollution can be significantly reduced by encouraging citizens to implement the "green roof" project (Taghavi, 2014).

Many studies have been conducted around the world on the economic and environmental dimensions of green roofs (e.g., Ruan, 2006; Nurmi et al., 2013; Zeng et al., 2017; Teotónio et al., 2021; Calheiros and Stefanakis, 2021; Manso et al., 2021; Mihalakakou et al., 2023; Mohamad Hamzah et al., 2023). Mohammadi et al. (2019) reported that using green roof technology is justifiable only by considering its benefits, such as reducing air pollution, decreasing energy consumption, and alleviating harmful effects on the environment, so that an initial cost of 29,76 \$/m² generates a profit of 33,33 \$/m². In addition, Peng and Jim (2015) emphasized the usage of green roofs in aspects of climate change, including thermal insulation and carbon dioxide decomposition, by utilizing the cost–benefit analysis (CBA) method in scenarios of extensive and centralized construction methods, indicating that extensive and centralized green roofs have values equal to 10,77 and 18,33 \$/m², respectively. Furthermore, Zhang et al. (2019) calculated the willingness to pay in Beijing, China, using a conditional valuation method and found that each family is willing to pay an average of 148,582 yuan (US\$22,446) per year for applying for a green roof to reduce the urban heat island (UHI). Abedi and Kheiri (2020) investigated the economic justification of the construction of a green roof in District 9 of Tehran Municipality. For this purpose, the Discrete Choice experiment and indicators of profitability indexes have been used. The results show that the construction of a green roof is not justifiable from an economic point of view in the study area. Importing the value of environmental benefits in the assessment leads to a net present value of 11.349 million rials and an internal rate of return of 53 percent. The results also show that the value of the environment that the citizens of this region are willing to pay for the construction of each square meter is equal to an average of 5.44 million rials. In this case, the benefit-to-cost ratio will be 1.92. Bus and Szelągowska (2021) calculated the ecological (EE) and economic effect (EcE) of water harvesting via Green roofs, by using the Net Present Value (NPV) method for both intensive and extensive GRs in 11 of the largest municipalities in Poland. Results showed that the economic and ecological effects of GRs equal 507,000 m³/yr and 621,000 USD/yr. The NPV results show that the average equals 60.77 and 4.47 USD/yr for intensive and extensive GRs, respectively. Hekrlé et al. (2023) aim to provide comparable

information on the economic value of three Green roof projects using two alternative CBA approaches in Czechia and Portugal. The results showed that the monetary GR benefits are four to six times greater than the costs, depending on the case study.

Green roof technology has not been widely used due to a lack of sufficient information on cost–benefit issues, although some studies have confirmed the environmental value of this technology (Mahdiyar et al., 2016). Furthermore, a large number of researchers have aimed to translate the environmental benefits of green roofs into monetary values (Peng and Jim, 2015). However, Williams et al. (2019) argued that the number of studies in this field is limited, despite proving the psychological effects of green roofs, including beauty, recreation, and health, probably because the studies related to this technology are in the early stages of development.

In this study, the information function of the green roof, including beauty, recreation, and health, is evaluated through the choice experiment method, and its economic value is calculated as the added value of the building. Finally, a cost–benefit analysis is used in scenarios with and without considering environmental benefits to investigate the justifiability of using this technology in Tehran. It should be noted that the paper could interest readers in urban environmental planning, urban economy, and natural resource economics. Regarding the valuable functions of green roofs, there is a significant gap in assessing this technology, especially in developing countries such as Iran. However, very few studies in Iran have descriptively examined the benefits of green roofs. Moreover, no studies have evaluated the specific functions of green roofs, such as "beauty, recreation, and health," especially by the contingent choice experiment method. Therefore, the present study is considered innovative in terms of considering economic and environmental value, as well as comparing the two scenarios, and its results can be used in economic and environmental policies.

2. Methodology and Data

Economic evaluation is regarded as a necessary process to calculate the potential or initial costs and benefits of a strategy and evaluate its feasibility, which is done by assessing the costs and benefits of each project over time. This technique makes it possible to compare the alternatives and provides a systematic system for decision-making and bargaining (Mahmoud et al., 2017). In this context, CBA is among the methods of economic evaluation implemented in public and private projects and is considered the practical application of modern welfare economics

in public policy-making. CBA seeks to account for the positive and negative consequences (advantages and disadvantages) of economic activities by converting them into financial flows and choosing the best possible option. The benefit–cost ratio (BCR), net present value (NPV), and internal rate of return (IRR) are utilized to accept or reject the investment plan in the framework of CBA (Boardman et al., 2018; Choy, 2018).

Benefit–Cost Ratio (BCR): This method is obtained by dividing the present value of the benefits by that of the costs as follows.

$$BCR = \frac{\sum_{t=1}^n \frac{B_t}{(1+r)^t}}{\sum_{t=1}^n \frac{C_t}{(1+r)^t}} \quad (1)$$

where r represents the discount rate (reflecting the opportunity cost of resources), and B_t and C_t indicate the benefits and costs of the project in year t , respectively. Deciding on the investment plan is conducted as follows. The plan is economically justified and accepted if the $BCR > 1$. In addition, the plan is at a breaking point if $BCR = 1$, in which it is not possible to comment on its acceptance or rejection. Finally, the plan has no economic justification and is not accepted if the $BCR < 1$.

Net Present Value (NPV): This index is regarded as the difference between expected discounted cash flows and initial investment. The discounted present value of the project is shown in Equation (2), if I represent the amount of zero-year capital, B_1 to B_n indicate project revenues in years 1 to n , and C_1 to C_n are considered project costs in different years. According to the decision criterion based on NPV, the plan is economically justified and accepted if $NPV > 0$, and it has no economic justification and is not accepted if $NPV < 0$.

$$NPV = -I + \frac{(B_1 - C_1)}{(1+r)} + \frac{(B_2 - C_2)}{(1+r)^2} + \dots + \frac{(B_n - C_n)}{(1+r)^n} \quad (2)$$

Internal Rate of Return (IRR): This rate is equivalent to the rate of return that an investor can earn by investing in a project. The IRR is regarded as the discount rate at which the present value of benefits equals that of costs. The IRR can be calculated as Equation (3) by setting the NPV equal to zero and considering r unknown. In this equation, r represents the discount rate, which is considered a reflection of the lost costs of resources in the plan. The IRR is greater than the discount rate (market interest rate + risk savings) in an acceptable scheme. In general, two scenarios can be regarded for IRR as follows. The plan is economically justified and accepted if $IRR > MARR$, and the plan has no economic justification and is not accepted if $IRR < MARR$. It is worth noting that MARR is

equal to the minimum acceptable rate of return and is regarded as the same as the discount rate.

$$\sum_{t=1}^n \frac{(B_t - C_t)}{(1+r)^t} - I = 0 \quad (3)$$

From an economic point of view, values can be due to the consumption of goods and services that are bought and sold in the markets. In addition, they are dependent on services received from the environment without payment (Pak et al., 2010). In the present study, the information function of green roofs in the fields of beauty, recreation, and health is among these values. For this aim, the choice experiment method was used for valuation as one of the subsets of modeling and an indirect method of expressing preferences, which has been used to evaluate nonmarket goods in the fields of environmental and health economics in recent years. The choice experiment method seeks to evaluate the mental structure of consumers with an emphasis on the relative importance of features. To this aim, individuals are asked to choose the alternative option with the most appropriate among the options gathered on a selection card (Champ et al., 2003). Based on the choice experiment method, the product is described according to a number of its features, which can be used to examine consumers' reactions to changes in the properties of goods. The suggested alternatives in each selection card are different levels of each feature. Variation among alternatives is created by considering different levels for each feature, which is based on a systematic process called experimental testing (Kjaer, 2004; Shanahan et al., 2019). According to this method, the indirect utility function for each respondent i (U) is divided into a definite section (V), usually regarded as a linear index of the feature of the various options j in the choice experiment set, and a random section (ε), which indicates the invisible effects on individuals' selection. The following equation displays the indirect utility function (Shin and Lyu, 2018).

$$U_{ij} = V_{ij}(X_{ij}) + \varepsilon_{ij} = \beta X_{ij} + \varepsilon_{ij} \quad (4)$$

The implicit prices can be calculated for the corresponding features and levels after assessing the model. The partial prices can be calculated as follows using the marginal rate of substitution (MRS) once the cost of selecting each option is entered as one of the features (Hogberg et al., 2007).

$$WTP_j = -1 \times \left(\frac{\beta_i}{\beta_{price}} \right) \quad (5)$$

2.1 Steps for Designing and Executing the Choice Experiment Method

a) Selecting the features and level allocation: The features or traits selected should be meaningful and understandable to the respondents. To determine the traits and identify the levels of each, previous studies in this field (e.g., Mohammadi et al., 2019; Vanstockem et al., 2018), as well as the experts' opinions in green roof design and construction companies such as "Chekad Bam" and "Iran Roof Garden", were used, and criteria such as operationally, separability, and having minimum size were considered. It is noteworthy that price is among the studied traits, which makes it possible to evaluate the willingness to pay (Champ et al., 2003). Finally, four features with three levels were selected (see Table 1).

b) Selecting a statistical plan: To combine the features with different levels, a statistical plan should be used to create some scenarios or profiles for presenting to the respondents from these combinations (Vanstockem et al., 2018). A fractional factorial design was applied because it is widely used to reduce the number of options (Street et al., 2008; Shin and Lyu, 2018).

Table 1. Selected Features and Levels for Designing a Choice Experiment

Features	Levels	1	2	3	4
1	Procedure	Extensive (Requires less infrastructure)	Centralized (Requires more) infrastructure	Boxlike (Preprepared box with plants)	
2	Vegetation	Grass and a variety of herbaceous plants	Combining a variety of grass, decorative plants, and fancy décor	Shrubs, decorative plants, and fancy decor	I do not want to pay extra to use this technology, or prefer the current condition of the roof
3	Percentage of greenery	Less than 30% of the roof surface	30-60% of the roof surface	More than 60% of the roof surface	
4	Price (value added per square meter of property)	\$83.5	\$137	\$190.5	

Source: Research finding.

Table 2. An Example of the Designed Selection Card

Which option do you prefer?				
	Option 1	Option 2	Option 3	
Procedure	Boxlike (preprepared boxes with plants)		Centralized (Requires more) infrastructure	
Dominant vegetation	Combining a variety of grass, decorative plants, and fancy décor		Grass and a variety of herbaceous plants	I do not want to pay extra to use this technology, or prefer the current condition of the roof
Amount of vegetation	30-60% of the roof surface		Less than 30% of the roof surface	
Extra payment per square meter of property (Which leads to an increase in the price of the property at the time of sale)	\$190,5		\$83,5	

Source: Research finding.

c) Constructing selection and blocking sets: The scenarios are grouped into the selection sets after determining the composition by the statistical plan, so that each has two or more alternatives with an option called "current situation", in which the person is not willing to change and does not choose any of the proposed options. In addition, the current situation option helps make the questionnaire more realistic (Lancsar et al., 2017). In the present study, 12 optimal options with the highest statistical efficiency were formed through orthogonal design using SPSS software. Then, the sets were selected considering conditions such as balance of levels (equal repetition of each level) and minimum overlap (existence of different levels in each selection set) (Hazlewood, 2018). Table 2 shows an example of the designed selection card.

d) Designing questionnaire, selecting statistical population, sample size, and sampling method: The questionnaire was designed in three parts. Some explanations about green roof technology and its procedures were given at the beginning of the questionnaire to acquaint the audience. Then, several questions were asked about individual features and socioeconomic status in the first part. The questions in the second part were related to the respondent's personal attitude toward the environment and its general acceptance among individuals. Finally, three sets of choices with three scenarios in each were presented in the third part as the most important part of the questionnaire, among which the respondents chose the most appropriate one. It is worth noting that the population included the residents in District 2 of Tehran municipality. Based on the air pollution data during the last three years extracted from the reports of Tehran Air Quality Control Company, as well as the statistical yearbooks of Tehran municipality, district 2 is among the regions with the highest per capita green space and the lowest air pollution. Therefore, studies can determine the importance of green roofs among the population without any need for this technology and facilitate policy-making for their expansion. Highly large and small samples (fewer than 30 people) lead to a waste of time and resources with no good results, since the sample size depends heavily on the researcher's budget and time (WHO 2012). Sampling was conducted in the clusters due to the selection of a specific area of the city. Then, 200 questionnaires were distributed considering the Morgan table, among which 60 completed and provable questionnaires were collected in 2020. Finally, 540 observations were obtained.

e) Level coding: In the present study, virtual coding was used (Hensher et al., 2005). To perform coding, the variables related to each feature should be determined, the number of which can be obtained as follows.

$$\text{Number of variables} = L-1$$

(6)

where L represents the number of levels of each feature.

f) Economic model: The conditional logit model was selected according to the existing theoretical literature (Strauss et al., 2018; Clark et al., 2014; Cleland et al., 2016; Costa et al., 2018). However, selecting from the selection sets should have the feature of independence of irrelevant alternatives in explaining this model (IIA hypothesis), which indicates that the ratio of the probability of choosing between the two alternatives does not depend on the presence or absence of the third one. Assessing the conditional logit pattern without considering this hypothesis provides biased results. There are various tests for examining this hypothesis, among which the Hausman-McFadden test is widely used. The conditional logit model is not considered reliable, and more complex models should be applied in case of violating the aforementioned hypothesis (Mogas et al., 2006).

2.2 Introducing the Experimental Regression Model

The experimental model utilized in the present study is expressed as follows, considering the studies conducted in the field of choice experiments (Ruokamo, 2016; Costa et al., 2018).

$$Choice_i = ASC + \beta_1 X_{1i} + \dots + \beta_s X_{si} + \delta_1 Z_{1i} + \dots + \delta_j Z_{ji} + \epsilon_i \quad (7)$$

where choice is regarded as a dependent variable indicating the individuals' selection. Choice represents the individual's selection among the three alternatives (options) in each selection set. ASC indicates Alternative-Specific Constant, which accepts 1 when individuals are willing to pay (options 1 and 2) and zero when they are reluctant to pay or maintain the status quo (option 3). X_s are considered the specific features of the alternatives (three green roof features with price), and β_s represent their coefficients. Individuals' personal-economic features should enter the model as a product of a particular feature, such as ASC or price, since they are considered constant during the alternatives of a selection set (Palmquist 2005). The abovementioned product was used in the present study because multiplying these features by the price led to more consistent results. In the above model, Z represents the individuals' personal-economic features, which are multiplied by P (price), and δ are regarded as their coefficients.

