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The Short and Long Run Causality between Agglomeration and Productivity

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Abstract

This study is to investigate the short- and long-run causal relationship between agglomeration (localization and urbanization) economies and labor productivity in the manufacturing sector of 28 Iranian provinces over an 11-year period, 2001–2011. Fully Modified Ordinary Least Squares (FMOLS) method was used to estimate our long-run panel data model. The empirical findings suggested that localization and urbanization economies had a positive and statistically significant effect on labor productivity in the long-run equilibrium. Then, the Generalized Method of Moments (GMM) was employed to examine Granger Causality between each pair of variables. The results revealed a bidirectional short-run Granger causality between localization economies and labor productivity. Additionally, a bidirectional short-run causal relationship was found between urbanization economies and labor productivity for all the manufacturing industries. In the long run, however, there seemed to be bidirectional causality between localization economies and productivity and also between urbanization economies and labor productivity in each manufacturing industry.

Keywords: Agglomeration Economies, Labor Productivity, Granger Causality, Cross-Section Dependence, Iranian Manufacturing Industries.

JEL Classification: C23, R12, L61, L62, L63, L64, L65, L66, L76, L68, L69.

1. Introduction

Agglomeration economies are the benefits that come when firms locate near one another together in cities and industrial clusters. They can be categorized into localization and urbanization economies.

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Localization economies exist when the average costs of firms' production in a particular industry shift down due to the expansion in size of the industry. Urbanization economies occur when costs of firms go down because they produce in a densely populated area. So, expansion in an urban area involves benefits to firms from a variety of industries.

Marshall (1920) has proposed three sources of agglomeration economies, namely input sharing, labor market pooling, and knowledge spillovers. Labor market pooling occurs when workers can easily move between firms in an industry. It leads to better skill ‘matches’ between workers and employers. Input sharing includes scale economies in input production that enable firms with greater purchased input intensity will benefit more from being located near the input suppliers.

Knowledge spillovers entail interactions among entrepreneurs and workers in close proximity. It is proportional to the number of firms and while each firm engages in some type of knowledge creation, all the nearby firms can benefit from its outcome (Hu et al., 2015).

The localization economies indicate that productivity is affected by firm clustering productivity. There are some channels through which localization economies affect productivity. First, proximity of the same firms may increase the quantity or improve the quality of the labor pool so that hiring can be done with more exact matches or lower risk and reduce frictional unemployment. Proximity of suppliers can also lead to easier access to or lower costs of material inputs. Second, geographical concentration of firms makes knowledge and skill sharing through formal and informal interactions among firms or individuals possible. The shared knowledge may not be confined to advanced technologies but can also include management skills and business knowledge (Hu et al., 2015). Third, concentration of an industry enables production of specialized intermediate inputs to the optimal level for exploiting scale economies which, in turn, allows firms to outsource higher shares of their intermediate inputs and to specialize in the most profitable activities (Holmes, 1999).

Agglomeration, On the other hand, can lead to several diseconomies. A dense firm location might cause congestion and increase business costs. Industrial concentration generates heavy traffic, causes pollution, and increases the probability of losing some key workers due to the sever competition between plants which, in turn will have a negative impact on productivity.

There are some channels through which urbanization economies influence productivity. Larger cities facilitate spillovers and learning within and across industries. They permit greater specialization and admit more complementarities in production and facilitate sharing and risk-pooling by their very size. Smaller firms in large cities can have access to specialized services offered in large urban areas. Proximity of population concentrations can facilitate product distribution. Moreover, the provision of public goods, due to the consumption of infrastructures which are spread over a large number of people in any one place, can help in achieving significant economies of scale. Finally, home-market effect persuades firms to be located near a large market.

On the other hand, a high degree of urbanization has such disadvantage as congestion, heightened competition, rising land price, intense competition in output markets, and increased trading cost which can negatively impact the productivity of firms located in spatially concentrated regions.

As it was mentioned above, the mainstream regional and urban economic theory supports a causal relationship running from agglomeration to increasing productive efficiency. As a result, much of the empirical research has also assumed the same unidirectionality. More recently, however, a number of researchers have conceded the possibility that density can be determined simultaneously with productivity. They argue that if mobile factors move to the most productive locations, high productivity will give rise to higher densities. This can imply that agglomeration variables are endogenous (Graham et al., 2010).Therefore, some researchers have attempted to correct for potential endogeneity concern, induced through reverse causation, but theoretical and empirical bases for this concern are still largely unknown.

Concerning all the above, this study is aimed at investigating the short- and long-run causality between agglomeration (localization and urbanization) and Productivity in some Iranian Industries.

In this regards, the paper is structured as follows. Section 2 reviews of literature. Section 3 explains data and measure of agglomeration.

Section 4 describes the model we use to test for the directionality of localization and urbanization economies and discusses some estimation issues. Results are presented in Section 5.Conclusions are then drawn in the final section.

