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RESEARCH PAPER

Hidden Cointegration among Borsa Istanbul Sector Indices

Kemal Eyuboglu[a], Sinem Eyuboglu [b,*]

a. Faculty of Applied Sciences, Department of Banking and Finance, Tarsus University, Mersin, Turkey
b. Faculty of Applied Sciences, Department of Custom Administration, Tarsus University, Mersin, Turkey

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Abstract
In this study, the cointegration relationship between the financial, industrial, services and technology indices in Borsa Istanbul is analyzed by employing the Johansen cointegration test and Hatemi-J and Irandoust (2012) hidden cointegration test. Daily data cover the period January 02, 2012, to September 24, 2018. While the Johansen cointegration test indicates no cointegration, the Hatemi-J and Irandoust test showed that there is a hidden cointegration among the four indices. Accordingly, an increase or decrease in the index prices will be effective in the formation of other index prices. Thus, it is not possible to diversify within the Turkish stock market.
Keywords: Hidden Cointegration, Stock Market, Sector Indices, Portfolio Diversification, Turkey.
JEL Classification: C58, G11, G32.

Introduction

Portfolio diversification can be defined as the portfolio of different investment instruments in order to obtain the maximum expected return for a given risk level or an expected return with the minimum risk level (Markowitz, 1952). One of these investment instruments is the stock markets. Investors may evaluate their funds in different countries' stock markets or among the sector indices in the same stock market that have little or negative correlations (Schwob, 2000; Black et al., 2002).

When the portfolio diversification is considered on the basis of sector indices, cointegration relationships of different indices should be analyzed. Investors and portfolio managers examine the interactions of financial instruments each other during the portfolio creation phase. A crisis that may occur in a sector index may cause fluctuations in the index as well as cause impact on other indices. If the indices are moving together, it can be concluded that the sectors react in a similar way to the information. Thus, diversification has no benefit. Otherwise, non-systematic risk can be minimized by diversification (Jorion, 1986; Francis and Leachman, 1998; Besser and Yang, 2003).

The study contributes to the literature in several aspects. First, many studies have tested the nexus between international stock markets (e.g. Kasa, 1992; DeFusco et al., 1996; Ghosh et al., 1999; Bessler and Yang, 2003; Johansson and Ljungwall, 2009; Guidi and Ugur, 2014; Chien et al., 2015; Caporale et al., 2016). However, as Berument et al. (2005) mentioned that stock markets of different countries are under the influence of various monetary, fiscal or policy structural shocks from their local governments. Thus, applying data from a single

*. Corresponding author email: sinemeyuboglu@tarsus.edu.tr

country enables us to remove the impacts of different policy and structural shocks on stock market indices.

Second, Turkey is a growing country. With economic growth, companies increase their profitability. Increase in profitability led investors to focus on Turkish capital markets. Increasing investors' interest in Turkey has motivated us to examine the return and risk characteristics of the stock prices.

Third, there are few studies testing the long-term nexus between sector-specific indices in the same stock market. Pioneer attempt by Arbelaez et al. (2001) investigated the short and long-term nexus between the sector indices (general, industrial, commercial and financial) in the Colombian Stock Market. The results show that the related indices are cointegrated. The existence of sector-specific cointegration is also found in China (Wang et al., 2005), Jordan (Al-Fayoumi et al., 2009), India (Krishnankutty and Tiwari, 2011; Deo, 2014), Qatar (Ahmed, 2012), Egypt (Ahmed, 2016). Whether there is cointegration among the sector-specific indices are also tested by Berument et al. (2005), Constantinou et al. (2008) and Surya and Natasha (2018) in Turkey, Cyprus, and Indonesia respectively. They found no evidence for sector-specific cointegration.

Fourth, this study also employs a relatively new technique. Previous sector-specific studies have analyzed the nexus by applying symmetric econometric techniques. They neglected new developments in econometrics such as asymmetric cointegration test. This technique has not been commonly applied in portfolio diversification studies. The disadvantage of symmetric techniques, they suppose the impact of negative shocks is familiar as the impact of positive shocks. While symmetric tests denote that there is no nexus between series, asymmetric tests may show a relationship between variables. Thus, results can provide spurious insights for investors and fund managers for applying sectorial diversified portfolio strategy. However, Granger and Yoon (2002) recommended that the trade-off between positive and negative shocks may be unfamiliar from the trade-off among the series. They suggested that the interactions among the series must be investigated by dividing them into positive and negative components. They explained this as hidden cointegration. In this study, different from the earlier studies, dividing the indices into positive and negative components, Hatemi-J and Irandoust hidden cointegration test is applied. Therefore, it is aimed to investigate the hidden cointegration among the Borsa Istanbul sector indices. As far as we concerned, the study is a pioneer attempt to investigate the asymmetric cointegration nexus among the sector indices.