2.3 Hypothesis Used in the Economic Evaluation

The hypothesis used in the CBA is shown in Table 3. The base year of 2018 is considered because the extracted costs used in the analysis were collected in the winter of 2018. The period under consideration is 30 years, which was selected according to the useful life of green roofs (30-40 years in Iran). The discount rate is 25%, which is regarded as attractive for investment and represents the opportunity cost of capital. The discount rate was obtained based on bank and stock market interest rates and previous studies (e.g., Feng and Hewage, 2018; Nurmi et

al., 2013), in which a single discount rate is used to discount all the benefits studied. The initial cost of green roofing, including the infrastructure of required layers and tree planting, as well as the cost of maintenance and irrigation, was obtained through field research and consultation with experts and green roofing companies in Tehran, such as "Iran Roof Garden" and "Negin Azin Part", which is equal to 238 \$/m² for initial implementation and 85 \$/m² per year for maintenance activities such as irrigation and gardening. The cost of replacing conventional roof insulation was obtained through field research and consultation with experts, which is equal to 119 \$/m². Replacing conventional roof insulation is among the advantages of green roofing since it eliminates the need for individuals to pay this cost. The added value of the property is among the economic benefits of green roofing, which is created by adding a welfare option to the building. According to some studies (e.g., Feng and Hewage, 2018; Bianchini and Hewage, 2012), as well as field studies, the added value created by green roofing for a building is equal to 5% of the price per square meter of the building. This amount was equal to \$190.5 and \$83.5/m² for district 2 of Tehran municipality, with a price of \$1667-3810/m² during 2020. The value of beauty, fun, and health, which are among the benefits of green roofs, was obtained through the choice experiment and calculated in maximum, average, and minimum modes.

Table 3. Hypotheses Used in the CBA

Title	Description	Unit
Base year	2020	Year
Review period	30	Year
Discount rate	25	Percentage
Initial cost of green roofing	238	\$/m ²
Maintenance and irrigation costs (monthly cost × 12)	85	Yearly \$/m ²
Cost of replacing conventional roof insulation	119	\$/m ²
Value added of the property in District 2 of Tehran municipality	190,5	Yearly \$/m ²
Value of beauty, fun, and health in District2 of Tehran municipality	Considering the maximum willingness to pay	307,1 Yearly \$/m ²
	Considering the average willingness to pay	182,1 Yearly \$/m ²
	Considering the minimum willingness to pay	147,4 Yearly \$/m ²

Source: Research finding.

3. Result

3.1 Choice Experiment Method

Table 4 shows the respondents' economic and social features, in which the majority of respondents in this region (55%) are men with an average age of 37.5 years. In addition, the highest and lowest relative frequencies belong to the

category of individuals under 30 years (55.8%) and over 50 years of age (3.5%). In terms of marital status, most of the respondents (76%) are married; it is noteworthy that the respondents who are single and live in their father's house or with their family were excluded from the sample to increase the accuracy of the questionnaire. Accordingly, all respondents have a relatively correct understanding of the cost of living and housing in their place of residence. Regarding the number of family members or housemates, the maximum and minimum numbers are equal to 5 and 1 persons, respectively, with an average of 3. The highest frequency of education is among bachelor respondents (40%), and the individuals' average level of education is equal to 16.4 years, indicating a high level of general education among the respondents. Regarding the respondents' economic features, 88.3% are employed (it is worth noting that the students and housewives are among the unemployed). In terms of monthly expenses, the highest frequency is in the category of 714, 3-1190, and 5 (48.1%), and the lowest, highest, and average monthly expenses are 476.2, 1904.8, and \$1061.9, respectively. Regarding the ownership status of residential housing, the majority of people (65.9%) are landlords, among whom 78.4% live in apartments and 21.6% live in villas. Most respondents live on the first floor, with a relative frequency of 40%.

Table 4. Respondents' Economic and Social Features

Variable	Relative frequency (%)		Mean	Variable	Relative frequency (%)		Mean
Employment status	Employed	88.3	-	Gender	Man	55	-
	Unemployed	11.7			Woman	45	
	238.1-\$714.3	34.0			Under 30	55.8	
Monthly family income (\$)	714.3-\$1190.5	48.1	\$1061.90	Age (year)	30-40	30.7	37.53 years
	1190.5-\$1666.7	15.5			40-50	9.9	
	1666.7-\$2142.8	2.3			50 and above	3.5	
Ownership status of residential housing	Landlord	66.0	-	Marital status	Married	76	-
	Tenant	34.0			Single	24	
Type of housing location	Apartment	78.4	-	Number of housemates	2 and less	35.8	3
	Villa	21.6			3	32.8	
	1	33.9			4	25.5	
Residential floor	2	24	2.35	Level of education	More than 5	5.8	16.43 years
	3	21.9			Diploma	1.2	
	4 and above	20.2			High school	13.8	

Source: Research finding.

Table 5. Respondents' Environmental and Personal-Economic Attitudes

Question code	Item	Percentage of responses					
Respondents' environmental attitudes							
		Strongly agreeing	Agreeing	Indifferent	Disagreeing	Strongly disagreeing	SD
Q1	A green roof can help improve my family's and my mood	63.7	21.8	1.9	0.7	0	0.6
Q2	A green roof helps increase the green space around my place of residence	62.4	28.4	7.1	1.4	0.7	0.8
Q3	Extensive use of green roofs reduces air pollution	53.5	26.4	12.3	7.0	0.7	0.1
Q4	A green roof plays a significant role in the beauty of individuals' living environment, freshness, and health.	75.5	21.6	2.2	0	0.7	0.7
Respondents' personal-economic attitudes							
Q5	A green roof has several benefits, and I am willing to pay extra for the property	30.9	29.2	24.2	13.0	2.7	1.2
Q6	A green roof is regarded as a luxury technology, which can only be used by the upper deciles of society	9.1	39.8	23.7	26.8	0.5	1.1
Q7	Using a green roof is considered expensive, and its implementation requires the support of government organizations and incentives such as tax breaks, overcrowding, construction loans, and the like	24.1	48.4	11.6	11.3	3.8	1.2
Q8	There is no culture for the common use of green roofs in Tehran, and implementing its technology is only appropriate for private property	26.5	43.6	18.2	9.3	2.2	1.1

Source: Research finding.

Table 6. Results of Assessing the Hybrid Conditional Logit Model

Symbol	Variable	Coefficient	Standard error	Z-statistic	Significance level
ASC	Alternative-specific constant	- 0.1246	0.4315	- 0.29	0.773
Motemarkez	Centralized construction method	** 1.2280	0.6070	2.02	0.043
Jabei	Boxlike construction model	*** 1.8093	0.6093	2.97	0.003
Chaman	A cover of grass and herbaceous plants	*** 5.6458	1.6099	3.51	0.000
Tarkibi	A combined cover of herbaceous and fancy plants	*** 6.8206	2.0112	3.39	0.001
Fantezi	A cover of fancy plants	*** 8.3008	2.6966	3.08	0.002
Less_than_30	greenery percentage of less than 30%	*** - 4.2065	1.5107	- 2.78	0.005
Mid	greenery percentage of 30-60%	*** -2.3150	0.8868	-2.61	0.009
Pr	Price	*** - 0.0110	0.0020	- 5.35	0.000
prHhExpmtoman	Price × Income	*** 0.0004	0.0001	3.46	0.001
PrEdu	Price × Education	*** 0.0003	0.0000	4.51	0.000
Prgnr	Price × Gender	* 0.0006	0.0003	1.86	0.063
prMarstatus	Price × Marital status	* 0.0006	0.0003	1.72	0.085
prHousestatus	Price × Home ownership status	* 0.0007	0.0003	1.91	0.056
Prob > chi ² = 0.000			N = 540		
Peseudo R ² =0.1426			LR chi ² = 75.80		
			Log likelihood = -227.94928		

Source: Research Finding.

Note: * Significance at the level of 10%, ** Significance at the level of 5% , *** Significance at the level of 1%.

Table 5 indicates the respondents' environmental and personal-economic attitudes. In the environmental attitude questions, the majority of respondents selected the options of agreeing and strongly agreeing. As shown, 85.5, 90.8, 79.9, and 97.1% of the respondents chose the options of agreeing or strongly agreeing in the questions with Q1, Q2, Q3, and Q4 codes, respectively.

Additionally, Table 5 represents the respondents' personal-economic attitudes in District 2 of Tehran municipality. As illustrated, the option of strongly agreeing has the most answers in questions with Q5 (30.9%), Q6 (39.8%), Q7 (48.4%), and Q8 (43.6%) codes.

3.2 Results of Assessing the Conditional Logit Model

In selecting the variables according to the study of Vanstockem et al. (2018), all of the features and levels were entered into the model, and the software used (STATA 14.2) eliminated two levels of "extensive" (from the construction method) and "more than 60%" (from the roof greenery) due to alignment. Therefore, the variables were excluded during the assessment, and the final model was evaluated with 14 variables, the results of which are shown in Table 6.

The heterogeneity of preferences created due to differences in people's tastes is among the issues in demand for environmental and tourism goods. Incorporating socioeconomic variables is regarded as the solution for addressing this issue. However, the individuals' personal-economic features should be entered into the model by multiplying by a specific feature, such as ASC or the price, because these features are considered constant during the alternatives of a choice experiment (Palmquist, 2005). In the present study, price interactions with individuals' socioeconomic variables were used. In the evaluated model, gender, income, education, marital status, and home ownership status had more consistent results among the individuals' socioeconomic variables, which were entered into the model as a product of the price variable. The IIA hypothesis should be examined before interpreting the results of the evaluated model, since there is a possibility of bias in the results, and another model should be applied when the hypothesis is not accepted. As represented in Table 7, the IIA hypothesis is not rejected, and the conditional logit model is considered appropriate for evaluation. In addition, the null hypothesis is not rejected, and the results of the evaluated model can be cited.

Table 7. Results of the Hausman-McFadden Test for the Conditional Logit Model

Eliminated option	Statistic	Significance level
First option	19.3	0.0134
Second option	14.4	0.0722

Source: Research finding.

As indicated in Table 6, the value of Pseudo R^2 in this model is equal to 0.1426, which is regarded as acceptable when its value is more than 0.1 (Louviere et al., 2000). The value of the statistic χ^2 , which is considered the ratio of likelihood and represents the overall significance of the coefficients, is equal to 75.8, and its probability is zero, meaning the overall significance and appropriateness of the model and its variables. Based on the results, ASC has a negative sign, which indicates that the respondents are generally reluctant to pay extra and change the current state of their roof, and their appropriateness does not increase by paying the amount and constructing a green roof in houses (e.g., Hashemibonab et al., 2012; Ruokamo, 2016; Cosmina et al., 2016; Bazzani et al., 2017). The aforementioned result is among the expected states for ASC. All variables have a positive coefficient, except for the greenery percentage of less than 30 and 30-60% and price, meaning that the presence of the feature leads to increased WTP. For example, the negative coefficient for coverage of 30 and 30-60% indicates that people do not prefer these two modes to the current state of the roof. In other words, these levels of roof greenery reduce people's WTP when other features remain constant. However, people prefer centralized and box-like methods to the current situation, which can increase their WTP for green roofs when other features are constant. Regarding the price feature, the negative coefficient indicates that people's willingness to pay extra to use the green roof decreases with an increase in the cost of this technology. Comparing the results of the study regarding price features with other studies confirmed that the coefficient of price features is negative, as in most studies of the choice experiment method (e.g., Isazade et al., 2013; Shin and Lyu, 2018; Cosmina et al., 2016). As observed, individuals' socioeconomic features have positive coefficients. Based on the coding, the positive coefficient of gender indicates that men are more willing to pay. According to the positive coefficient regarding individuals' marital status, married people are more willing to pay than single people. In addition, individuals' willingness to pay the price rises with an increase in income and the years of education. Furthermore, home ownership status is regarded as a positive sign, meaning that landlords are more willing to pay than tenants.

In the choice experiment studies, the marginal rate of substitution between the features and the price variable is calculated according to Equation (2) to make more practical use of the obtained coefficients. The choice experiment eases calculating the value of each feature separately, in addition to evaluating the willingness to pay overall and assessing the total value of an environmental commodity, which is among its advantages. It is noteworthy that in the present study, the willingness to pay the total is considered, and analyses are entered. Table 8 shows the results related to the calculation of the WTP for the environmental features of green roofs. To analyze more accurately and calculate all the cases, the

studies were conducted in maximum, average, and minimum scenarios, which represent the highest, average, and lowest willingness to pay for each feature and the sum of the features.

Table 8. Results of the Willingness to Pay for the Features of the Green Roof

Feature	Procedure	Type of covering	Percentage of greenery	Sum (\$/m ²)
Maximum willingness to pay (\$/m ²)	38,8	178,1	- 90,2	307,1
Average willingness to pay (\$/m ²)	32,5	149,6	- 69,9	182,1
Minimum willingness to pay (\$/m ²)	26,2	121,2	- 49,5	147,4

Source: Research finding.

As shown in Table 8, the respondents in District 2 of Tehran municipality are willing to pay 307, 1 \$/m² at best to have a green roof. The lowest WTP in this area is equal to \$147.4/m². In addition, the highest WTP of 178.1 \$/m² is for the type of green roof covering, which is related to fancy plants. Furthermore, the lowest WTP is related to centralized green roofing, which is equal to 26,2 \$/m². Regarding the percentage of roof greenery, WTP cannot be interpreted and analyzed due to its negative coefficients.

3.3 Cost-Benefit Analysis (CBA)

The CBA was conducted only in terms of the costs and economic benefits of green roofing. Table 3 shows the hypothesis used in the CBA.

As shown in Table 9, the NPV of green roofing in district 2 of Tehran municipality over a period of 30 years (useful life of green roof) is economically equal to 180.8 \$/m², meaning that green roofing in this area creates a value of 180.8 \$/m², considering all the costs and economic benefits. In addition, the IRR of green roofing is only 44% considering the economic benefits and costs, and its BCR is equal to 2 if we regard green roofing as the equivalent of an investment project. These figures improve significantly by increasing the environmental benefits so that the NPV triples to \$769.6, considering the minimum willingness to pay. Furthermore, the IRR increases by 62% in this case and reaches 106%. Given the maximum willingness to pay, the NPV increases approximately 6.5 times to \$1407.8. In this case, the IRR increases by 129% and reaches 173%.