2. Literature Review

Many empirical studies have investigated the influence of agglomeration on productivity. For instance**,** Ciccone & Hall (1996) examined the spillover effect of manufacturing concentration on labor productivity through the use of state-level data from the United States. Their findings revealed that employment density increased labor productivity. They also reported that doubling local employment density increased labor productivity by 5–6%. In another study, Ciccone (2002) employed data from, France, Germany, Italy, Spain, the UK, and the US in order to study the influence of employment density on labor productivity. He found that labor productivity increased by approximately 4.5% through doubling the employment rate. Similarly, Henderson (2003) employed firm-level panel data for the machinery and high-tech industries and examined the impacts of different externalities forged by agglomeration on the firm production. His findings indicated that a ten-fold increase in the number of local plants in a high-tech industry led to an increase in labor productivity by over 20%. Rosenthal & Strange (2004) surveyed the relevant literature and reported that, generally and with respect to the city size or the industry size, the elasticity of productivity ranged from 3% to 8%. Maré & Timmins (2006) did another study in New Zealand and found labor productivity higher for firms in geographically concentrated industries (localization), firms in more industrially-diversified labor markets (urbanization), and also firms operating in larger labor markets. Brulhart & Mathys (2008) used 245 NUTS-2 regions in the European Union in conducting their studies. Their results demonstrated that agglomeration significantly contributed to the labor productivity with a long-term elasticity of 13%. Furthermore, Ke (2010) employed the data from 617 Chinese cities to estimate the effect of the spatial concentration of industrial production on labor productivity. He observed that agglomeration caused higher productivity in large industrial cities and also in neighboring cities. Lee, Jang, and Hong

(2010) examined the effects of localization, urbanization, and local competition on labor productivity through the use of establishment-level data related to the Korean manufacturing industries. Based on their findings, when an establishment was located in a more localized/specialized, more urbanized/diversified, and more competitive area, the workers, due to the external benefits from agglomeration, became more productive. Martin, Mayer, & Mayneris (2011) assessed the effect of spatial agglomeration of activities on plant-level productivity. To conduct their study, they used French firm and plant-level data from 1996 to 2004. They exploited short-run variations of variables by making use of GMM estimation which allowed them to control for endogeneity biases that appears in the estimation of agglomeration economies. The results showed that French plants benefited from localization economies; however, they found very little evidence for urbanization economies. Dehghan Shabani (2013) investigated the influence of density of economic activity, which is defined as the intensity of labor and physical capital per square kilometer, on labor productivity in 28 Iranian provinces. The empirical results indicated that a high density of economic activity led to an increase in labor productivity in the provinces over the period from 2001 to 2011. Hu, Xu and Yashiro (2015) used the dataset of manufacturing firms active in 176 three-digit industries and in 2860 counties in order to evaluate the role of industrial agglomeration in productivity growth of China's industrial sector. They found that congestion and fiercer competition offset the advantages of agglomeration for firms which were operating within agglomerated regions. They further stated that industrial agglomeration had contributed up to 14% to productivity growth in China's industrial sector between 2000 and 2007. In another study, Azari, Kim, Kim & Ryu (2016) investigated the effect of agglomeration on urban labor productivity in the manufacturing sector of Korea. The researchers benefitted from a panel data analysis of 200 Korean cities during 2004 to 2008. Based on their results, labor density had a negative impact on urban labor productivity, while output density had a positive impact on urban manufacturing productivity.

Despite the fact that many studies have been done on the effect of agglomeration on labor productivity, there is still a remarkable lack of research on the impact of productivity on agglomeration. A few researchers, such as Brulhart & Mathys (2008), Ciccone (2002), Ciccone & Hall (1996), Combes et al. (2008), Henderson (1986), and Henderson (2003) have also done some attempts to address the issue of endogeneity in the estimation of agglomeration economies.

Specifically, Graham et al. (2010) examined the long-run causality between productivity and agglomeration (localization and urbanization) economies for different sectors of the UK. The results showed that agglomeration economies were not strictly unidirectional and that higher levels of productivity could induce industrial growth in local and urban environments.

This study contributes to the previous literature through considering both the short- and long- run causality between agglomeration and labor productivity in the Iranian manufacturing industries.