Yilanci and Aydin (2017) expressed time series responses are different for their components. The neglecting of these differences cannot reveal the linkages among the series. Therefore, it reduces the robustness of the analysis. If we consider the asymmetry, the existence of hidden interactions among series can be revealed. Also, Hatemi-J et al. (2014) expressed that the asymmetric cointegration test is unique due to the fact that it can reveal the different impact of negative shocks on other indices than positive shocks. This kind of information can guide investors to form their investment decisions more effectively.

The rest of the study is structured as follows. Section2 gives information about the development of Borsa Istanbul. Section3 summarizes earlier studies in the literature. Section4 describes the data and methodology applied in the study. The findings are reported in Section 5. The last section summarizes and concludes the study.

Development of Borsa Istanbul

The Ottoman Empire began to develop its commercial relations with Europe from the 16th century. However, developing commercial relations caused a foreign trade deficit in the Ottoman Empire. The increase in deficits revealed the need for financing. Although the Ottomans first applied to domestic borrowing methods, due to insufficient domestic

borrowing, it had to go to borrowing from Europe. The foreign trade deficits and borrowings accelerated the establishment of foreign banks in the Ottoman Empire. In the following years, the number of joint-stock companies increased and the bonds and stocks issued by these companies accelerated the development of the capital market. In 1864, a market was established in the Ottoman Empire under the leadership of Galata bankers. In 1866, the Ottoman Empire gave its official status to Dersaadet Tahvilat stock exchange. In 1906, the name of the stock exchange was changed as Esham and Tahvilat Exchange and the market continued its activity until the Republic Period. In the following years, the First World War and the Turkish War of Independence influenced the activities of the Esham and Tahvilat Exchange and after the proclamation of the Republic; the transfer of the market to Ankara was the end of this first capital market. Although the stock exchange was re-established in 1938 in Ankara in the name of Kambiyo, Esham and Tahvilat Exchange, it moved back to Istanbul in 1941 when its activities came to a halt.

In the eighties, Turkish capital markets made important movements in improving the legislative structure. The institutions needed to establish the background to make possible sound capital market progress. In 1981, the Capital Market Law No. 2499 was enacted and the Capital Markets Board (CMB), an institution responsible for the management, control, and regulation of the securities market, was established one year later. On December 18, 1985, the Istanbul Stock Exchange (ISE) regulation was published. The official opening of the stock exchange took place on 26 December 1985.

Table 1. Number of Companies and Market Capitalization in Borsa Istanbul

Year	Number of Companies	Market Capitalization (million USD)	Year	Number of Companies	Market Capitalization (million USD)
1986	80	938	**2003**	285	69003
1987	82	3125	**2004**	297	98073
1988	79	1128	**2005**	306	162814
1989	76	6756	**2006**	322	163775
1990	110	18737	**2007**	327	289986
1991	134	15564	**2008**	326	119698
1992	145	9922	**2009**	325	235996
1993	160	37824	**2010**	350	307551
1994	176	21785	**2011**	375	201983
1995	205	20782	**2012**	422	311246
1996	228	30797	**2013**	438	237641
1997	258	61879	**2014**	437	269800
1998	277	33975	**2015**	428	190152
1999	285	114271	**2016**	414	174491
2000	315	69507	**2017**	411	233368
2001	310	47689	**2018**	414	150506
2002	288	34402	**2019(May)**	412	123180

Source: https://www.borsaistanbul.com

On January 03, 1986, ISE started its operations with a total of 41 stocks which had a total market value of 900 million dollars. As seen from Table 1, the number of traded companies reached 412 and the market capitalization reached 123 billion dollars at the end of May, 2019.