Table 9. Financial Indices

Value		NPV-(\$)	IRR	BCR
Economic		180.8	44%	2
	Considering the maximum willingness to pay	1407.8	173%	4.5
Economic-environmental	Considering the average willingness to pay	908.5	121%	3.2
	Considering the minimum willingness to pay	769.6	106%	2.8

Source: Research finding.

4. Conclusion

The prevalence of apartment dwellings, lack of green space per capita, and the high value of land are among the factors that increase the need of urban residents for an environment for relaxation. Due to the importance of this issue for the Tehran metropolis, the present study aimed to assess the economic justifiability of green roofing in District 2 of the Tehran municipality. Based on the results, the NPV is 180.8 \$/m², the IRR is equal to 44%, and the BCR is equal to 2, considering only the economic benefits and costs. In addition, the residents of district 2 are willing to pay an average of 182.1 \$/m² for green roofs, which increases the NPV to \$908.5 in terms of the environmental benefits. In this case, the IRR grows by 175% and reaches 121%. Furthermore, the BCR improves by approximately 60% to 3.2.

Furthermore, a high percentage of residents chose a strongly agree option, which can justify their high WTP considering four statements related to the environmental attitude of people in District 2 of Tehran municipality. The tendency to pay high can be attributed to the young population responding in district 2 and their willingness to accept new technologies and change their lifestyle, which are consistent with the results of conversations with individuals when completing questionnaires and developing their mental patterns, so that most people who were not familiar with this technology were older and did not want to change their lifestyle.

Based on the theoretical foundations in the field of economic evaluation, a positive NPV and an IRR higher than the individual discount rate, which is usually obtained by adding market interest rates and risk savings and is considered equal to 25% in common studies in Iran, and a BCR greater than one make a project economically justifiable. Green roofing has both economic and economic-environmental justifications, considering only two benefits among others, such as beauty and recreation, along with health and economic added value. Therefore, future studies can be conducted by assessing the overall value of the environmental functions related to green roofs through the results of the present and other studies in this field and implementing incentive policies such as collecting less toll, expediting issuance, licensing, and density through their results since most people

believe that using this technology is considered costly and requires the support of government organizations and incentives. In addition, investigating the field of comparative study of metropolises in the world to provide a practical model for implementing this technology can be useful.

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The Impact of Benevolent (Interest-Free) Loans on Poverty in Iran

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Abstract

Although extensive research has been conducted on the impact of microfinance on poverty reduction, limited studies exist on the effect of charitable loans (interest-free or Qard al-Hasan) as an Islamic microfinance tool, primarily due to a lack of data. This article addresses this gap by employing a micro-data econometric model to investigate whether charitable loans have effectively reduced poverty among Iranian households. The study utilizes comprehensive data from 36 official financial institutions in Iran, including two specialized Qard al-Hasan banks - Resalat and Mehr of Iran - as well as data from numerous voluntary informal charity funds. Additionally, it incorporates household budget data from a large sample. The findings, derived from 24 distinct models, indicate that charitable loans significantly enhanced the spending power of poor urban and rural households, thereby having a positive and substantial impact on poverty reduction in Iran. Therefore, it is appropriate for the government to implement policies to expand them.

Keywords: Benevolent Loan, Micro-data Econometrics, Micro-financing, Poverty Reduction, Qard al-Hasan Instrument.

JEL Classification: C01, G21, I32, P36.

1. Introduction

Poverty reduction remains one of the most pressing challenges faced by countries today. In response, the United Nations has prioritized the eradication of poverty in all its forms as the first goal of its Sustainable Development Goals (SDGs). Specifically, the UN emphasizes the need to "ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation, to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programs and policies to end poverty in all its dimensions." (United Nations Organization, 1945). The ultimate

aim is that by 2030, no more than 3% of the global population will live on less than \$1.90 a day.

One of the fundamental strategies for alleviating poverty is microfinance. This innovative concept of providing small loans to local villagers based on trust and localized information was pioneered in the 1970s by Bangladeshi economist Muhammad Yunus, leading to the establishment of the Grameen Bank in 1983. Microfinance primarily supports impoverished individuals and women engaged in informal economic activities or entrepreneurial ventures who typically lack access to traditional bank loans. These microcredits impact household welfare in two key ways: by smoothing consumption and by enhancing the capacity to generate income. The significance of microfinance was underscored when the United Nations designated 2005 as the "Year of Microcredit."

The potential of microfinance to reduce poverty has been a subject of considerable research and debate. For instance, Duong and Thanh (2015) found that microcredits improved the living standards of rural households by increasing their income and consumption levels. Similarly, Choudhuri et al. (2017) reported significant positive effects on household income, expenditures, and savings in Bangladesh. Numerous other studies, including those by Khandker (2005), Nghiem et al. (2007), Imai et al. (2012), Yu et al. (2020), Thu and Goto (2020), Kaka (2020), and Chapagain and Dhungana (2020), have confirmed the positive role of microfinance in poverty alleviation through various mechanisms.

In the Iranian context, research on microfinance has also provided valuable insights. Hasanzadeh et al. (2012) proposed the adoption of a two-stage Islamic partnership (Musharakah) contract model, which has been successfully used in Sri Lanka for microfinance, and found it suitable for Iran as well. Di Pucchio (2015) highlighted an effective microfinance program implemented by the Iranian Agricultural Bank in collaboration with IFAD, which demonstrated significant impacts on women's empowerment and poverty reduction. However, Mosaviyan and Shahidinasab (2016) identified several challenges associated with microfinance in Iran's banking system, including moral hazard, high supervision costs, inadequate collateral, credit diversion, strategic default, low returns, and resource constraints.

Many religions, including Islam, emphasize poverty alleviation through specific mechanisms. Islamic microfinance is a notable tool in this regard, incorporating practices such as Qard al-Hasan (benevolent loans) and monetary endowments to assist the needy. A key distinction between Islamic and conventional microfinance lies in the prohibition of interest, making interest-free

loans more accessible. This cost-effective approach may enhance the efficacy of Islamic microfinance in reducing poverty compared to conventional methods.

Empirical studies have explored the impact of Islamic microfinance tools on poverty alleviation. For instance, Widiyanto et al. (2011) examined the performance of Baitul Mal Wat Tamwil, an Islamic microfinance institution in Indonesia, and concluded that Qard al-Hasan loans effectively empowered the poor to engage in economic activities. Rokhman (2013) highlighted the role of Islamic microfinance in improving household income and children's education. Iqbal and Shafiq (2015) evaluated the Akhuwat organization in Pakistan, which provides Qard al-Hasan loans, and found it successful in fostering entrepreneurship among economically and socially disadvantaged families. Zahid Mahmood et al. (2017) reported that loans from Islamic microfinance institutions significantly improved monthly income and increased spending on essentials like food, education, and health, as well as household assets. Muneer and Khan (2019) confirmed the positive effects of interest-free loans on poverty reduction. Selim (2018), using a mathematical model, demonstrated that the low cost of Qard al-Hasan loans promotes production, reduces price levels, and stabilizes the economy by addressing supply-demand imbalances.

Despite their potential, benevolent loans remain underutilized, even in Islamic countries, due to limited data availability. In Iran, however, two specialized banks exclusively provide Qard al-Hasan loans, and numerous charitable organizations also engage in this practice.¹ This creates a relatively rich dataset for analyzing their impact. Additionally, comprehensive household budget data from the Statistical Center of Iran enables the exploration of novel aspects of Islamic microfinance. This study leverages data from 12,258 households, divided into experimental and control groups, a sample size unparalleled in prior research. Furthermore, the use of multiple models to address the research questions is a key innovation of this article.

The remainder of the article is organized as follows: Section 2 discusses the charity sector in Iran, with a focus on benevolent loans and relevant institutions. Section 3 describes the research methodology, including the model, variables, and data. Section 4 presents the results and findings, while Section 5 outlines the policy implications. Finally, the conclusions are provided in Section 6.

¹. This issue will be discussed in the next section.

2. Charity Sector and Benevolent Loans in Iran

2.1 Charity Sector in Iran

In Iran, religious teachings and long-standing traditions emphasize helping the needy as a fundamental duty of every individual. As a result, donations are considered a regular part of living expenses, though financial limitations mean that many donors contribute modest amounts. Despite these constraints, Iran ranks 23rd out of 120 countries in charitable giving, according to the CAF report (2019). The needs of the poor are addressed through a combination of government initiatives and non-governmental organizations (NGOs). Currently, 52,233 charities and NGOs are officially registered in Iran (Information Database of Charities and Foundations in the Country), with most focusing on assisting the underprivileged.

Several government institutions play a central role in supporting the deprived, most notably the Imam Khomeini Relief Foundation (IKRF) and the Barakat Foundation. According to the IKRF's 2020 report, the organization provides 120 types of services, including pensions, social insurance, healthcare, marriage and dowry assistance, mortgage and rental allowances, scholarships for students, pilgrimage programs, education, housing support (construction, purchase, repair, and reconstruction), job creation, and client empowerment. As Iran's primary support institution, the IKRF has made significant contributions, such as providing 60,000 marriage grants, 20,500 mortgage loans, 64,000 essential items, constructing 26,627 urban and rural housing units, repairing 84,906 housing units for the needy, and creating over 172,000 jobs for those in need (IKRF¹, 1979).

2.2 Benevolent (Qard al-Hasan) Loan in Iran

In Iran, two types of financial institutions collect funds and extend interest-free loans. The first type consists of numerous voluntary small funds typically formed informally within social networks such as families, colleagues, or neighbors. Members contribute to the fund, and the pooled money is lent to a randomly selected member based on rules agreed upon by the participants, including frequency and loan duration. These funds are not formally registered as charitable organizations, and their operations are managed by volunteers.

The second type includes 34 official financial institutions that offer interest-free loans as part of their services, comprising Islamic banks and dedicated interest-free lending institutions (Tohidinia et al., 2021). Additionally, two banks in Iran specialize exclusively in providing Qard al-Hasan loans: the publicly owned Qarz Al-Hasaneh Mehr Iran Bank and the privately owned Gharzolhasaneh Resalat

¹. Imam Khomeini Relief Foundation

Bank. These banks fund their loans through benevolent savings accounts, which do not pay interest to depositors.

Based on Article 3 of Iranian “Law for Usury (Interest) Free Banking”⁴ ratified on 1983, banks are authorized to accept deposits under each of the following categories: (1) Qard al-Hasan and (2) Term Investment. Qard Hassan accounts can in turn be of two categories: current accounts’, which is similar to the current accounts in the conventional banking system, and interest-free saving accounts that differs from a conventional saving account. Banks finance their benevolent loans from Qard al-Hasan saving accounts or benevolent accounts, which pay no interest to the depositors. The benevolent loans are generally paid for marriage costs, home renovation, residential rents and mortgages, medical expenses, and educational expenditures of poorer households. Term investment account is an investment account that has positive return similar to the ones in conventional banking system. In summary, there are three types of accounts in Iran: Qard al-Hasan current accounts, Qard al-Hasan saving accounts (or benevolent/interest-free accounts), and investment accounts (Ibid).

Limited studies have investigated the effectiveness of Qard al-Hasan loans in Iran, but available research suggests they have made, or could make, significant contributions to the Iranian economy, particularly in poverty alleviation. For instance, Arabi and Meisami (2013) examined Qard al-Hasan loans in Iran, highlighting the differences between Islamic and conventional microfinance and demonstrating the positive impact of Islamic microfinance on financing poor and middle-class households. Similarly, Tohidinia et al. (2021), using the Toda-Yamamoto causality test, found that benevolent savings have short-term positive effects on total consumption and investment. Furthermore, Qelich and Taheri (2021) proposed a new model for microfinance in the Iranian banking system. Their model involves attracting deposits through a special mandate contract and providing facilities using Qard al-Hasan and Murabaha contracts, aiming to support the financial needs of the lower and middle classes.

3. Model and Data

This research utilizes household budget data collected by the Iranian Statistics Center for the years 2017 to 2020 (Statistical Center of Iran, 2020). The dataset includes detailed information on household expenses and incomes. Using R software, households that received Qard al-Hasan (benevolent loans) with a repayment rate of 4% or less were identified by location (urban or rural). The values of the analyzed variables for these households were then extracted.

To ensure robust analysis, a matching technique was applied: for each household that received a Qard al-Hasan loan, five comparable households that did not receive such loans were selected. Matching was conducted separately for urban and rural areas, and data on the relevant analysis variables were collected for these groups.

The final dataset consists of 12,258 household budgets divided into two groups: the treatment group (households receiving benevolent loans) and the control group (households not receiving these loans). The treatment group comprises 2,043 households (1,377 urban and 666 rural), while the control group includes 10,251 households (6,885 urban and 3,330 rural).

Table 1 provides a detailed breakdown of the sample households by year, location (urban or rural), and loan status (receiving or not receiving benevolent loans):

Table 1. Sample Household Distribution by Year, Urban/Rural, and Loan Status

year	Urban or rural sector	Households not receiving loans		Households receiving loans	
		SUM		SUM	
2017	Urban	2045	2860	409	572
	Rural	815		163	
2018	Urban	1815	2665	363	533
	Rural	850		170	
2019	Urban	1680	2550	336	510
	Rural	870		174	
2020	Urban	1345	2140	269	428
	Rural	795		159	

Source: Research finding.

The criteria used to select the closest households to the treatment group for the control group are outlined in Table 2. Five households were selected to match each household in the treatment group based on the following characteristics: gender of the household head, age of the household head, household size (number of family members), city of residence (since economic conditions vary significantly between cities within each province, we considered the city rather than the province), percentage of men in the household, percentage of household employment, and the weight of the household (where each household represents several others in the population). This matching process, carried out using R software, resulted in the selection of 10,215 households for the control group.

For example, as shown in Table 2, 42.8% of the treatment group and 29.11% of the control group were female, while 58.91% of the treatment group and 71.88% of the control group were male.