3. Data and Measurement of Agglomeration

Concerning the measurement of industrial agglomeration, The present researchers followed Lall et al. (2004) and used Location quotient (LQ) index for measuring spatial industry concentration (Localization economies). The Location quotient implies the percentage (share) of productive activity of industry i in region j relative to the percentage (share) of total productive activity in region j, expressed in terms of employment. Therefore,

$$LQ_{ij}^{C} = \frac{S^{C}{}_{ij}}{S_{*j}} = \frac{\dfrac{X_{ij}}{X_{i*}}}{\dfrac{X_{*j}}{X_{**}}} \qquad (1)$$

And

$$S^{C}{}_{ij} = \frac{X_{ij}}{\sum_{j=1}^{n} X_{ij}} = \frac{X_{ij}}{X_{i*}} \text{ and } S_{*j} = \frac{\sum_{i=1}^{I} X_{ij}}{\sum_{i=1}^{I}\sum_{j=1}^{j} X_{ij}} = \frac{X_{*j}}{X_{**}}\,,\ j=1,\dots,J\ ; i=1,\dots,I \qquad (2)$$

Assuming that there are J region and i industries, in the present study, of i and j were equaled to 9 and 28, respectively. X_{ij} implies the number of employees of industry i in region j and $S^{C}{}_{ij}$ refers to the concentration of industry i in region j as compared to the all regions (Nakamura & Paul, 2009).

Although the expressions "population" or "population density", which has often been used as an index for estimating the degree of urbanization in studies that address urbanization economies, might be considered as useful indicators, they are in fact catch-all terms. Especially, such measures are not very adequate for capturing or distinguishing backward linkage effects, such as home market effects where concentration of employment from density of economic activity attracts more firms. Considering this, the present researchers followed Martin et al. (2011) and used two variables to capture urbanization economies. The first one was the number of workers in all industries on region j where industry i was located and the second was the number of workers in industry i and region j. Therefore,

$$LU_t = \ln\left(employees_t^j - employees_t^{ij} + 1\right) \tag{3}$$

In order to compute LQ and LU, industrial manufacturing employment statistics were collected from statistical yearbook of Iranian provinces provided by the Statistical Center of Iran.

Labor productivity measures the real gross domestic product produced by a labor $\frac{Y}{L}$.Value-added and labor force of Iranian Manufacturing Industries were also collected from statistical yearbook of 28 Iranian provinces from 2001 to 2011. The annual data was provided by the Statistical Center of Iran the manufacturing industries were subsumed under International Standard Industrial Classification (ISIC).

4. Econometric Methodology and Results

In this section, the results of short- and Long-run causality between agglomeration and productivity in Iranian Provinces from 2001 to 2011 will be presented. In line with this, the results of cross-section dependence test will be reported first.

4.1. Cross Section Dependence Test

Before even investigating, the stationarity of the series, the researchers performed the cross-section dependence (CD) test (Pesaran, 2004) to examine the cross-section of the variables under consideration. It is well known that when T>N (as is the case in this paper). The null hypothesis of Pesaran test is cross-section independence. As Table 1 indicates, however, the null hypothesis of cross-section independence has been rejected. This finding is especially important when one selects unit root and cointegration tests.

Table 1: The Results of Pesaran's Test of Cross Sectional Independence

		LOC		LU	
number	**Industry**	**statistic**	**Prob**	**statistic**	**Prob**
1	Manufacture of beverages, food and tobacco products	17.57	0.000	16.15	0.000
2	Manufacture of textiles, wearing apparel and leather and related products	9.84	0.000	9.58	0.000
3	Manufacture of wood and of products of wood and cork and furniture	8.989	0.000	3.045	0.000
4	Manufacture of paper and paper products, printing and reproduction of recorded media	11.53	0.000	4.21	0.000
5	Manufacture of chemical[1]	31.02	0.000	10.37	0.000
6	Manufacture of other non-metallic mineral products	16.54	0.000	7.98	0.000
7	Manufacture of metals	27.37	0.000	19.50	0.000
8	Manufacture of machinery and equipment and metal products[2]	20.48	0.000	12.72	0.000
9	Other manufacturing	17.79	0.000	4.05	0.000

Notes:

1) Authors' calculations are based on data files obtained from Statistical Center of Iran.
2) The null hypothesis is cross- section independence.
3) LLOC and LU are logarithm Localization and Urbanization economies, respectively.

4.2. Panel Unit Root Tests

This part presents the stationarity properties of the variables under investigation. Although different panel unit root tests, (such as

1. Coke and refined petroleum products, Manufacture of chemicals and chemical products, Manufacture of rubber and plastics products.

2. Manufacture of fabricated metal products, except machinery and equipment, Manufacture of computer, electronic and optical products, Manufacture of electrical equipment, Manufacture of machinery and equipment n.e.c., Manufacture of motor vehicles, trailers and semi-trailers, Manufacture of other transport equipment.