On November 21, 1994, the electronic trading system was completed and all shares were traded in electronically. On 30 December 2012, the new Capital Market Law (no: 6362) was published. In 2013, Borsa Istanbul (BIST) was founded on April 5 with the merger of the ISE, Turkish Derivatives Exchange (VIOP) and Istanbul Gold Exchange. In Borsa Istanbul; there are four markets, namely, the equity market, the debt securities market, the derivatives

market, the precious metals, and the diamond market. Equity market indices have been generated to measure the performances of a group of stocks traded on the BIST. By the end of 1996, BIST calculated only the BIST-100, industrials and financials price indices. As of 1997, sector and sub-sector indices began to be calculated by BIST. Today, many stock indices are calculated in real time. Table 2 denotes the main sector and sub-sector indices calculated in Borsa Istanbul.

Table 2. Sector and Sub-sector Indices in Borsa Istanbul

BIST Industrials	
BIST Food, Beverage	BIST Services
BIST Textile, Leather	BIST Electricity
BIST Wood, Paper, Printing	BIST Transportation
BIST Chemical, Petroleum, Plastic	BIST Tourism
BIST Non-Metal Mineral Products	BIST Wholesale and Retail Trade
BIST Basic Metal	BIST Telecommunication
BIST Metal Products, Machinery	BIST Sports
BIST Mining	BIST Construction
BIST SME Industrial	
BIST Financials	
BIST Banks	BIST City Indices
BIST Insurance	Adana, Ankara, Antalya, Balıkesir,
BIST Leasing, Factoring	Bursa, Denizli, İstanbul, İzmir,
BIST Holding and Investment	Kayseri, Kocaeli, Konya, Tekirdağ
BIST Real Est. Inv. Trusts	
BIST Brokerage Houses	
	BIST Investment Trusts
BIST Technology	BIST Sustainability
BIST Information Technology	BIST Corporate Governance
	BIST Dividend

Source: https://www.borsaistanbul.com

Literature Review

Most of the studies that analyse the cointegration between indices use various indices across countries. Earlier studies have mostly indicated that stock markets around the world becoming more integrated. This tendency to integrate may be due to technological changes in many countries, which facilitate the transfer of information as well as the removal of financial barriers (Cheng and Glascock, 2005). Thus, the transmission of shocks in a stock market to others makes it difficult to create an efficient portfolio in international markets.

In addition, some studies have been carried out to investigate the links between the national stock markets in the literature. As stated by Weiss (1998), approaches to global capital management among country stock markets may be less effective than in the past; sector-based portfolios can offer greater potential to control value-added and risk.

Therefore, investigating linkages among sectorial indices has become a scope of focus. However, despite a wide range of literature on how different stock markets links over time, few studies have been conducted so far to analyze the dynamic linkages between sector indices within the same market.

For example, Arbelaez et al. (2001) investigated the short and long-term nexus among the sector indices in the Colombia Stock Exchange for the period 1988-1994. General, industrial, commercial and financial indices were used in the study. The analysis showed that indices were cointegrated. Wang et al. (2005) tested the linkages among Shanghai and Shenzhen Stock indexes in China by using both daily and monthly data for the 1994-2001 period. The results showed that the indices were cointegrated and the index value was affected by the information from other

indices. In addition, it was determined that the industrial index was the index with the most effect on other indices and the financial index was the least affected by other sectors.

Berument et al. (2005) tested the trade-off among the services, industrial and financial indices in Borsa Istanbul cover the period 1997-2003. They found there is no evidence of cointegration relationship between the indices. Constantinou et al. (2008) taking into account the 12 indices, they investigated the long and short-term linkages among sector indices in Cyprus during the period 1996-2005. Results indicated there is no cointegration among the variables. In addition, the causality analysis showed that the indices were independent of each other.

Patra and Poshakwale (2008) examined the interactions between the indices in the Greek stock market for the period 1996-2003. Although the results did not denote a strong long-term nexus among the indices, the banking sector has shown a strong impact on the return and volatility of other sectors in the short-term. Al-Fayoumi et al. (2009) analyzed the linkages among general, financial, industrial and service indices on the Jordanian Stock Exchange cover the period 2000-2007. They found that there is a cointegration vector among the indices in the long-term. The VECM results also showed that there is causality between general, financial and industrial indices towards other indices. Krishnankutty and Tiwari (2011) tested whether there is any relationship among the 7 indices listed on the Indian Stock Exchange covering the period 1999-2011. They found cointegration only in three groups (automobile and capital goods, oil-gas, automobile, and automobile-metal). Ahmed (2012) investigated the cointegration and causality relationships between the banking, financial institutions, industrial, insurance and services indices during the period 2008-2011 in the Qatar Stock Exchange. The results showed that there is cointegration nexus among the sector indices.