Table 2. Statistical Characteristics of Selected Variables for Matching the Control Group

		Borrowing group	Non-borrower group
Gender of the head of the household	Female	8/42%	11/29%
	Male	91/58%	88/71%
Age of the head of the household	Average	48/24 (13/13)	50/56 (14/68)
Family size	Average	3/56 (1/17)	3/3 (1/23)
City of residence	maximum ¹	10/62%	5/56%
Percentage of males in the household	Average	49/64 (19/11)	48/79 (20/81)
Percentage of household employment	Average	31/11 (22/32)	29/5 (22/78)
Percentage of household weight	Average	85/92 (89/6)	74/2 (79/93)

Source: Research finding.

Note: The numbers in parentheses indicate the standard errors.

In this research, the expenditures and incomes of poor households are analyzed separately as dependent variables. Changes in these variables serve as criteria for evaluating the poverty status of households. If receiving a Qard al-Hasan loan leads to an increase in the income or expenses of a poor household, it can be concluded that the loan has enhanced the household's purchasing power. This improvement indicates a higher level of welfare and likely, a reduction in the severity of poverty compared to the period before receiving the loan.

Household expenditures are categorized into seven main groups: food, clothing, healthcare, education, communication, housing, and insurance. Household income, on the other hand, is derived from three primary sources: fixed-salary employment, variable-salary employment, and miscellaneous income.

To investigate these factors comprehensively, the research considers total expenditures and total income, as well as each of their components, as dependent

¹. In both treatment and control groups, Isfahan is the city with the most matching.

variables in the model. For ease of reference, each model is assigned a number, as shown in Table 3.

Table 3. Dependent Variables

Dependent variable	Symbol	Model number
Total expenditures	T.C	1
Food expenditure	F.C	2
Clothes expenditure	CL.C	3
Housing expenditure	HO.C	4
Healthcare expenditure	HE.C	5
Connections expenditure	CO.C	6
Education expenditure	E.C	7
Insurance expenditure	I.C	8
Total Income	T.I	9
Income from fixed salary jobs	F.I	10
Income from jobs with variable salaries	V.I	11
Miscellaneous income	M.I	12

Source: Research finding.

The study analyzes eight models where the dependent variables represent various types of expenditures and four models where the dependent variables represent types of income. To assess whether the impact of Qard al-Hasan loans differs between urban and rural poor households, these 12 models were run separately for urban and rural households. As a result, the research examines 24 models. The explanatory and control variables included in the models are detailed in Table 4, derived from theoretical foundations and prior literature.

As noted in Table 4, a dummy variable was used to distinguish households that received Qard al-Hasan loans from those that did not, as well as to differentiate between poor and wealthier households. Additionally, qualitative control variables - such as the gender of the household head, marital status, housing tenure (owned or rented), and access to basic utilities (piped water, piped gas, and telephone) - were incorporated into the model using dummy variables. The city of residence was also included to capture location-specific economic and social factors.

Table 4. Explanatory and Control Variables

$treat_i$	A household that received a benevolent loan will receive a value of one and a household that did not receive a loan will receive a value of zero.
$poverty_i$	A household that is below the poverty line is given a value of one, and a household that is above the poverty line is given a value of zero.
$treat_i * poverty_i$	A household that has both received a benevolent loan and is below the poverty line.
$gender_i$	The gender of the head of the household is set to one if it is a woman and zero if it is a man.
age_i	Age of the head of the household.
$familysize_i$	Number of household members.
a_i	The number of people under 15 years of age in the household.
$marital2_i$	Marital status of the head of the household, the head of the household is married.
$marital3_i$	The marital status of the head of the household is the head of the household without a spouse (his wife is deceased or divorced).
$residence2_i$	Housing situation of the household, the household lives in a rented house.
$residence3_i$	Housing situation of the household, the household lives in a house where they do not pay rent and do not own the house.
$employed_i$	Percentage of household employment.
$female_i$	Percentage of women in the household.
$Aedu_i$	Average years of family education.
$Aage_i$	Average age of the family.
gas_i	Access to piped gas, a household that has access gets a value of one and a household that does not have access gets a value of zero.
$phone_i$	Access to phone, a household that has access gets a value of one and a household that does not have access gets a value of zero.
$water_i$	Access to piped water, a household that has access gets a value of one and a household that does not have access gets a value of zero.
$city_i$	City of residence of the household.
$year_i$	The year in which the household information was collected.

To account for events that may occur in specific years (e.g., elections, easing of sanctions), the dummy variable "year" was included in the model.

It is worth noting that some households receiving Qard al-Hasan loans are financially well off. Such households can access charitable loans by depositing money for a certain period, thereby increasing the financial resources available for granting benevolent loans. However, the primary purpose of these loans is to serve as a microfinance tool for poor households. Therefore, using the annual poverty

line for 2017–2020, recipients of Qard al-Hasan loans were categorized as either poor or non-poor.

The nominal poverty line, differentiated by urban and rural areas, was obtained from the Majlis Research Center reports for 2017–2018 and the Ministry of Labor, Cooperative, and Social Welfare reports for 2019–2020. To ensure comparability over time, the same basket of basic goods used to calculate the poverty line was applied to calculate the expenditure of sample households. Both the poverty line and household expenditures for each year were adjusted to real values by dividing them by the consumer price index (CPI), derived from Central Bank reports. A household was classified as poor if its expenditures fell below the poverty line.

The analysis revealed that only about one-third of loan recipients were poor, while approximately two-thirds were above the poverty line. Among non-loan recipients in the control group, about 39% were poor. Poor households received an average monthly loan of 0.747 million rials, while non-poor households received 1.385 million rials, meaning that non-poor recipients obtained loans approximately 1.85 times larger than their poorer counterparts. Consequently, a new explanatory variable, "poor household borrowing loans" (treatpoverty*), was added to the model.

Given the unique advantages of the Ordinary Least Squares (OLS) method—such as being an unbiased and efficient estimator—it was deemed suitable for analyzing the effect of one variable on another. However, since each sampled household in the Iranian Statistical Center data represents a certain number of households in the overall population, weighted least squares (WLS) was also applied. In the WLS method, each household is assigned a weight corresponding to the number of similar households in the population, ensuring more precise extrapolation of sample results to the national level.

To examine the impact of benevolent loans on the expenditures of poor households, functional form (a) was employed, while functional form (b) was used to analyze their effect on income:

a):

$$\begin{aligned} \log(C_i + 1)' = & \alpha + \beta_0 treat_i + \beta_1 poverty_i + \beta_2 (treat_i * poverty_i) \\ & + \beta_3 gender_i + \beta_4 age_i + \beta_5 familysize_i + \beta_6 a_i + \beta_7 marital2_i \\ & + \beta_8 marital3_i + \beta_9 residence2_i + \beta_{10} residence3_i \\ & + \beta_{11} employed_i + \beta_{12} female_i + \beta_{13} Aedu_i + \beta_{14} Aage_i \\ & + \beta_{15} gas_i + \beta_{16} phone_i + \beta_{17} water_i + \beta_{18} city_i + \beta_{18} year_i + \varepsilon_{1i} \end{aligned}$$

b):

$$\begin{aligned} \log(I_i + 1) = & \alpha + \beta_0 treat_i + \beta_1 poverty_i + \beta_2 (treat_i * poverty_i) \\ & + \beta_3 gender_i + \beta_4 age_i + \beta_5 familysize_i + \beta_6 a_i + \beta_7 marital2_i \\ & + \beta_8 marital3_i + \beta_9 residence2_i + \beta_{10} residence3_i \\ & + \beta_{11} employed_i + \beta_{12} female_i + \beta_{13} Aedu_i + \beta_{14} Aage_i \\ & + \beta_{15} gas_i + \beta_{16} phone_i + \beta_{17} water_i + \beta_{18} city_i + \beta_{18} year_i + \varepsilon_{2i} \end{aligned}$$

4. Result and Research Finding

The estimation results for urban households are presented in Table 5, enabling an evaluation of whether Qard al-Hasan loans have effectively reduced poverty. A significant increase in any category of expenditure or income for poor households influenced by the loan indicates an enhancement in their purchasing power, thereby demonstrating its effectiveness in poverty reduction.

As shown in Table 5, Qard al-Hasan loans have had a positive impact on the housing and education expenditures of poor urban households. Additionally, the loans have contributed to increases in total income, income from self-employment, and miscellaneous income among the urban poor. These findings suggest that Qard al-Hasan loans play a meaningful role in alleviating poverty in urban areas.

¹. Using log (x+1) as the dependent variable (instead of x) is a practical transformation that improves model fit, accommodates zeros in the data, and facilitates interpretation in terms of relative changes. This approach is particularly beneficial for skewed distributions or when working with count data or non-negative continuous variables.

Table 5. Results of Models for Urban Households

	T.C	F.C	CL.C	HO.C	HE.C	CO.C	E.C	I.C	T.I	F.I	V.I	M.I
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Intercept	1/69***	1/46***	0/6***	0/66***	-0/07	-0/11*	33***/-0	-0/31***	-25/97***	-0/05	-7/43**	-0/64**
	(0/11)	(0/16)	(0/14)	(0/09)	(0/16)	(0/05)	(0/09)	(0/09)	(3/12)	(0/3)	(2/54)	(0/24)
treat_i	0/01	0/01	0/002	-0/06***	0/12***	0/01	-0/05**	0/08***	-0/68	0/24***	-2/63***	0/04
	(0/02)	(0/02)	(0/02)	(0/01)	(0/03)	(0/01)	(0/01)	(0/01)	(0/48)	(0/05)	(0/39)	(0/04)
poverty_i	-0/82***	-0/86***	-0/45***	-0/31***	-0/35***	-0/1***	-0/12***	-0/18***	-6/82***	-0/14***	-1/88***	-0/33***
	(0/01)	(0/02)	(0/02)	(0/01)	(0/02)	(0/01)	(0/01)	(0/01)	(0/35)	(0/03)	(0/29)	(0/03)
treat_i * poverty_i	0/01	-0/02	-0/02	0/07***	-0/09*	-0/01	0/06**	-0/001	1/91*	-0/08	1/64**	0/19**
	(0/03)	(0/04)	(0/04)	(0/02)	(0/04)	(0/01)	(0/02)	(0/02)	(0/77)	(0/07)	(0/62)	(0/06)
gender_i	0/02	-0/02	0/06	0/06*	0/12**	0/02	0/01	-0/08**	0/74	-0/02	-0/74	0/09
	(0/03)	(0/05)	(0/04)	(0/02)	(0/05)	(0/01)	(0/03)	(0/03)	(0/89)	(0/08)	(0/72)	(0/07)
age_i	0/003**	0/003*	0/00	0/003***	0/002	0/002***	0/01***	0/000	0/07*	-0/01*	0/003	0/02***
	(0/001)	(0/001)	(0/001)	(0/001)	(0/001)	(0/000)	(0/001)	(0/001)	(0/03)	(0/003)	(0/02)	(0/002)
familysize_i	0/16***	0/19***	0/07***	0/02***	0/05***	0/06***	0/07***	0/04***	2/53***	0/19***	0/62***	0/09***
	(0/01)	(0/01)	(0/01)	(0/01)	(0/01)	(0/003)	(0/01)	(0/01)	(0/22)	(0/02)	(0/18)	(0/02)
a_i	0/05***	0/01	0/05***	0/07***	0/03*	-0/02**	0/01	0/09***	2/75***	0/23***	0/26	-0/18***
	(0/01)	(0/01)	(0/01)	(0/01)	(0/01)	(0/004)	(0/01)	(0/01)	(0/26)	(0/025)	(0/211)	(0/02)
marital2_i	0/06	-0/06	0/025	0/14***	0/15*	0/01	0/02	0/12***	6/85***	0/44***	2/82**	-0/32***
	(0/04)	(0/06)	(0/05)	(0/03)	(0/06)	(0/02)	(0/04)	(0/03)	(1/18)	(0/11)	(0/96)	(0/09)
marital3_i	-0/03	-0/13*	0/01	0/06	0/01	-0/01	0/02	0/07*	4/56***	0/46***	1/49	-0/18*
	(0/04)	(0/07)	(0/06)	(0/04)	(0/07)	(0/02)	(0/04)	(0/04)	(1/28)	(0/12)	(1/04)	(0/1)
residence2_i	-0/03*	-0/09***	-0/04*	0/09***	-0/03	-0/01*	-0/03**	-0/09***	-2/33***	-0/01	-0/14	-0/21***
	(0/01)	(0/02)	(0/02)	(0/01)	(0/02)	(0/01)	(0/01)	(0/01)	(0/37)	(0/04)	(0/3)	(0/03)
residence3_i	-0/05*	-0/04	0/02	-0/04**	0/02	-0/002	-0/01	-0/1***	-3/18***	-0/19***	0/41	-0/24***
	(0/02)	(0/03)	(0/02)	(0/01)	(0/03)	(0/01)	(0/02)	(0/02)	(0/52)	(0/05)	(0/42)	(0/04)
employed_i	0/001***	0/003***	0/002***	-0/001***	-0/001**	0/001***	-0/001***	0/002***	0/12***	0/03***	0/1***	-0/02***
	(0/000)	(0/000)	(0/000)	(0/000)	(0/000)	(0/000)	(0/000)	(0/000)	(0/01)	(0/001)	(0/01)	(0/001)
female_i	-0/001*	-0/001*	0/001	-0/000	-0/000	-0/000*	0/000	0/000	-0/03***	0/001	-0/01	-0/004***
	(0/000)	(0/000)	(0/000)	(0/000)	(0/000)	(0/000)	(0/000)	(0/000)	(0/01)	(0/001)	(0/01)	(0/001)
Aedu_i	0/04***	0/03***	0/01***	0/04***	0/01***	0/02***	0/02***	0/03***	1/4***	0/03***	0/03	0/07***

	(0/001)	(0/002)	(0/002)	(0/001)	(0/002)	(0/001)	(0/001)	(0/001)	(0/04)	(0/004)	(0/04)	(0/003)
Aage_i	0/0004	-0/002	-0/004**	0/003***	0/004*	-0/002***	-0/01***	0/002*	0/21***	-0/004	-0/02	0/02***
	(0/001)	(0/002)	(0/001)	(0/001)	(0/002)	(0/000)	(0/001)	(0/001)	(0/03)	(0/003)	(0/03)	(0/002)
gas_i	0/12	0/03	0/07	0/13*	0/03	0/08*	0/002	0/04	4/53*	-0/22	4/66*	0/24
	(0/08)	(0/12)	(0/1)	(0/06)	(0/12)	(0/03)	(0/07)	(0/07)	(2/26)	(0/21)	(1/84)	(0/17)
phone_i	0/07***	0/04 [·]	0/03	0/05***	-0/02	0/07***	0/03*	0/05***	0/9*	-0/01	1/31***	-0/03
	(0/01)	(0/02)	(0/02)	(0/01)	(0/02)	(0/01)	(0/01)	(0/01)	(0/4)	(0/04)	(0/32)	(0/03)
water_i	0/08 [·]	-0/001	0/05	0/16***	0/01	0/01	0/03	0/03	1/44	0/09	-0/05	0/06
	(0/05)	(0/07)	(0/06)	(0/04)	(0/07)	(0/02)	(0/04)	(0/04)	(1/3)	(0/12)	(1/06)	(0/1)
city_i	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
year_i	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Adjusted R^2 ($\bar{R}^2$)	0/61	0/43	0/19	0/5	0/12	0/4	0/21	0/27	0/33	0/31	0/10	0/50
Degrees of freedom (DF)	7993	7993	7993	7993	7993	7993	7993	7993	7993	7993	7993	7993
number of samples (N)	8262	8262	8262	8262	8262	8262	8262	8262	8262	8262	8262	8262

Source: Research finding.