Breitung, 2000; Choi, 2001; Hadri, 2000; Im et al., 2003, Levin et al., 2002; Maddala & Wu, 1999; and Pesaran, 2007) have been mentioned in the literature, and Pesaran's test or CIPS[1] test was used in this study because the series were cross-sectionally dependent. Pesaran's test eliminates the probability of cross section dependence by augmenting the ADF regressions with cross section averages. CIPS test assumes that cross-section dependence is in the form of a single unobserved common factor. Regarding Pesaran's (2007) panel unit root test, the following equation has been proposed:

$$\Delta y_{it} = a_i + b_i y_{it-1} + c_i \bar{y}_{t-1} + d_i \Delta \bar{y}_t + e_{it} \tag{4}$$

Where $\bar{y}_{t-1} = N^{-1}\sum_{i=1}^{N} y_{it-1}$ and $\Delta \bar{y}_t = N^{-1}\sum_{i=1}^{N} \Delta y_{it}$

Then,

The test obtained as $CIPS = N^{-1}\sum_{i=1}^{N} t_i(N,T)$

Where $t_i(N,T)$ is the crosssectionally augmented Dicky-Fuller for the t_i^{th} cross section unit given by the ratio of the coefficient of y_{it-1} in the regression has been defined by equation 4 (Pesaran, 2007).

The results of CIPS test has been provided in Table 2. Based on the obtained findings, the null hypothesis of non-stationarity is accepted. In general, the findings provided evidence that the variables contained a panel unit root. The first differences of these variables were stationary. This meant that the variables were integrated of order one, i.e. I(1).

Given that the variables were integrated of the same order, it was natural for the researchers to proceed with the cointegration test to discover if there was any long-run equilibrium relationship among the variables. This will be focused on in the next section.

1. Crosssectionally augmented Im, Pesaran, & Shin.

Table 2: CIPS Panel Unit Root Test Results

Industry	Test	LLP		LLOC		LU	
		No trend	Trend	No trend	Trend	No trend	Trend
Manufacture of beverages, food and tobacco products	Level	-0.84 (0.19)	-1.57 (0.057)	-0.15 (0.439)	0.48 (0.68)	-1.249 (0.106)	-1.119 (0.132)
	First difference	-6.33 (0.000)	-4.39 (0.000)	-5.343 (0.000)	-2.878 (0.002)	-5.666 (0.000)	-3.190 (0.001)
Manufacture of textiles, wearing apparel and leather and related products	Level	0.199 (0.57)	0.368 (0.644)	-0.186 (0.42)	-1.721 (0.043)	-1.650 (0.059)	-1.134 (0.124)
	First difference	-4,00 (0.00)	-3.885 (0.000)	-7.799 (0.000)	-5.282 (0.000)	-6.077 (0.000)	-3.913 (0.000)
Manufacture of wood and of products of wood and cork and furniture	Level	0.151 (0.560)	0.347 (0.636)	-0.594 (0.276)	-0.346 (0.365)	0.895 (0.815)	-0.174 (0.431)
	First difference	-3.953 (0.000)	-2.260 (0.012)	-5.950 (0.000)	-3.768 (0.000)	-4.928 (0.000)	-2.723 (0.003)
paper and paper products, Printing and reproduction of recorded media	Level	-1.825 (0.034)	0.858 (0.805)	-1.357 (0.087)	-0.533 (0.297)	-1.742 (0.041)	-0.703 (0.241)
	First difference	-4.91 (0.000)	-2.60 (0.004)	-5.599 (0.000)	-3.039 (0.001)	-5.883 (0.000)	-4.272 (0.000)
Manufacture of chemical	Level	0.614 (0.730)	2.046 (0.980)	0.332 (0.630)	1.811 (0.965)	-1.257 (0.112)	-1.220 (0.133)
	First difference	-2.709 (0.003)	-5.130 (0.000)	-3.719 (0.000)	-2.889 (0.001)	-7.600 (0.000)	-5.237 (0.000)
Manufacture of other non-metallic mineral products	Level	-0.646 (0.258)	2.075 (0.981)	1.264 (0.897)	0.490 (0.688)	-0.727 (0.233)	-1.99 (0.073)
	First difference	-4.359 (0.000)	-3.224 (0.001)	-5.989 (0.000)	-3.575 (0.000)	-6.149 (0.000)	-3.582 (0.000)
Manufacture of basic metals	Level	-2.306 (0.011)	-0.313 (0.377)	-1.459 (0.072)	-1.310 (0.095)	0.476 (0.683)	-0.365 (0.358)
	First difference	-5.176 (0.000)	-2.893 (0.002)	-6.613 (0.000)	-3.814 (0.000)	-5.333 (0.000)	-2.843 (0.002)
Manufacture of machinery and equipment and metal products	Level	-1.050 (0.120)	-0.604 (0.273)	-1.629 (0.064)	-1.424 (0.077)	-0.620 (0.268)	-1.595 (0.059)
	First difference	-5.618 (0.000)	-4.487 (0.000)	-5.833 (0.000)	-3.200 (0.001)	-6.711 (0.000)	-3.965 (0.000)
Other manufacturing	Level	-1.311 (0.095)	-0.687 (0.246)	-1.338 (0.091)	-1.028 (0.152)	1.297 (0.903)	0.998 (0.841)
	First difference	-3.888 (0.000)	-1.770 (0.038)	-5.012 (0.000)	-1.995 (0.023)	-3.363 (0.000)	-1.551 (0.081)

Notes:

1) Authors' calculations are based on data files obtained from Statistical Center of Iran. 2) LLP, LLOC and LU are logarithm labor productivity, localization and urbanization, respectively. 3) The null hypothesis of CIPS is nonstationary. 4) The *p* values have been provided in parentheses.