Deo (2014) investigated the long-term trade-off among CNX Small Cap, CNX Mid Cap, CNX Nifty and CNX Nifty 500 indices in India for the period 2004-2012 by using Engle-Granger and Johansen cointegration tests. Findings revealed that there is cointegration among the relevant indices. Rajamohan and Muthukamu (2014) analyzed the impact of the banking sector with on the other sector indices in India for the period of 2008-2013 and concluded that the impact of the banking sector on other sectors is positive. Guha et al. (2016) tested the linkages among the Nifty index and 11 sector indexes in India. Findings indicated that all indices move in the same direction with Nifty index; also real estate, metal, and information technology indices were more sensitive to changes in the Nifty index.

Surya and Natasha (2018) examined the short, medium and long-run nexus among 9 industry indices in the Indonesian stock exchange for the period 2012-2016. They found no cointegration relationship among indices in the short-run. In the medium-run, they found only one cointegrating vector. In the long-run, they explored that all sectors are cointegrated. They concluded that sectorial diversification can be valid only in the short-run. Causality results also confirmed that there is no benefit of portfolio diversification in the medium-run.

Data and Methodology

We used daily data from January 02, 2012 to September 24, 2018. The use of daily data had several advantages. For example, Copeland (1991) emphasized that more information can be obtained from daily data, while Eun and Shim (1989) underlined that weekly and monthly data cannot be sufficient to get a few days of interaction. Data were taken from Borsa Istanbul. All series were in their natural logarithm.

In the study, whether there is a long-term relationship among the indices is examined with both standard and hidden cointegration tests. Augmented Dickey-Fuller (ADF) is employed to determine the integration level. It is determined that the series are non-stationary in log levels while the first differences are stationary at 1% significance level. Then, Johansen (1988), Johansen and Juselius (1990) cointegration test is applied to determine the possible long-term

nexus among the indices.

However, Granger and Yoon (2002) recommended that the trade-off between positive and negative shocks may be unfamiliar. They expressed that the series were cointegrated because they reacted to the shocks together but there would be no cointegration nexus between the variables if they react differently to the shocks. They recommended that the linkages among the series should be investigated by dividing them into positive and negative components. They defined this approach as hidden cointegration.

Hidden cointegration is a simple cointegration analysis. The test is introduced by Granger and Yoon (2002), is based on the Engle and Granger (1987) cointegration test, while the hidden cointegration test introduced by the Hatemi-J and Irandoust (2012) is based on the Johansen cointegration (1988) test. In both tests, the variables are firstly divided into components, and then the long-term relationship between these components is examined. Hidden cointegration test can be written as follows:

$$X_t = X_{t-1} + \varepsilon_t = X_0 + \sum_{i=1}^{t} \varepsilon_i$$
$$Y_t = Y_{t-1} + e_t = Y_0 + \sum_{i=1}^{t} e_i \quad (1)$$

where X_t and Y_t are the variables that the long-term relationship is examined $\varepsilon_t \sim N(0, \delta_{\varepsilon_i}^2)$ and $e_t \sim N(0, \delta_{e_t}^2)$ are white noises. Positive and negative shocks of each variable can be defined as:

$$\varepsilon_i^+ = \max(\varepsilon_i, 0), \varepsilon_i^- = \min(\varepsilon_i, 0)$$
$$e_i^+ = \max(e_i, 0), e_i^- = \min(e_i, 0) \quad (2)$$

The disturbance terms can be explained as $\varepsilon_i = \varepsilon_i^+ + \varepsilon_i^-$ and $e_i = e_i^+ + e_i^-$, the first equation can be modeled as follows:

$$X_t = X_{t-1} + \varepsilon_t = X_t + \sum_{i=1}^{t} \varepsilon_i^+ + \sum_{i=1}^{t} \varepsilon_i^-$$
$$Y_t = Y_{t-1} + e_t = Y_t + \sum_{i=1}^{t} e_i^+ + \sum_{i=1}^{t} e_i^- \quad (3)$$

where $\sum_{i=1}^{t} \varepsilon_i^+$ and $\sum_{i=1}^{t} \varepsilon_i^-$ are positive and negative shocks of X_t, and $\sum_{i=1}^{t} e_i^+$, $\sum_{i=1}^{t} e_i^-$ are positive and negative shocks of Y_t. If Engle-Granger (1987) cointegration test is applied to these shocks, Granger and Yoon (2002) test, and if Johansen cointegration test is applied to these shocks Hatemi-J and Irandoust (2012) are performed.