Note: symbols ***, **, * and [·] In order to indicate the significance of the coefficients in the levels 99/9%, 99%, 95% and 90% and the numbers in the parentheses indicate the standard error of the coefficients.

Table 6. Results of Models for Rural Households

	T.C	F.C	CL.C	HO.C	HE.C	CO.C	E.C	I.C	T.I	F.I	V.I	M.I
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Intercept	1/79***	1/59***	0/25 [·]	0/97***	0/06	0/05	-0/27***	-0/12	-1/28	0/74**	-1/84	-0/000
	(0/11)	(0/13)	(0/13)	(0/07)	(0/14)	(0/04)	(0/05)	(0/08)	(2/2)	(0/28)	(1/99)	(0/21)
treat_i	0/08***	-0/01	0/08**	0/04**	0/12***	0/01	0/01	0/07***	0/04	-0/003	-0/73 [·]	0/07 [·]
	(0/02)	(0/03)	(0/03)	(0/01)	(0/03)	(0/01)	(0/01)	(0/02)	(0/44)	(0/06)	(0/4)	(0/04)

poverty_i	-0/81*** (0/02)	-0/67*** (0/02)	-0/35*** (0/02)	-0/22*** (0/01)	-0/31*** (0/02)	-0/07*** (0/01)	-0/04*** (0/01)	-0/13*** (0/01)	-4/56*** (0/34)	-0/01 (0/04)	-2/65*** (0/31)	-0/23*** (0/03)
treat_i	-0/02 (0/04)	-0/02 (0/05)	-0/09 (0/05)	-0/03 (0/03)	-0/03 (0/05)	-0/02 (0/01)	0/02 (0/02)	-0/06 (0/03)	-0/54 (0/8)	-0/21* (0/1)	1/21 (0/72)	-0/01 (0/07)
* poverty_i	-0/1* (0/04)	-0/11* (0/05)	0/09 (0/05)	-0/07** (0/03)	0/02 (0/06)	-0/01 (0/02)	0/01 (0/02)	-0/08* (0/03)	0/08 (0/87)	-0/02 (0/11)	-0/65 (0/79)	0/06 (0/08)
age_i	0/003** (0/001)	0/003* (0/002)	0/003* (0/001)	0/001 (0/01)	-0/001 (0/002)	-0/001** (0/000)	-0/001* (0/001)	-0/000 (0/001)	-0/01 (0/03)	-0/01* (0/003)	-0/03 (0/02)	0/01*** (0/002)
familysize_i	0/15*** (0/01)	0/15*** (0/01)	0/03** (0/01)	0/03*** (0/01)	0/05*** (0/01)	0/05*** (0/003)	0/05*** (0/01)	0/01 (0/01)	2/35*** (0/2)	0/18*** (0/03)	1/47*** (0/18)	0/01 (0/02)
a_i	0/01 (0/01)	-0/01 (0/02)	0/06*** (0/02)	-0/002 (0/01)	0/004 (0/02)	-0/03*** (0/004)	0/02*** (0/01)	0/04*** (0/01)	-0/41 (0/25)	0/05 (0/03)	-0/81*** (0/23)	-0/07** (0/02)
marital2_i	0/06 (0/08)	0/03 (0/09)	0/01 (0/09)	-0/01 (0/05)	0/08 (0/09)	0/01 (0/03)	0/05 (0/03)	0/08 (0/06)	0/56 (1/49)	-0/14 (0/19)	1/22 (1/34)	-0/16 (0/14)
marital3_i	-0/03 (0/08)	-0/01 (0/09)	-0/01 (0/09)	-0/07 (0/05)	0/04 (0/1)	0/01 (0/03)	0/08* (0/04)	0/08 (0/06)	0/6 (1/53)	0/12 (0/2)	0/92 (1/38)	-0/14 (0/14)
residence2_i	-0/03 (0/03)	-0/12*** (0/04)	-0/04 (0/03)	0/1*** (0/02)	0/02 (0/04)	-0/03** (0/01)	-0/04** (0/01)	-0/05* (0/02)	0/25 (0/57)	0/23** (0/07)	-1/24* (0/51)	-0/08 (0/05)
residence3_i	-0/16*** (0/03)	-0/17*** (0/03)	0/01 (0/03)	-0/09*** (0/02)	-0/05 (0/03)	-0/004 (0/01)	-0/02 (0/01)	-0/04 (0/02)	-0/7 (0/51)	-0/06 (0/07)	-0/24 (0/46)	-0/02 (0/05)
employed_i	0/002*** (0/000)	0/003*** (0/000)	0/001* (0/000)	-0/0002 (0/000)	0/0003 (0/0004)	0/000*** (0/000)	-0/001*** (0/000)	-0/000 (0/000)	0/09*** (0/01)	0/01*** (0/001)	0/07*** (0/01)	-0/01*** (0/001)
female_i	0/001 (0/000)	0/000 (0/000)	0/001 (0/000)	0/000 (0/000)	0/001 (0/001)	-0/000 (0/000)	0/000 (0/000)	0/000 (0/000)	-0/03*** (0/01)	-0/003** (0/001)	-0/01 (0/01)	-0/002** (0/001)
Aedu_i	0/03*** (0/003)	0/01*** (0/003)	0/02*** (0/003)	0/01*** (0/002)	0/01* (0/003)	0/01*** (0/001)	0/02*** (0/001)	0/03*** (0/002)	0/53*** (0/06)	0/04*** (0/01)	-0/12* (0/05)	0/05*** (0/01)
Aage_i	-0/003* (0/001)	-0/003 (0/002)	-0/01** (0/002)	-0/001 (0/001)	0/01** (0/002)	0/000 (0/000)	0/003*** (0/001)	0/001 (0/001)	0/06* (0/03)	-0/01* (0/003)	0/01 (0/03)	0/01** (0/001)

gas_i	0/07* (0/03)	-0/002 (0/04)	0/02 (0/04)	0/1*** (0/02)	0/09* (0/04)	0/04*** (0/01)	0/03* (0/01)	0/06** (0/02)	0/29 (0/61)	0/34*** (0/08)	-1/43** (0/55)	-0/04 (0/06)
phone_i	0/05** (0/02)	0/06*** (0/02)	-0/002 (0/02)	0/03*** (0/01)	-0/04` (0/02)	0/07*** (0/01)	0/004 (0/01)	0/04** (0/01)	0/8* (0/32)	-0/04 (0/04)	0/69* (0/29)	0/04 (0/03)
water_i	-0/19*** (0/05)	-0/28*** (0/07)	0/06 (0/06)	0/02 (0/03)	-0/05 (0/07)	-0/05** (0/02)	-0/01 (0/03)	-0/04 (0/04)	0/54 (1/06)	-0/19 (0/14)	3/17*** (0/96)	-0/24* (0/1)
city_i	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
year_i	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Adjusted R^2 ($\bar{R}^2$)	0/64	0/47	0/21	0/57	0/17	0/46	0/24	0/35	0/35	0/29	0/18	0/29
Degrees of freedom (DF)	3789	3789	3789	3789	3789	3789	3789	3789	3789	3789	3789	3789
number of samples (N)	3996	3996	3996	3996	3996	3996	3996	3996	3996	3996	3996	3996

Source: Research finding.

Note: symbols ***, **, * and ` In order to indicate the significance of the coefficients in the levels 99/9%, 99%, 95% and 90% and the numbers in the parentheses indicate the standard error of the coefficients.

The estimation results for rural households are presented in Table 6. As shown, Qard al-Hasan loans have significantly increased only the variable income of the rural poor. Unlike the urban poor, where Qard al-Hasan loans were effective in improving livelihoods and reducing poverty through multiple channels, the loans for rural poor households have enhanced purchasing power and alleviated poverty through a single channel. This disparity will be explored further in the following sections.

Based on Tables 5 and 6, Figure 1 summarizes the types of expenditures and incomes that have increased as a result of receiving Qard al-Hasan loans. The table categorizes these increases by poor and non-poor borrowers and distinguishes between urban and rural households. This detailed breakdown highlights the specific areas where Qard al-Hasan loans have had a measurable impact, providing insights into their effectiveness across different demographic and socioeconomic groups.

According to Figure 1, Qard al-Hasan loans have increased the purchasing power of urban poor households through two expenditure channels and three income channels. In contrast, rural poor households have experienced a positive impact only on their variable income. Non-poor urban households receiving Qard al-Hasan loans have seen improvements in welfare through two expenditure channels: healthcare and insurance. Meanwhile, rural non-poor households have been the most positively affected by the loans, with increases in four expenditure categories—clothing, housing, healthcare, and insurance—along with an increase in miscellaneous income.

The benevolent loans have had a significant positive effect on housing and education expenditures, as well as on total income, income from variable salaries, and miscellaneous income for poor urban households. However, the poverty status of urban households has led to a decrease in all types of expenditures and incomes. This suggests that receiving benevolent loans has improved the welfare of the urban poor.

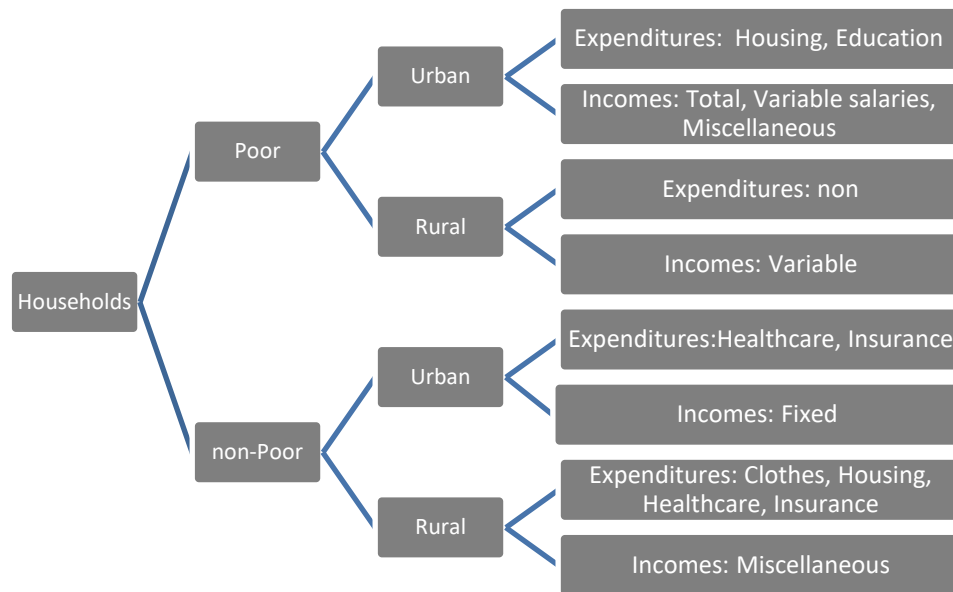


Figure 1. The Benevolent Loans Have a Positive Effect on Some Expenditures and Incomes

Source: Research finding.

On the other hand, the loans have not had a significant positive impact on the expenditures of rural poor households, though they have increased their variable income. This is a typical outcome, as the poor generally need to earn money before they can spend it. Additionally, most rural income comes from self-started businesses such as agriculture and animal husbandry. Despite this, clothing and insurance expenditures of rural poor households that received loans have slightly decreased, while other expenses remained largely unchanged. This could be because loans for rural households are, on average, lower than those for urban residents. During the study period, after adjusting for inflation, urban poor households borrowed an average of 1.65 times more than rural poor households did. One reason for this discrepancy could be that official employees, who are less

likely to default on loans, tend to live in cities and are therefore able to secure loans more easily. As a result, they often have to reduce their expenses to generate the capital needed to start a business.

For non-poor urban households, receiving loans has led to a significant increase in healthcare and insurance expenditures, while some other expenses, including housing, have decreased. This suggests that many non-poor households have turned to loans and reduced other expenditures to cover sudden and unexpected healthcare costs, either now or in the future. This highlights the positive impact of loans in improving the welfare of the middle class. Regarding fixed-salary jobs, it is worth noting that while these urban-oriented jobs offer income stability, they tend to have lower average earnings. As a result, many individuals likely choose such jobs only after receiving benevolent loans that help meet some of their financial needs. Therefore, the loans have a positive effect on this type of income in urban areas.

For non-poor rural households, most types of expenditures significantly increased with the receipt of loans, with none decreasing significantly. Additionally, the loans have had a positive impact on their miscellaneous incomes, possibly because starting miscellaneous income-generating activities requires a small amount of initial capital, which the loan helps provide. This indicates a positive welfare effect of the loan on the rural middle class. However, the loans have negatively affected the income of self-employed non-poor individuals. This could be because these individuals needed money to increase their expenditures, and by receiving a benevolent loan, their financial needs were reduced. As a result, they may have scaled back their income-generating activities.

Regarding the robustness of the model results, it is important to note that the same data and variables were first estimated using the OLS method. When comparing the OLS and WLS estimates, in the eight models where the dependent variable represents one of the types of expenditures, the coefficient for the variable "receiving a benevolent loan by the poor" was not significant for urban dwellers in almost all of the OLS models. In contrast, some coefficients in the WLS estimates were significant. Moreover, the sign and magnitude of the coefficients were similar in both methods, but the standard errors of the coefficients were smaller in the WLS estimates, resulting in estimates that are more accurate. This observation also applies to rural expenditures, where the standard errors of the coefficients were smaller in the WLS method, making the estimates more precise. Thus, the WLS model is preferred over the OLS model in this case.