4.3. Panel Cointegration Tests

To test for cointegration among the variables, the researchers used panel cointegration test proposed by Westerlund (2007) which is indeed derived from the Lagrange multiplier (LM) based unit root tests, such as Ahn (1993), Amsler & Lee (1996), and Schmidt & Phillips (1992) to the test was specifically used to accommodate heteroskedastic and serially correlated errors, individual specific intercepts and time trends, cross-sectional dependence and unknown breaks in both intercepts and slopes of the cointegrated regression. Westerlund (2007) proposed four different statistics to test panel cointegration. Two of them are designed to test the hypothesis that the whole panel is cointegrated, while the other two are group-mean tests. The group mean statistics G_t and G_α test the null hypothesis of no cointegration against the alternative that at least one element in the panel is cointegrated, whereas statistics P_t and P_α test the null hypothesis of no Cointegration against the simultaneous alternative that the panel is cointegrated. This test provides a robust *p*-value against cross-sectional dependencies via bootstrapping.

Table 3: The Results of Westerlund Panel Cointegration Test between LLP and LLOC

Industry	Statistic	Constant		Constant and	
		Value	Robust *p* value	Value	Robust *p* value
Manufacture of beverages, food and tobacco products	Gt	-1.335	0.000	-1.520	0.000
	Ga	-3.410	0.000	-5.641	0.000
	Pt	-8.887	0.000	-8.136	0.000
	Pa	-4.016	0.000	-4.982	0.000
Manufacture of textiles, wearing apparel and leather and related products	Gt	-1.746	0.000	-2.927	0.000
	Ga	-4.456	0.000	-7.255	0.000
	Pt	-12.215	0.000	-18.238	0.000
	Pa	-5.519	0.000	-9.054	0.000
Manufacture of wood and of products of wood and cork and furniture	Gt	-1.927	0.000	-2.305	0.000
	Ga	-5.115	0.000	-6.36	0.000
	Pt	-10.478	0.000	-12.28	0.000
	Pa	-5.653	0.000	-7.232	0.000
Manufacture of paper and paper products, Printing and reproduction of recorded media	Gt	-1.757	0.000	-2.313	0.000
	Ga	-4.994	0.000	-6.616	0.000
	Pt	-10.101	0.000	-12.240	0.000
	Pa	-5.188	0.000	-7.828	0.000
Manufacture of chemical	Gt	-1.203	0.000	-1.669	0.000
	Ga	-2.895	0.000	-6.179	0.000
	Pt	-7.323	0.000	-8.061	0.000
	Pa	-3.335	0.000	-4.866	0.000
Manufacture of other non-metallic mineral products	Gt	-1.186	0.000	-1.630	0.000
	Ga	-3.049	0.000	-4.543	0.000
	Pt	-8.729	0.000	-15.056	0.000
	Pa	-4.075	0.000	-7.634	0.000
Manufacture of basic metals	Gt	-1.800	0.000	-2.343	0.000
	Ga	-4.994	0.000	-6.338	0.000
	Pt	-13.199	0.000	-12.497	0.000
	Pa	-7.857	0.000	-8.562	0.000
Manufacture of machinery and equipment and metal products	Gt	-2.484	0.000	-2.853	0.000
	Ga	-5.002	0.000	-7.312	0.000
	Pt	-22.403	0.000	-25.539	0.000
	Pa	-10.082	0.000	-13.809	0.000
Other manufacturing	Gt	-1.915	0.000	-2.137	0.000
	Ga	-5.627	0.000	-6.451	0.000
	Pt	-12.985	0.000	-11.944	0.000
	Pa	-9.124	0.000	-8.453	0.000

Notes:
1) Authors' calculations are based on data files obtained from Statistical Center of Iran.
2) The null hypothesis is no cointegration.