1. Empirical Results

Table 3 presents the descriptive statistics of the sector indices. It is determined that the highest volatile index is technology and the lowest volatile index is financial over the sample period.

Table 3: Descriptive Statistics

Indices	Mean	Maximum	Minimum	Std. deviation	Skewness	Kurtosis
Financial	11.58	11.90	11.13	0.14	-0.08	2.85
Industrials	11.28	11.82	10.76	0.26	0.47	2.39

Services	10.92	11.37	10.43	0.18	0.13	3.27
Technology	10.74	12.03	9.88	0.57	0.49	1.93

Source: Research finding.

Table 4 indicates unit root test results for Financial, Industrials, Services and Technology indices. It is clear from the table unit root exists in all series, in other words, the series are non-stationary in log levels while the first differences are stationary at 1% significance level.

Table 4. Unit Root Test Results

Indices	ADF test	
	Constant	Constant and Trend
Financial	-2.61	-3.03
Industrials	-0.92	-2.90
Services	-2.19	-2.99
Technology	-0.47	-1.93
ΔFinancial	-43.90***	-43.90***
ΔIndustrials	-41.26***	-41.25***
ΔServices	-39.68***	-39.67***
ΔTechnology	-39.60***	-39.58***

Note: *** indicates significance at 1% level.
Source: Research finding.

Since the integrated levels of the series are determined, the Johansen cointegration test is applied to examine the long-term relationship among the indices. The results of trace and max-eigen statistics are reported in Table 5. It is clear that no existence of cointegration among the four indices in both trace and max-eigen statistics. These findings reveal that the sector indices are not moving together in the long-term.

Table 5. Johansen Cointegration Method Results

H_0	Trace statistic	5% Critical value	p-value	H_0	Max-Eigen statistic	5% Critical value	p-value
r = 0	42.42	54.07	0.3548	r = 0	17.85	28.58	0.58
r ≤ 1	24.56	35.19	0.4270	r ≤ 1	14.95	22.29	0.37
r ≤ 2	9.60	20.26	0.6780	r ≤ 2	8.31	15.89	0.51
r ≤ 3	1.29	9.16	0.9088	r ≤ 3	1.29	9.16	0.90

Note: Based on the information criteria of the SIC and HQ optimal lag length is selected 1. The selected lag length is excluded autocorrelation in the residuals of the VAR. We follow Pantula principle (Pantula, 1989) and model 2 is selected.
Source: Research finding.

Then to test the possible hidden long-term relationship among the sector indices, we employed Hatemi-J and Irandoust (2012) hidden cointegration test. Prior to applying the hidden cointegration test, it is crucial to determine whether the positive and negative components are integrated of the same order. Thus, ADF is employed to determine the integration order of the components. The results of the ADF unit root test are presented in Table 6.

Table 6. Unit Root Test Results (Positive and Negative Components)

Indices	ADF	
	Constant	Constant and Trend

Indices	ADF	
	Constant	Constant and Trend
Financial(+)	-2.123	-1.590
Financial(-)	-0.453	-1.090
Industrial(+)	0.914	-2.176
Industrial(-)	0.474	-1.716
Services(+)	0.199	-1.582
Services(-)	0.670	-1.581
Technology(+)	0.850	-1.187
Technology(-)	0.459	-0.855
ΔFinancial(+)	-43.83*	-43.91*
ΔFinancial(-)	-20.25*	-20.25*
ΔIndustrial(+)	-41.44*	-41.45*
ΔIndustrial(-)	-20.09*	-20.08*
ΔServices(+)	-41.65*	-41.64*
ΔServices(-)	-20.14*	-20.15*
ΔTechnology(+)	-37.67*	-37.68*
ΔTechnology(-)	-36.78*	-36.77*

Note: * indicates significance at 1% level.
Source: Research finding.