For income as the dependent variable, four models were estimated using the OLS method for urban households and four models for rural households. Similar to expenditures, for rural households' income, the WLS estimates provided more precise results than the OLS estimates, making the WLS model the preferred choice. However, for urban households' income, the results from both the OLS and WLS models were very similar, suggesting that the two models produce equivalent outcomes. Nonetheless, since the WLS method accounts for the fact that each household represents multiple households, it is more appropriate for the data structure. Therefore, overall, the WLS model is favored over the OLS model.

In the next step, we ran the WLS model while retaining the variables of loan, poverty, and poverty multiplied by loan, household size, city of residence, and year of data collection, while removing other control variables. As a result, the significance, sign, and size of the coefficients remained largely unchanged, but the standard errors of the significant coefficients increased slightly. This indicates that including all control variables in the model enhances the accuracy of the estimation. Therefore, the reported model is robust.

5. Policy Implication

According to the results of the model, the following points should be considered for more effective policy-making regarding charitable loans:

- a) Increase the share of loans allocated to the poor: In addition to the humanitarian benefits, these loans are more impactful for the poor than for the non-poor. A fixed amount of money increases their welfare more significantly, leading to a greater overall increase in social welfare.
- b) Increase the share of loans for poor rural households: The loan amounts for rural households are considerably lower compared to those for urban residents. Increasing these loans could lead to higher spending and, in turn, reduce poverty in rural areas.
- c) Adopt the collective loan model used by Grameen Bank and other similar initiatives: This approach could help mitigate the risk of default in rural areas. By offering group loans, the financial charity would be more inclined to lend to rural households. Additionally, if the government allows cash subsidies to be directed to these institutions in the event of loan defaults, it would increase the number of loans allocated to rural areas, further supporting poverty reduction efforts.

6. Conclusion

The impact of micro-financing on poverty reduction has been widely examined by researchers. Practical studies have shown that microcredits improve the welfare of the poor and contribute to poverty alleviation. In Islamic literature, however, there is a focus on a specific micro-financing instrument known as the benevolent (Qard al-Hasan) loan, which is provided at zero interest to the poor. Islamic scholars believe that this non-conventional loan, more common in Muslim countries, is particularly effective in reducing poverty. However, due to the relatively small size of these loans compared to interest-based loans, as well as the limited availability of data, research on the topic has been relatively scarce.

This study aimed to determine whether benevolent loans have reduced poverty among Iranian households. It utilized data from 36 official Iranian financial institutions, along with data from various non-official charity funds and household budgets, to investigate the issue through 24 different models, with a large sample size and a distinction between urban and rural households. Since about two-thirds of the recipients of benevolent loans were above the poverty line, the study separately analyzed the impact of the loans on both poor and non-poor households.

The findings revealed that the loans had a significant positive impact on the housing and education expenditures of poor urban households, as well as on most of their income sources. This indicates that the loans effectively reduce poverty, especially since housing and education are key drivers of economic growth, and strengthening these sectors improves economic conditions and increases social welfare.

For poor rural households, the results showed that the loan had a significant positive effect on income from self-employment. However, it had a negative effect on income from fixed-salary jobs and certain types of expenditure. Nonetheless, when considering the effects of other variables on expenditures and incomes across different models, the decrease in certain areas does not suggest a negative causal relationship between the benevolent loan and these factors. Instead, the loan still has a significant positive effect on some sources of income, contributing to poverty reduction.

Finally, a comparison of the magnitude and types of effects of benevolent loans on poor and non-poor borrowers, whether urban or rural, suggests that increasing the share of benevolent loans allocated to poor households compared to non-poor households, as well as increasing the share for rural households compared to urban households, should be a priority for policymakers.

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Construction and Back-Testing of an Indexed Portfolio by Using Constrained Regression with Transaction Costs, Weight Constraints, and Asset Turnover in the Iranian Capital Market

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Abstract

This paper considers 5 large stocks for retail investors and 14 stocks that cover almost the entire market for institutional investors to build an indexed portfolio. This research uses a constrained regression approach to build this portfolio for a 1-year and 2-year period, taking into account real-world constraints including transaction costs, asset turnover in the portfolio, and weight constraints. First, the companies under study are introduced, and then their performance over the entire period is examined. Second, the portfolio weights are updated in 21-day periods for one year and two years. Third, a t-test is run to statistically evaluate the performance of this portfolio with the overall index. The results show that in the two-year and one-year periods, these portfolios have statistically significantly outperformed the overall index. It seems that by balancing the portfolio weights in a periodic manner, one can achieve better performance than the overall index. Therefore, this approach can be suitable for retail and institutional investors.

Keywords: Constrained Regression, Indexed Portfolio Construction, Market Outperformance, Portfolio Rebalancing, Transaction Costs.

JEL Classification: C61, G11.

1. Introduction

In contemporary financial theory and practice, the construction and management of investment portfolios are central to optimizing the trade-off between risk and return. As financial markets become increasingly complex, investors—both institutional and individual—face the challenge of constructing portfolios that not only maximize returns but also align with their financial goals, risk tolerances, and investment horizons. Three interrelated pillars address this challenge: portfolio construction, portfolio optimization, and indexing. Each concept contributes

uniquely to investment decision-making, yet they form a cohesive framework for achieving disciplined and evidence-based portfolio management.

Portfolio construction is the foundational step in investment management. It involves the selection and allocation of asset classes, sectors, and individual securities, guided by investor-specific constraints and objectives. The necessity of this stage lies in the pursuit of diversification, which reduces unsystematic (idiosyncratic) risk (Fabozzi et al., 2002). Strategic asset allocation frameworks often incorporate macroeconomic indicators, investor preferences, and regulatory limitations to establish a structured and resilient investment strategy.

The evolution of portfolio optimization began with the groundbreaking work of Harry Markowitz (1952), who introduced Modern Portfolio Theory (MPT). MPT formalized the notion of diversification by demonstrating that investors can construct an efficient frontier of portfolios that maximize expected return for a given level of risk. The model uses statistical measures—expected return, standard deviation, and asset correlations—to determine optimal asset weights.

This theoretical framework was extended by the Capital Asset Pricing Model (CAPM) (Sharpe, 1964; Lintner, 1965), which introduced beta as a measure of an asset's systematic risk relative to the market. CAPM provided a way to estimate expected returns based on market sensitivity and the risk-free rate, strengthening the analytical foundation of portfolio selection.

As empirical research began to question the consistent outperformance of active strategies, the concept of indexing—or passive portfolio management—emerged as a cost-efficient alternative. Indexing involves replicating the performance of a broad market index (e.g., S&P 500, MSCI World) using full or partial replication techniques. The rationale behind indexing is grounded in the Efficient Market Hypothesis (EMH), which argues that asset prices reflect all available information, making it difficult to consistently outperform the market (Fama and French, 1993).

Malkiel (2003) and Bogle (1999) championed this approach, emphasizing lower costs, tax efficiency, and simplicity. Longitudinal studies (Fama and French, 2010; SPIVA, 2023) consistently show that a large majority of actively managed funds underperform their benchmarks over long horizons.

Modern portfolio optimization has advanced well beyond the mean-variance framework. Key innovations include:

- Post-Modern Portfolio Theory (PMPT): Recognizes investor asymmetry in risk preferences and emphasizes downside risk over variance (Sortino and Price, 1994).

- Black-Litterman Model: Combines equilibrium returns with investor views in a Bayesian framework to produce more stable portfolios (Black and Litterman, 1992).
- Robust Optimization: Tackles parameter uncertainty by incorporating confidence intervals into optimization inputs (Fabozzi et al., 2007).
- Machine Learning Applications: Techniques like neural networks and reinforcement learning offer dynamic and adaptive approaches to asset allocation (Dixon et al., 2020).

Moreover, practical portfolio implementation must navigate real-world constraints, such as:

- Transaction costs (Lobo et al., 2007),
- Cardinality constraints (Jobst et al., 2001),
- Liquidity considerations (Almgren and Chriss, 2001).

Indexing has diversified beyond traditional market-cap weighted indices. New methodologies include:

- Fundamental Indexing: Weights stocks based on financial metrics (e.g., earnings, dividends) rather than market capitalization (Arnott et al., 2005).
- Equal-Weighting: Allocates equal capital to each constituent, enhancing diversification (Fernholz et al., 1998).
- Smart Beta: Applies factor-based tilts (e.g., value, momentum, low volatility) within an index-based framework (Ang, 2014; Arnott et al., 2013).

Recent developments blur the line between active and passive strategies:

- Smart Beta Strategies: Factor investing with passive implementation (Asness et al., 2013).
- Direct Indexing: Custom index replication with tax-loss harvesting and personalization (Sullivan, 2021).
- Risk-Targeted Index Funds: Combine passive indexing with volatility targeting (Chow et al., 2011).

Empirical data consistently supports the superior cost-efficiency and performance persistence of indexed strategies:

- Indexed funds typically have lower expense ratios compared to actively managed funds (Bogle, 1999).
- Over a 15+ year period, approximately 90% of active U.S. equity funds underperformed the S&P 500 benchmark (SPIVA, 2023).

Smart beta and hybrid indexing approaches offer the promise of improved risk-adjusted returns while maintaining the structural benefits of passive investing. This research extends the theoretical and empirical portfolio management literature to the Iranian capital market, an emerging market with high investment potential. The specific contributions of this study include:

- Development of an Indexed Portfolio: Tailored for both retail and institutional investors within Iran's capital market, considering local asset characteristics and market structure.
- Incorporation of Real-World Constraints: The model accounts for transaction costs, turnover limits, and weight constraints relevant to domestic trading conditions.
- Constrained Regression Model: An index-tracking model is built using constrained regression to approximate the Tehran Stock Exchange benchmark index using a limited subset of representative companies.
- Back-testing and Performance Evaluation: The constructed portfolio is evaluated using historical data to assess tracking error and relative performance.

The study provides practical implications for portfolio managers and policymakers in emerging markets by showcasing how index-based strategies can be adapted under localized constraints.

The remainder of the paper is organized as follows:

- Section 2 presents a detailed review of the relevant literature.
- Section 3 introduces the dataset and outlines the methodology, including the constrained regression model.
- Section 4 reports the empirical results and back-testing performance.
- Section 5 concludes the paper with key findings and policy recommendations.

2. Research Literature

This section reviews the academic and empirical literature across four key areas: (1) portfolio construction, (2) portfolio optimization, (3) indexing and passive management, and (4) new frontiers in investment theory and practice.

2.1 Literature on Portfolio Construction

2.1.1 Foundations of Diversification and Risk Management

The concept of diversification is one of the earliest principles in finance, formalized through Modern Portfolio Theory (MPT) by Markowitz (1952). MPT

introduced the mean-variance framework, showing that combining assets with low correlations can reduce overall portfolio risk. The theory emphasized optimizing the trade-off between expected return and variance.

This framework was expanded by Sharpe (1964) with the Capital Asset Pricing Model (CAPM), which introduced beta as a systematic risk measure. Later, Ross (1976) developed the Arbitrage Pricing Theory (APT), and Fama and French (1993; 2015) introduced multi-factor models, showing that size, value, profitability, and investment factors explain cross-sectional asset returns more comprehensively than market beta alone.

2.1.2 Strategic and Behavioral Extensions

From a practical standpoint, Strategic Asset Allocation (SAA) and Tactical Asset Allocation (TAA) became key portfolio construction approaches, with SAA defining a long-term asset mix and TAA allowing short-term market-based adjustments (Illmanen, 2011).

However, MPT faced critiques for relying on unrealistic assumptions such as normal return distributions and static correlations, especially during financial crises. Mandelbrot (1963) and Taleb (2007) emphasized the need to consider fat tails and extreme events, arguing that traditional models underestimate tail risks. Rockafellar and Uryasev (2000) responded with Conditional Value-at-Risk (CVaR) as a more robust risk metric.

Behavioral finance scholars, notably Kahneman and Tversky (1979) and Thaler (1999), demonstrated that psychological biases distort investor decision-making. Shefrin and Statman (2000) proposed Behavioral Portfolio Theory, where investors create mental "layers" in portfolios based on goals rather than optimizing global utility.

2.1.3 Innovations in Asset Classes and Methods

Advances in portfolio construction also include the Black-Litterman model (1992), which combines market equilibrium with investor views to improve portfolio weights, and Risk Parity (Qian, 2005), which allocates capital by risk contribution rather than notional amounts.

The rise of alternative assets—including private equity, real estate, and commodities—was championed by Swensen (2000) and Gorton and Rouwenhorst (2006), who demonstrated diversification and inflation-hedging benefits. More recently, Brière et al. (2015) explored the inclusion of cryptocurrencies as diversifiers, despite their high volatility and unstable correlations.

2.2 Portfolio Optimization Literature

2.2.1 Classical Optimization and Critiques

Portfolio optimization builds directly on MPT. Yet its practical limitations—particularly estimation error—have been well documented. Michaud (1989) critiqued mean-variance optimization (MVO) for being overly sensitive to input assumptions. Best and Grauer (1991) showed that small variations in expected returns can yield dramatically different portfolio outcomes.

2.2.2 Bayesian and Resampling Enhancements

To improve robustness, researchers introduced Bayesian and resampling approaches. Jorion (1986) proposed Bayesian shrinkage estimators, which reduce noise by blending priors with sample statistics. Black and Litterman (1992) improved optimization by blending equilibrium market returns with subjective investor views.

Michaud and Michaud (2008) developed resampling methods that create multiple efficient frontiers through Monte Carlo simulation, leading to more stable and diversified portfolios. He and Litterman (2002) showed that these approaches reduce turnover by up to 70% while maintaining intuitive allocations.

2.2.3 Real-World Constraints and Multidimensional Objectives

Contemporary research integrates practical constraints:

- Liquidity-aware optimization models by Acharya and Pedersen (2005),
- Tax-aware frameworks by Apelfeld et al. (1996),
- and robust optimization by Fabozzi et al. (2007) to address parameter uncertainty.

A further evolution has been the inclusion of Environmental, Social, and Governance (ESG) considerations. Pedersen et al. (2021) developed the ESG-efficient frontier, allowing investors to assess trade-offs between financial returns and sustainability.