Table 4: The Results of Westerlund Panel Cointegration Test between LLP and LU

industry	Statistic	Constant		Constant and trend	
		Value	Robust *P*-value	Value	Robust *P*-value
Manufacture of beverages, food and tobacco products	Gt	-1.776	0.000	-2.277	0.000
	Ga	-4.324	0.000	-5.135	0.000
	Pt	-7.540	0.000	-8.584	0.000
	Pa	-3.660	0.000	-3.756	0.000
Manufacture of textiles, wearing apparel and leather and related products	Gt	-1.635	0.000	-2.736	0.000
	Ga	-4.061	0.000	-5.541	0.000
	Pt	-12.915	0.000	-17.984	0.000
	Pa	-6.052	0.000	-7.451	0.000
Manufacture of wood and of products of wood and cork and furniture	Gt	-2.001	0.000	-2.259	0.000
	Ga	-5.518	0.000	-6.319	0.000
	Pt	-10.669	0.000	-11.005	0.000
	Pa	-5.947	0.000	-6.105	0.000
Manufacture of paper and paper products, Printing and reproduction of recorded media	Gt	-2.412	0.000	-2.520	0.000
	Ga	-6.454	0.000	-5.746	0.000
	Pt	-10.803	0.000	-10.982	0.000
	Pa	-6.738	0.000	-6.264	0.000
Manufacture of chemical	Gt	-1.619	0.000	-1.978	0.000
	Ga	-4.096	0.000	-5.114	0.000
	Pt	-5.612	0.000	-6.160	0.000
	Pa	-2.978	0.000	-3.941	0.000
Manufacture of other non-metallic mineral products	Gt	-2.118	0.000	-2.603	0.000
	Ga	-4.413	0.000	-5.230	0.000
	Pt	-12.321	0.000	-18.684	0.000
	Pa	-4.986	0.000	-7.329	0.000
Manufacture of basic metals	Gt	-2.145	0.000	-2.409	0.000
	Ga	-5.883	0.000	-5.553	0.000
	Pt	-10.162	0.000	-12.050	0.000
	Pa	-6.365	0.000	-6.177	0.000
Manufacture of machinery and	Gt	-2.997	0.000	-2.977	0.000

equipment and metal products	Ga	-7.152	0.000	-7.082	0.000
	Pt	-31.030	0.000	-22.020	0.000
	Pa	-12.831	0.000	-9.891	0.000
Other manufacturing	Gt	-2.316	0.000	-2.117	0.000
	Ga	-6.785	0.000	-5.818	0.000
	Pt	-10.919	0.000	-10.844	0.000
	Pa	-6.932	0.000	-7.426	0.000

Notes:
1) Authors' calculations are based on data files obtained from Statistical Center of Iran.
2) The null hypothesis is no cointegration.

The results of this test, as depicted in Tables 3 and 4, confirmed the existence of co-movement among the series. Therefore, there is a long-run equilibrium relationship between agglomeration (urbanization and localization) and productivity.

4.5. Panel Long-Run Elasticities

The long-run equilibrium relationship between the agglomeration (urbanization and localization) and productivity was examined through the use of the fully modified OLS (FMOLS) technique. Pedroni (2001) FMOLS is an estimation technique of non-parametric type which is useful for handling with the problems of endogenous regressors and serial correlation in the error term. The technique allows the researchers to have consistent and efficient estimators of the long-run relationship. As Table 5 indicates, all the variables had the expected sign and were statistically significant at a 0.05 level of significance.

This finding is consistent with the results of Ciccone (2002), Ciccone and Hall (1996), Dehghan Shabani (2013), Hu, Xu, & Yashiro (2015), Jang & Hong (2010), and Ke (2010), who found that an increase in localization and urbanization was accompanied with an increase in labor productivity. The long-run elasticity of the labor productivity was 0.059–1.893 and 6.314-34.48 for localization and urbanization economies, respectively.

Table 5: The Results of the Fully Modified OLS Estimates Technique (FMOLS)

Industry	LLP as the dependent variable	LLP as the dependent variable
	LOC	LU
Manufacture of beverages, food and tobacco	0.109 (0.000)	6.573 (0.000)
Manufacture of textiles, wearing apparel and leather and related products	0.059 (0.032)	7.987 (0.000)
Manufacture of wood and of products of wood and cork and furniture	1.893 (0.001)	34.48 (0.000)
Manufacture of paper and paper products, Printing and reproduction of recorded media	0.261 (0.000)	33.78 (0.000)
Manufacture of chemical	0.184 (0.001)	6.314 (0.003)
Manufacture of other non-metallic mineral products	0.118 (0.001)	6.647 (0.000)
Manufacture of basic metals	0.337 (0.000)	12.617 (0.008)
Manufacture of machinery and equipment and metal products	0.037 (0.042)	11.911 (0.000)
Other manufacturing	0.436 (0.000)	26.599 (0.000)

Notes:
1) Authors' estimation is based on data files obtained from Statistical Center of Iran.
2) *p* values have been provided in parentheses.