It is determined that the positive and negative components are non-stationary in log levels while the first differences are stationary at 1% significance level. Then, the relationship between the positive and negative components is tested by Hatemi-J and Irandoust (2012) hidden cointegration test. Table 7 shows the Hatemi-J and Irandoust (2012) cointegration test results for positive and negative components.

It is clear that the existence of a single cointegration vector among the positive components of four sector indices in trace and two cointegration vectors among the positive components of four sector indices in max-eigen statistics. These findings indicate that the positive components of the sector indices have a relationship in the long-term.

Table 7. Hatemi-J & Irandoust (2012) Hidden Cointegration Test Results

H_0	Trace statistic	5% Critical value	p-value	H_0	Max-Eigen statistic	5% Critical value	p-value
Positive Components							
r = 0	573.41	54.07	0.0001	r = 0	539.69	28.58	0.0001
r ≤ 1	33.71	35.19	0.0715	r ≤ 1	22.97	22.29	0.0402
r ≤ 2	10.74	20.26	0.5666	r ≤ 2	7.721	15.89	0.5812
r ≤ 3	3.02	9.16	0.5760	r ≤ 3	3.025	9.16	0.5760
Negative Components							
r = 0	293.04	54.07	0.0000	r = 0	265.70	28.58	0.0001
r ≤ 1	27.34	35.19	0.2719	r ≤ 1	12.90	22.29	0.5660
r ≤ 2	14.43	20.26	0.2603	r ≤ 2	9.978	15.89	0.3363
r ≤ 3	4.45	9.16	0.3479	r ≤ 3	4.459	9.16	0.3479

Note: Based on the information criteria of the SIC and HQ optimal lag length is selected 1 for positive components and 2 for negative components. We follow Pantula principle and selected model 2 for components.
Source: Research finding.

In the case of negative components, both trace and max-eigen statistics are confirmed that there is a single cointegrating vector among the negative components of four sector indices. Therefore, it is possible to conclude that there is a hidden cointegration relationship among the prices of four sector indices.

Conclusion

A way to minimize portfolio risk is to make a portfolio divided into some sectors that have a low correlation in the same market condition. In all earlier literature on sector-specific cointegration analysis, there was no separation between the impact of negative and positive shocks. This study examines the relationship among the sector indices by using daily data for the period January 02, 2012 to September 24, 2018. To test whether sector indices are cointegrated, we employed the Johansen cointegration method. According to the Johansen method, it is not found any cointegration nexus among the four sector indices. No cointegration refers that there are benefits from the reduction of risk without loss in the expected returns. These results are similar to Berument et al. (2005); Constantinou et al. (2008) and Surya and Natasha (2018).

However, it may be a hidden cointegration which can be revealed by dividing series into the positive and negative components. Therefore, we applied Hatemi-J and Irandoust (2012) hidden cointegration test. Results reveal that there exists a cointegration nexus both in positive shocks and negative shocks of indices. According to the results, positive and negative shocks are the determinants of the prices of the sector indices. In other words, an increase or decrease in index prices will be effective in the formation of other index prices.

Our empirical findings show the importance of utilizing disaggregated data in the analyses. Symmetric cointegration test asserts no cointegration, but asymmetric test denotes there are interactions among the series. Thus, results can provide spurious insights for investors and fund managers for creating an efficient portfolio. If they consider symmetric cointegration results there will be no significant long-run benefits from the reduction of risk without loss in the expected returns because of the transmission of positive shocks or negative shocks in one sector to others.

Thus, the findings will be useful for institutional and individual investors interested in modeling the sector movements in Borsa Istanbul. Our evidence suggests that potential diversification benefits from a sector-level investment may also be relatively limited, in the light of hidden cointegration linkages. In other words, there will be no potential diversification benefit from portfolio investments at the sector level. This result is consistent with Arbelaez et al. (2001); Patra and Poshakwal (2008); Al-Fayoumi et al. (2009); Ahmed (2012; 2016); Deo (2014); Rajamohanand and Muthukamu (2014), Guha et al. (2016). In the following studies, it is possible to contribute to the literature by analyzing the hidden nexus between different indices.

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