2.2.4 Machine Learning in Optimization

Recent work explores machine learning to overcome the limitations of linear models. Gu et al. (2020) applied deep learning to detect nonlinear patterns in alternative data, improving portfolio predictions. Reinforcement learning techniques (Dixon et al., 2020) are being used for dynamic allocation and rebalancing under uncertainty.

2.3 Literature on Indexing and Passive Portfolio Management

2.3.1 Theoretical Underpinnings

The rise of indexing stems from the Efficient Market Hypothesis (EMH) by Fama (1970), which argues that market prices fully reflect all available information. Malkiel (1995; 2003) and Fama and French (2010) provided empirical evidence that most active managers underperform passive benchmarks after fees and taxes. French (2008) quantified this underperformance at 0.67% annually—a persistent drag that supports passive strategies.

2.3.2 Growth and Cost Advantages of Indexing

The first index fund, introduced by Vanguard in 1976, and the later development of ETFs in the 1990s (Gastineau, 2001) revolutionized investing through low cost, transparency, and liquidity. Bogle (2017) emphasized that indexing reduces expenses (0.03–0.20%), improves tax efficiency, and minimizes manager risk.

2.3.3 Factor Investing and Smart Beta

Carhart (1997) introduced a four-factor model (adding momentum), showing that most fund returns can be attributed to systematic factors. This laid the groundwork for smart beta, which Arnott et al. (2016) showed can improve returns using factor tilts (e.g., value, quality, low volatility) while retaining the benefits of indexing.

2.3.4 Systemic Concerns about Passive Dominance

Scholars have raised alarms about excessive passive ownership. Wurgler (2011) and Babina et al. (2021) found that indexing distorts price discovery, as index constituents may trade based on flows rather than fundamentals. Ben-David et al. (2018) showed that ETF-driven rebalancing increases volatility during crises, and Petajisto (2017) warned of potential degradation in market efficiency.

Greenwood and Thesmar (2011) identified three systemic risks: mechanical trading, correlated ownership, and reduced active oversight—leading to greater price fragility.

2.3.5 ESG and Zero-Fee Innovations

The ESG-efficient frontier proposed by Pedersen et al. (2021) extends passive strategies into sustainable investing. Meanwhile, Huang (2022) studied the impact of zero-fee ETFs (e.g., Fidelity's ZERO funds), noting both the democratization of access and the risk of reduced innovation in fund management.

2.4 Literature on New Frontiers

2.4.1 AI and Alternative Data Integration

Recent innovations apply AI and alternative data to portfolio management. Gu et al. (2023) introduced neural portfolio networks that adapt asset weights using real-time data (e.g., sentiment, satellite imagery), outperforming traditional MVO by 4.2% annually. Dixon and Halperin (2024) implemented reinforcement learning-based rebalancing that cuts turnover costs by 30%.

2.4.2 Climate-Aware and Sentiment-Based Risk Models

Pedersen et al. (2023) created a Climate-Efficient Frontier, quantifying the return-risk impact of carbon constraints. Engle et al. (2024) developed Dynamic Climate Value-at-Risk (DCVaR), which forecasts portfolio losses under global warming scenarios. Barberis and Jin (2024) modeled investor sentiment to mitigate downside risk during panic-driven selloffs.

2.4.3 Quantum and Custom Indexing Innovations

Harrow et al. (2023) demonstrated the potential of quantum optimization, solving complex portfolio problems 100x faster than classical methods. Chincó et al. (2024) proposed AI-driven customized indices, tailored to ESG or risk preferences. In practice, BlackRock (2025) launched dynamic ETFs that adjust exposures in real time using machine learning. However, Begenau and Farboodi (2025) found that when passive ownership exceeds 50%, price efficiency falls by 18%, raising concerns about systemic vulnerabilities in markets dominated by automated flows.

3. Data and Modeling

In this paper, a constrained regression model with real-world constraints is used to estimate asset weights in the portfolio that are able to reproduce the performance of the overall index.

3.1 Data Selection and Preprocessing

In this paper, share price data of 14 companies including Fars, Vabshahr, Tapico, Tipico, Vasapa, Vama'aden, Femli, Foolad, Parsan, Sefars, Vabemellat, Vabank, Remapna, and VaGhadir, along with the overall index (as a benchmark), have been used. These companies comprised approximately 34 percent of the total market on 17 May 2025. The data is from the time each company entered the stock exchange until 17 May 2025. The reason for selecting these 14 companies is due to their fundamental conditions, being a holding and investment company, and the consideration of approximately all industries, which can be suitable for

institutional investors. Table 1 shows these companies. Also, for retail investors, 5 large companies on the stock exchange, which comprise approximately 30 percent of the total market, were considered. These companies include Fars, Femli, Foolad, Vabemellat and, Nouri. Table 2 shows these companies. The risk-free interest rate was assumed to be 21 percent annually. The data was obtained through the TseClient software on the TSETMC.com website. Tables 3 and 4 show the performance of these companies from the period of listing on the stock exchange to May 17 of this year. The value of the companies was calculated at 820,000 Rials per dollar.

Table 1. The 14 Companies Mentioned

Company symbol	Description	Company value on the last day- Billion Rials	Company value on the last day- Dollars	Company value ranking on the last day
Fars	Persian Gulf Petrochemical Industries Co	9,260,000	11,292,682,927	1
Femli	National Iranian Copper Industry Co	7,549,500	9,206,707,317	2
Foolad	Mobarakeh Steel Company	5,923,500	7,223,780,488	3
Vabemellat	Bank Mellat	3,397,680	4,143,512,195	4
Parsan	Parsian Oil and Gas Development Co	2,525,580	3,079,975,610	7
VaGhadir	Ghadir Investment Holding Company	2,451,600	2,989,756,098	8
Tapico	Tamin Petroleum & Petrochemical Investment Co	2,274,615	2,773,920,732	9
Vama'aden	Mines and Metals Development Investment Company	1,099,595	1,340,969,512	26
Remapna	Mapna Group	1,012,200	1,234,390,244	29

Company symbol	Description	Company value on the last day- Billion Rials	Company value on the last day- Dollars	Company value ranking on the last day
Vabank	Tose'e Melli Group Investment Company	481,898	587,680,488	46
Sefars	Fars Cement Company	418,000	509,756,098	53
Tipico	Tamin Pharmaceutical Investment Company	353,870	431,548,780	58
Vasapa	Saipa Investment Group co.	176,020	214,658,537	118
Vabshahr	Behshahr Industries Development Group	165,250	201,524,390	122

Source: Research finding.

Table 2. The 5 Companies Mentioned

Company symbol	Description	Company value on the last day- Billion Rials	Company value on the last day- Dollars	Company value ranking on the last day
Fars	Persian Gulf Petrochemical Industries Co	9,260,000	11,292,682,927	1
Femli	National Iranian Copper Industry Co	7,549,500	9,206,707,317	2
Foolad	Mobarakeh Steel Company	5,923,500	7,223,780,488	3
Vabemellat	Bank Mellat	3,397,680	4,143,512,195	4
Nouri	Nouri Petrochemical Company Co	3,116,400	3,800,487,805	5

Source: Research finding.

Table 3. Performance of the 14 Companies Mentioned

Company symbol	Average annual return	Annual risk	Sharpe Annual
<i>overall index</i>	0.389	0.169	1.058
<i>Parsan</i>	0.523	0.324	0.966
<i>Vabank</i>	0.473	0.288	0.913
<i>Vabemellat</i>	0.465	0.319	0.800
<i>Femli</i>	0.447	0.298	0.797
<i>VaGhadir</i>	0.446	0.297	0.792
<i>Tipico</i>	0.419	0.270	0.759
<i>Vama'aden</i>	0.448	0.321	0.742
<i>Fars</i>	0.410	0.279	0.715
<i>Foolad</i>	0.427	0.307	0.708
<i>Tapico</i>	0.399	0.322	0.587
<i>Remapna</i>	0.419	0.357	0.585
<i>Sefars</i>	0.371	0.326	0.495
<i>Vabshahr</i>	0.332	0.302	0.406
<i>Vasapa</i>	0.367	0.434	0.363

Source: Research finding.

Table 4. Performance of the 5 Companies Mentioned

Company symbol	Average annual return	Annual risk	Sharpe Annual
<i>Nouri</i>	0.838	0.380	1.652
<i>overall index</i>	0.389	0.169	1.058
<i>Vabemellat</i>	0.465	0.319	0.800
<i>Femli</i>	0.447	0.298	0.797
<i>Fars</i>	0.410	0.279	0.715
<i>Foolad</i>	0.427	0.307	0.708

Source: Research finding.

The key implementation steps are:

- Receiving data from the TseClient software
- Preprocessing data, including removing outliers using quantiles
- Calculating asset returns
- Considering warm-up and back-test periods

- Then running the algorithm and presenting the model results.

3.2 Portfolio Construction and Optimization Techniques

The three major types of portfolios are as follows:

1. Simple (equal-weighted) portfolio

This portfolio assigns equal weights to all selected assets. This portfolio serves as a benchmark to demonstrate an uninformed but diversified strategy.

2. Mean-variance optimized portfolio

Using the Markowitz mean-variance framework, the weights of the assets are optimized to maximize the expected return for a given level of risk.

3. Indexed portfolio

This portfolio mimics a market-weighted index, such as the overall index. The weight of each asset corresponds to its proportion in the benchmark index.

In addition, alternative optimization models are as follows:

The Black-Litterman model, incorporating investor perspectives, equal risk allocation, balancing the risk contribution from each asset, and the minimum variance portfolio, focusing solely on risk minimization.

3.3 Performance Evaluation Criteria

The portfolio is evaluated using the following performance criteria:

- Annual Return: The average daily return scaled (multiplied by 252) by the annualized return.
- Annualized Volatility: The standard deviation of the daily return scaled (multiplied by the square root of 252) by the annualized return.
- Sharpe Ratio: The excess return (minus the risk-free rate) per unit of risk.
- Maximum Drawdown: The largest peak-to-trough decline in the portfolio value.
- Tracking Error: The standard deviation of the difference between the portfolio return and the index (used to compare active versus passive portfolios).
- Calmar Ratio: The excess return (minus the risk-free rate) divided by the maximum peak-to-trough.
- Statistical tests such as t-tests or bootstrap analysis are applied to assess the significance of performance differences across portfolios.

3.4 Model Used

Suppose:

$R_b \in \mathbb{R}^T$ is the vector of total index returns for period T.

$R \in \mathbb{R}^{T \times N}$ is the matrix of asset returns.

$w \in \mathbb{R}^N$ are the optimal weights of the portfolio.

$w_{\text{prev}} \in \mathbb{R}^N$ are the current weights of the portfolio.

Now the portfolio optimization problem is as follows:

$$\begin{aligned} & \min \|R_b - R * w\|_2^2 \\ & s.t. \quad \sum_{i=1}^N w_i = 1 \\ & \quad \quad l_i \leq w_i \leq u_i \\ & \quad \|w - w_{\text{prev}}\|_1 \leq \tau \end{aligned} \tag{1}$$

τ is limitation of asset turnover in the portfolio. Transaction costs are added to the model in two ways: one is approximated using asset turnover, and the second is deducted as a cost from the total portfolio return during each rebalancing period of the portfolio weights. For example, the total return of the portfolio is calculated as follows:

$$\text{pret} = \sum (\mu_i \cdot w_i \cdot T_e - b \cdot \max(c, W_{0i} - w_i) - d \cdot \max(e, w_i - W_{0i})) \tag{2}$$

where:

- μ_i is the expected return of asset,
- w_i is the portfolio weight,
- W_{0i} is the initial weight,
- and the penalty terms discourage deviations from a preferred or policy allocation.
- T_e is the investment horizon.
- C and e are vectors of zero values with the dimension of the number of assets.
- B and d are transaction costs of buying and selling.

The model is run and the weights are updated every 21 days, based on the past time window. Also, for more information, see the corresponding Python code on GitHub, in the section of “Declaration”.

3.5 Tools and Software

This analysis is implemented using Python with libraries such as NumPy, pandas, cvxpy, and statsmodels.

4. Results

This section presents the results of the empirical analysis and discusses its implications for portfolio management. In this analysis, transaction costs (0.00371 for long and 0.0088 for short), asset weight limits (minimum 1 percent and maximum 10 percent), and asset turnover in the portfolio (25 percent) are considered. First, back-tests are presented for a portfolio of 14 companies and then for the 5 companies mentioned. The balancing period of the portfolio weights is considered every 21 days and then the results are presented for 2-year and 1-year periods.

4.1 Comparing the Performance of a 14-company Stock Portfolio with the Overall Index

- 2-year period:

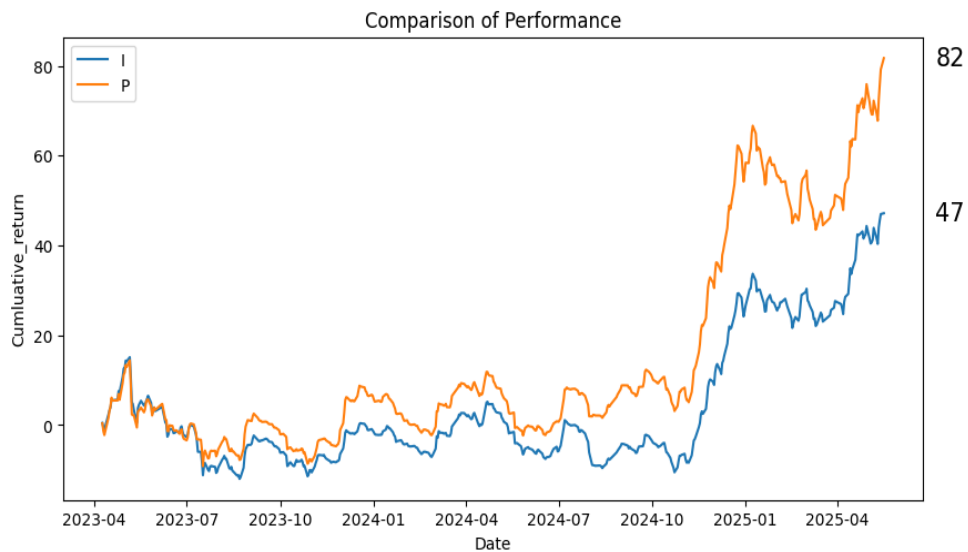


Figure 1. Comparison of Cumulative Returns of the Indexed Portfolio and the Total Index
Source: Research finding.