4.6 Panel Causality Tests

To test for the presence short- and Long-run causality between agglomeration and productivity, the present researchers drew from the concept of Granger causality and used a panel vector error-correction model (Pesaran et al., 1999) which is a two-step procedure (Engle & Granger, 1987) estimated to perform Granger-causality tests. First, the long-run equilibrium model was estimated in order to obtain the estimated residuals which were then these residuals lagged for one period and used as the error correction term. The equations for Granger-causality test associated with the error correction term have been presented below.

$$\Delta LLP_{it} = \alpha_{1j} + \sum_{q=1}^{p} \pi_{11_{iq}} \Delta LLP_{it-q} + \sum_{q=1}^{p} \pi_{12_{iq}} \Delta LU_{it-q} + \xi_{1i} ECT_{it-1} + \omega_{1it} \quad (1)$$

$$\Delta LU_{it} = \alpha_{2j} + \sum_{q=1}^{p} \pi_{21_{iq}} \Delta LU_{it-q} + \sum_{q=1}^{p} \pi_{22_{iq}} \Delta LLP_{it-q} + \xi_{2i} ECT_{it-1} + \omega_{2it} \quad (2)$$

The equations for Granger-causality between localization (LOC) and Labor productivity (LLP) are:

$$\Delta LLP_{it} = \alpha_{1j} + \sum_{q=1}^{p} \pi_{31_{iq}} \Delta LLP_{it-q} + \sum_{q=1}^{p} \pi_{32_{iq}} \Delta LOC_{it-q} + \xi_{3i} ECT_{it-1} + \omega_{1it} \quad (3)$$

$$\Delta LOC_{it} = \alpha_{2j} + \sum_{q=1}^{p} \pi_{41_{iq}} \Delta LOC_{it-q} + \sum_{q=1}^{p} \pi_{42_{iq}} \Delta LLP_{it-q} + \xi_{4i} ECT_{it-1} + \omega_{2it} \quad (4)$$

In the above equations, p is the lag length set that was selected based on the Schwarz Bayesian information criteria (SBC). ECT Stands for error correction term (For checking Long-run causality) and ω refers to serially uncorrelated error term.

Two sources of causation can be derived from estimation of the dynamic error correction model, the short- and long-run causality. For instance, if $\pi_{12_{iq}} = 0 \ \forall_{iq}$ is rejected, then short causality runs from ΔLU to ΔLLP. Similarly, if $\pi_{22_{iq}} = 0 \ \forall_{iq}$ is rejected, there will be short-run causality from ΔLLP to ΔLU. Concerning the long run causality, the present researchers considered the significance of error correction term. For instance, the significance of $\xi_{1i} = 0 \ \forall_{i}$ means that ΔLLP responds to deviations from the long-run equilibrium, whereas the significance of $\xi_{2i} = 0 \ \forall_{i}$ implies that ΔLU responds to deviation from the long-run equilibrium.

Table 6 presents the results of the short- and long-run Granger causality tests between labor productivity and localization economies. The results revealed that localization granger led to higher labor productivity in all the manufacturing industries. This is consistent with the theory that industrial concentration increases productivity and efficiency.

Table 6: The Results of Panel Causality Tests

industry	Dependent variable	Source of Causation (independent variable)		
		Short-run		Long- run
		ΔLLP	$\Delta LLOC$	ECT
Manufacture of beverages, food and tobacco	ΔLLP		32.98 (0.000)	-5.46 (0.000)
	$\Delta LLOC$	60.30 (0.000)		-8.85 (0.000)
Manufacture of textiles, wearing apparel and leather and related products	ΔLLP		426.53 (0.000)	-189.16 (0.000)
	$\Delta LLOC$	252.51 (0.000)		-11.49 (0.000)
Manufacture of wood and of products of wood and cork and furniture	ΔLLP		100.91 (0.000)	-3.56 (0.000)
	$\Delta LLOC$	17.77 (0.006)		-3.52 (0.000)
paper and paper products, Printing and reproduction of recorded media	ΔLLP		43.17 (0.000)	-16.77 (0.000)
	$\Delta LLOC$	457.08 (0.000)		-10.55 (0.000)
	ΔLLP		1086.75 (0.000)	-71.06 (0.000)
Manufacture of chemical	$\Delta LLOC$	119.67 (0.000)		-53.56 (0.000)
Manufacture of other non-metallic mineral products	ΔLLP		32.39 (0.000)	-16.18 (0.000)
	$\Delta LLOC$	176.01 (0.000)		-4.28 (0.000)
	ΔLLP		706.77 (0.000)	-14.06 (0.000)
Manufacture of basic metals	$\Delta LLOC$	3423.67 (0.000)		-34.05 (0.000)
	ΔLLP		9492.23 (0.000)	-121.36(0.000)
Manufacture of machinery and equipment and metal products	$\Delta LLOC$	3.0e+05 (0.000)		-19.39 (0.000)
	ΔLLP		174 (0.000)	-43.50 (0.000)
Other manufacturing	$\Delta LLOC$	383.86 (0.000)		-12.33 (0.000)

Notes:
1) Authors' estimation is based on data files obtained from Statistical Center of Iran.
2) Partial F-statistics reported with respect to short-run changes in the independent variables while t-statistic reported with respect to long-run.
3) *p*-values are given in parentheses.

With regard to reverse causation, granger causality was running from labor productivity to localization for all the manufacturing industries. This suggests that localization economies are indeed endogenous and the lagged values of productivity help in predicting localization for all manufacturing industries and vice versa. Overall, the results of short-run panel causality test showed a bidirectional granger causality between localization and labor productivity.

Considering the long-run causality, results revealed bidirectional causality between localization and productivity.

As Table 7 indicates, urbanization granger has caused labor productivity in all the manufacturing industries. This can imply that we can predict productivity level via information about urbanization level.

Table 7: The Results of Panel Causality Tests

industry	Dependent variable	Source of Causation (independent variable)		
		Short-run		Long- run
		ΔLLP	ΔLU	ECT
Manufacture of beverages, food and tobacco	ΔLLP		265.61 (0.000)	-15.69 (0.000)
	ΔLU	450.77 (0.000)		-7.78 (0.000)
Manufacture of textiles, wearing apparel and leather and related	ΔLLP		1574.7 (0.000)	-126.54 (0.000)
	ΔLU	2137.15 (0.000)		-12.86 (0.000)
Manufacture of wood and of products of wood and cork and furniture	ΔLLP		13.29 (0.009)	-5.32 (0.000)
	ΔLU	47.77 (0.000)		-3.61 (0.000)
Manufacture of paper and paper products, Printing and	ΔLLP		584.55 (0.000)	-25.94 (0.000)
	ΔLU	3892.49 (0.000)		-17.58 (0.000)
Manufacture of chemical	ΔLLP		14356.8 (0.000)	-769.59 (0.000)
	ΔLU	2712.25 (0.000)		-69.30 (0.000)
	ΔLLP		188.14 (0.000)	-82.23 (0.000)
Manufacture of other non-metallic mineral products	ΔLU	5352.20 (0.000)		-31.72 (0.000)
Manufacture of basic metals	ΔLLP		5.35 (0.068)	-50.06 (0.000)
	ΔLU	12.29 (0.006)		-4.80 (0.000)
Manufacture of machinery and equipment and metal products	ΔLLP		286.94 (0.000)	-112.01 (0.000)
	ΔLU	878.79 (0.000)		-26.57 (0.000)
Other manufacturing	ΔLLP		172.18 (0.000)	-45.32 (0.000)
	ΔLU	289.55 (000)		-12.02 (0.000)

Notes:
1) Authors' estimation is based on data files obtained from Statistical Center of Iran.
2) Partial F-statistics reported with respect to short-run changes in the independent variables while t-statistic reported with respect to long-run.
3) p-values are given in the parentheses.

Referring back to the evidence for reverse causation, running from labor productivity to urbanization, there was evidence that labor productivity granger is caused urbanization for all the manufacturing industries at a 10 level of significance. The long-run dynamics conveyed that there were bidirectional causalities between productivity and urbanization in Manufacture of beverages, food and tobacco, Manufacture of textiles, wearing apparel and leather and related products, Manufacture of wood and of products of wood and cork and furniture , Manufacture of paper and paper products, Printing and reproduction of recorded media, Manufacture of chemical, Manufacture of basic metals, Manufacture of machinery and equipment and metal products, Other manufacturing products.

As predicted by the theory, the results of the present study revealed that both localization and urbanization affected labor productivity for all the manufacturing industries. The results further offered the evidence for endogenous agglomeration economies.

5. Conclusion

This study has benefitted from the granger causality test for panel data model in order to determine the direction of causality between agglomeration economies (localization and urbanization) and labor productivity. To conduct the study, a panel data set of two -digit ISIC manufacturing industries in 28 Iranian provinces over an 11-year period, from 2001 to2011, was used. Before using panel error correction models and examining the probable causal and dynamic relationships among variables, the researchers first checked the series, using cross-sectional dependence test, and found that the cross-correlations were statistically significant at 1% significance level. Then, panel unit root tests (CIPS test) and panel cointegration tests (Westerlund test), that accounted for cross-sectional dependence, were used to examine the data. The results indicated that the variables were integrated of order one. Next, FMOLS technique was used to examine the long-run equilibrium relationship between agglomeration economies and labor productivity. Based on the findings, an increase in agglomeration economies was associated with an increase in labor productivity. Finally, panel error correction models were used to examine short- and long-run Granger causality between localization (or urbanization) economies and labor productivity. Granger causality test results showed a strong bidirectional causal relationship between localization economies and labor productivity in all manufacturing industries in both the short-and long-run. Furthermore, based on panel Granger causality test results, there was a bidirectional causal relationship between urbanization and labor productivity in all the manufacturing industries in both short- and long-run. In general, bidirectional causality was found between agglomeration and productivity.

the results of the present study can becomes helpful for policy makers to recognize the new evidence from relationship between productivity and agglomeration, because Agglomeration economies are also important policy issues for regional municipalities, because they engender industrial clustering and clusters bring productivity gains in the short run and long run. Furthermore, policy makers attention to level of productivity because it can induce growth in the scale of local urban and industrial environments.

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