Comparing the cumulative returns shows that after 2 years, this rate is 82% for the portfolio and 47% for the overall index (Figure 1). As Table 5 shows, the Sharpe ratio, Sortino ratio, peak-to-trough ratio, and Kalmar ratio of the indexed portfolio

are better than those of the overall index. The indexed portfolio also has a beta of 1.06.

Table 5. Comparing the Performance of the Indexed Portfolio with the Overall Index

	SHARPE	SORTINO	MAX_DRAWDOWN	CALMAR, ALPHA, BETA
INDEXED PORTFOLIO	0.56	0.81	-0.21	[0.52, 0, 1.06]
OVERALL INDEX	-0.01	-0.0136	0.24	[-0.01, -0, 1]

Source: Research finding.

The difference in returns between this model and the overall index during this period is significant, and the t-statistic is -2.58 with a significance probability of 1 percent.

$$t = \frac{\mu_{P-I}}{\sigma_{P-I}/\sqrt{N}} = -2.58$$

- One-year period:

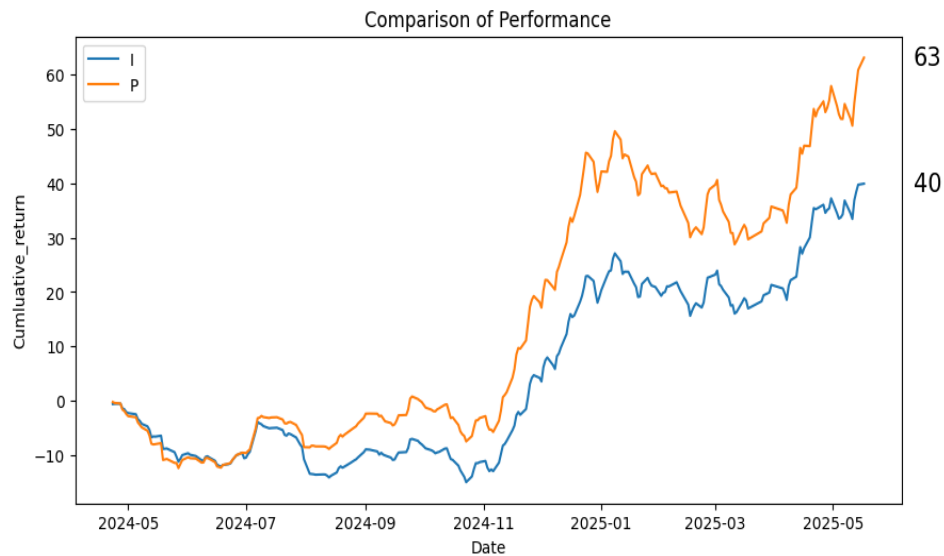


Figure 2. Comparison of Cumulative Returns of the Indexed Portfolio and the Total Index

Source: Research finding.

Comparing the cumulative returns shows that after 1 year, this rate is 63% for the portfolio and 40% for the overall index (Figure 2). As Table 6 shows, the Sharpe ratio, Sortino ratio, peak-to-trough ratio, and Kalmar ratio of the indexed

portfolio are better than those of the overall index. The indexed portfolio also has a beta of 1.07.

Table 6. Comparing the Performance of the Indexed Portfolio with the Overall Index
[2.16, 0, 1.07]

	SHARPE	SORTINO	MAX_DRAWDOWN	CALMAR, ALPHA, BETA
INDEXED PORTFOLIO	1.56	2.32	-0.14	[2.16, 0, 1.07]
OVERALL INDEX	0.84	1.24	-0.15	[0.98, -0, 1]

Source: Research finding.

The difference in returns between this model and the overall index during this period is significant, and the t-statistic is -2.40 with a significance probability of 1.71 percent.

$$t = \frac{\mu_{P-I}}{\sigma_{P-I}/\sqrt{N}} = -2.40$$

4.2 Comparing the Performance of a 5-Company Stock Portfolio with the Overall Index

- 2-year period:

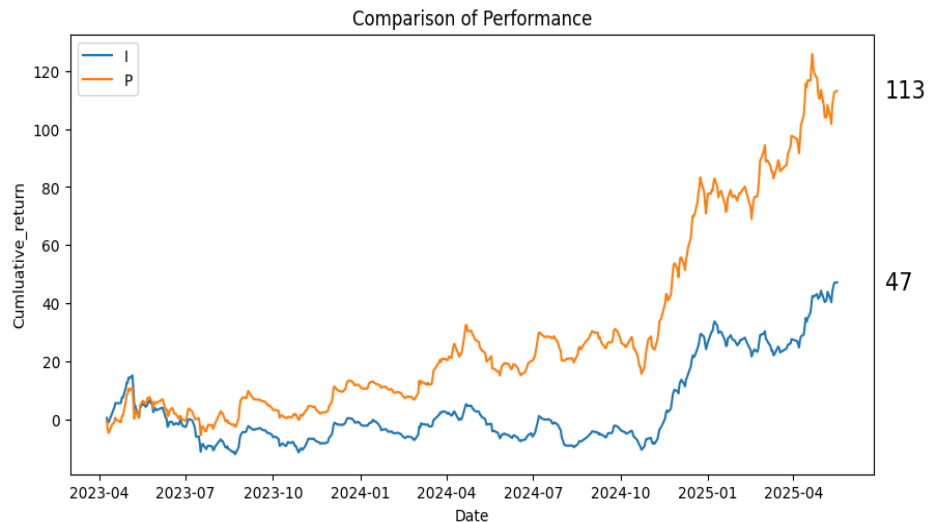


Figure 3. Comparison of Cumulative Returns of the Indexed Portfolio and the Total Index

Source: Research finding.

Comparing the cumulative returns shows that after 2 years, this rate is 113% for the portfolio and 47% for the overall index (Figure 3). As Table 7 shows, the Sharpe ratio, Sortino ratio, peak-to-trough ratio, and Kalmar ratio of the indexed portfolio are better than those of the overall index. The indexed portfolio also has a beta of 1.12.

Table 7. Comparing the Performance of the Indexed Portfolio with the Overall Index

	SHARPE	SORTINO	MAX_DRAWDOWN	CALMAR, ALPHA, BETA
INDEXED PORTFOLIO	0.91	1.33	-0.15	[1.29, 0, 1.12]
OVERALL INDEX	-0.01	-0.01	-0.24	[-0.01, -0, 1]

Source: Research finding.

The difference in returns between this model and the overall index during this period is significant, and the t-statistic is -3.07 with a significance probability of 0.2 percent.

$$t = \frac{\mu_{P-I}}{\sigma_{P-I}/\sqrt{N}} = -3.07$$

- One-year period:

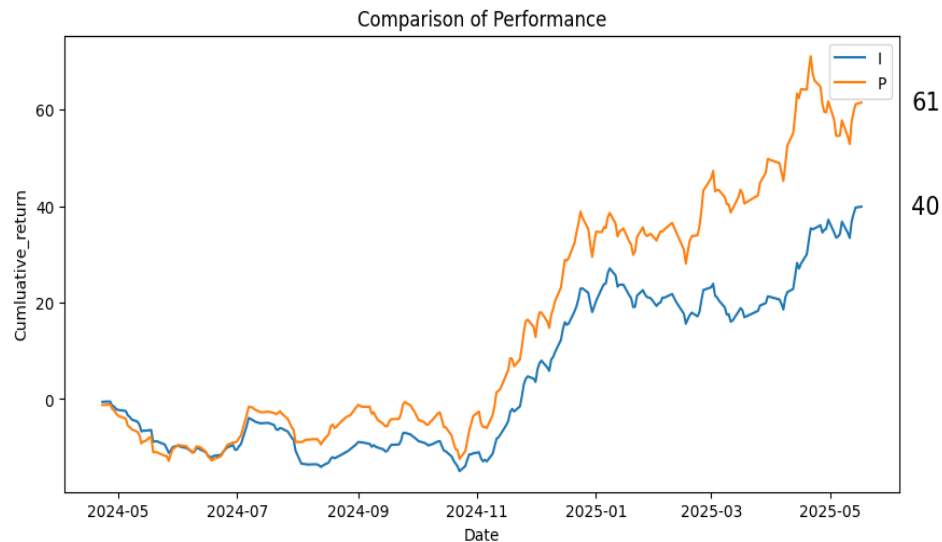


Figure 4. Comparison of Cumulative Returns of the Indexed Portfolio and the Total Index

Source: Research finding.

Comparing the cumulative returns shows that after 1 year, this rate is 61% for the portfolio and 40% for the overall index (Figure 4). As Table 8 shows, the Sharpe ratio, Sortino ratio, peak-to-trough ratio, and Kalmar ratio of the indexed portfolio are better than those of the overall index. The indexed portfolio also has a beta of 1.07.

Table 8. Comparing the Performance of the Indexed Portfolio with the Overall Index

	SHARPE	SORTINO	MAX_DRAWDOWN	CALMAR, ALPHA, BETA
INDEXED PORTFOLIO	1.36	1.97	-0.12	[2.49, 0, 1.17]
OVERALL INDEX	0.84	1.24	-0.14	[0.98, -0, 1]

Source: Research finding.

The difference in returns between this model and the overall index during this period is significant, and the t-statistic is -1.60 with a probability of 5%, one-sided, or significant at the 10% level.

$$t = \frac{\mu_{P-I}}{\sigma_{P-I}/\sqrt{N}} = -1.60$$

4.3 Implication for Investors

Indexing remains a valuable strategy for institutional investors with access to advanced tools and predictive models. Therefore, by selecting these 14 stocks (of course, periodically changing these 14 stocks) and using this indexed portfolio, these investors can outperform the overall index in the medium and long term. Of course, these investors can adjust their portfolios in different periods and with greater frequency.

For retail investors or in environments with low expected alpha, indexing offers a low-cost and tax-efficient approach that often outperforms active management. Therefore, these investors can outperform the overall index in the medium and long term by selecting these 5 stocks (of course, periodically by changing these 5 stocks) and using this index portfolio.

5. Conclusion and Suggestions

This paper investigated the theoretical foundations and empirical effectiveness of indexed portfolio construction, positioning it as a practical and cost-effective strategy for both retail and institutional investors. Drawing on a comprehensive

review of literature and rigorous quantitative testing within the Iranian capital market, the study offers compelling evidence that indexing serves as a robust alternative to traditional optimization-based portfolio strategies.

Indexing provides a low-cost, transparent, and scalable approach to gaining market exposure. Particularly in emerging markets like Iran—where liquidity constraints, transaction costs, and behavioral inefficiencies are more pronounced—passive strategies can offer superior long-term performance. The indexed portfolio developed in this study outperformed the benchmark index over one- and two-year periods, even when constrained by realistic implementation conditions.

5.1 Key Contributions

This research makes the following contributions to the academic and practical discourse on portfolio management:

- **Localized Application:** It introduces an indexed portfolio tailored specifically to the structure and characteristics of the Iranian capital market, targeting both retail (5-stock) and institutional (14-stock) investor segments.
- **Practical Constraints:** It integrates real-world implementation constraints, including transaction costs, turnover limits, and weight bounds, ensuring that the proposed strategy reflects conditions investors actually face.
- **Empirical Back-testing:** The performance of the portfolio was tested through historical back-tests, and evaluated using statistical significance tests, specifically t-tests, to validate robustness and consistency over different horizons.

5.2 Comparative Analysis

To position this research within the broader literature, Table 9 presents a comparative evaluation of this study's methodology and findings against three well-known studies in the field.

Table 9. Comparing the Performance of the Indexed Portfolio with the Overall Index

Feature	This Paper	Beasley (2003)	Benidis (2018)	Clarke (2006)
Sample Size	5 (retail) + 14 (institutional)	50-100 stocks	50-500 stocks	100+ stocks
Optimization Method	Constrained regression	Quadratic programming	Lasso regression	Mean-variance
Rebalancing	21-day periods	Monthly	Annual	Quarterly
Constraints	Turnover, weights, costs	Weights, turnover	Sparsity, turnover	Turnover, costs
Statistical Test	t-test for significance	None	None	Sharpe ratio comparison
Outperformance	Yes (1Y & 2Y)	Yes (long-term)	Mixed results	Yes (with constraints)

Source: Research finding.

This comparison shows that while earlier studies employed more conventional optimization techniques (e.g., quadratic programming or mean-variance), this paper distinguishes itself by focusing on a constrained regression framework tailored to local conditions. Moreover, the use of t-tests for statistical evaluation strengthens the credibility of its performance claims.

5.3 Limitations and Directions for Future Research

While this study offers valuable insights, several limitations must be acknowledged:

- **Limited Stock Universe:** The research focuses on a relatively small sample of stocks due to data availability and implementation constraints. This limits the generalizability of findings to broader asset classes or the full market universe.
- **Constraint-Driven Design:** The real-world constraints (e.g., transaction costs, turnover limits, and position bounds) necessary for practical relevance also restrict the theoretical efficiency of the portfolio.
- **Market-Specific Focus:** The results are derived from the Iranian capital market, and while transferable insights exist, external validation in other emerging or developed markets is needed.

Building upon the findings of this study, future research may explore several promising directions:

- Machine Learning and Predictive Modeling: Employ supervised learning or reinforcement learning for expected return prediction and adaptive rebalancing strategies.
- Scenario Analysis & Stress Testing: Simulate performance under extreme market conditions (e.g., sanctions, currency devaluation) using Monte Carlo or historical scenarios.
- Comparative Strategy Analysis: Evaluate the performance of different portfolio construction frameworks such as:
 - Equal-weighting
 - Traditional mean-variance optimization
 - Black-Litterman model
 - Risk-parity strategies
- Factor-based and ESG Indexing: Extend the analysis to smart beta or ESG-based indexing, particularly relevant for institutional mandates.
- Behavioral Factors and Adoption: Study investor behavior and the barriers to widespread adoption of passive strategies in local markets.

By combining empirical analysis with practical constraints, this study demonstrates that indexed portfolio construction is not only feasible but also advantageous in emerging markets. It paves the way for future work that can build more dynamic, adaptive, and robust investment frameworks for investors across varying market environments.

Declaration

Availability of data and material: The datasets used in this study are publicly accessible on <https://github.com/user-attachments/files/20634766/Adjusted.zip>.

The codes used in this study are publicly accessible on <https://github.com/baminro/Indexed-Portfolio/blob/main/Indexed%20Portfolio%20Codes>.

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