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DOES AGGLOMERATION PROCESS EXIST IN SMALL PROVINCIAL URBAN CENTERS? EVIDENCES FROM SVERDLOVSK REGION

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Abstract: In this paper we analyze the agglomeration of three small urban centers in Sverdlovsk Region (Russia). We describe agglomeration economies as the process where firm can be divided into those based on internal economies and those based on external economies, and also that each kind of economy can be viewed from the perspectives of scale, scope, and complexity. In our example, agglomeration economies are based on the internal economies. All analyzed towns are different in the level of industrial production, economies of scale and increasing returns. Industrial agglomeration effects are conceptually classified into localization and urbanization economies. We believe that agglomeration is strong only in small towns with the effective industrial production. As methods we used the Cobb-Douglas production function. Results of the research showed that only a town with industrial specialization (Verkhnyaya Salda) is characterized by constant returns to scale and the growth of total production which is mainly determined by increasing of capital. The other two cases of the towns (which are not industrial specialized) do not generate these results. Moreover, the town which not develops industrial production has no any effect of agglomeration. Agglomeration effects can be observed at different levels of aggregation. Large cities provide greater opportunity for economies of scale, availability of quality human capital, cluster effects, innovation processes and knowledge spillover, but under certain conditions smaller towns can also achieve some of the effects of agglomeration.

Keywords: economic geography, agglomeration, small urban centers, industry, NEG Approach

Introduction

The new theoretical approach, generally known as New Economic Geography (NEG Approach) has influenced that imperfect competition, increasing returns to scale and perfect mobility of key factors become crucial in the models of the

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process of agglomeration (Krugman, 1991a; Vuković, Jovanović, & Đukić, 2012). Moreover, it plays a critical role in spatial models of the economy based on monopolistic competition (Duranton & Puga, 2000; Fujita & Thisse, 1996; Fujita, Krugman., & Venables, 1999; Krugman, 1991a; Krugman, 1991b; Parr, 2002; Kochetkov, Larionova, & Vuković, 2017). Further, factors such as knowledge spillovers and household location decisions could be more important sources of economy agglomeration than pecuniary externalities of the NEG (Glaeser & Kohlhase, 2004; Fujita & Mori, 2005; Vuković, Marković, & Hanić, 2016). Burger and Meijers (2016) claimed that growing awareness in the theoretical spatial literature is reflected in the introduction of new terms "urban network externalities" (Capello, 2000; Burger & Meijers, 2016; Petrović et al., 2017), "regional externalities" (Parr, 2002), "externality fields" (Phelps, 1992), and "borrowed size" (Phelps, Fallon, & Williams, 2001; Burger & Meijers, 2016). According to Parr (2002), concept of agglomeration economies is in central place in any discussion concerning the location of the firm and the process of regional economic development. Using Parr's definition, we describe agglomeration economies as the process where firms can be divided into those based on internal economies and those based on external economies, and also that each kind of economy can be viewed from the perspectives of scale, scope, and complexity. In our example, agglomeration economies are based on internal economies.

The interest in this scientific problem is large and mainly relates to researches and analysis of large cities. However, there are examples which have shown that certain small towns also generate the effects of agglomeration. In this paper, we analyze the agglomeration of three small towns in Sverdlovsk region. For this purpose, we estimate the *Cobb-Douglas production function*. We believe that a city with the greatest industrial potential will realize the largest effects of agglomeration. All three towns are different in industrial activity and represent a good basis for comparison of the effects of their agglomeration. Our research is based on the idea that it is possible to apply *Cobb-Douglas production function* related in explanation of economy of agglomeration. In the typical Russian scientific literature, economy of agglomeration is not measured by *Cobb-Douglass production function* used by Dixit and Stiglitz (1977), as well as Krugman (1979; 1980; 1991a; 1992), Yang and Heijdra (1993), Romer (1994), Venables (1994) and Fujita et al. (1999). Generally, the approach in explaining economy of agglomeration in the Russian literature is not based on production functions (Lappo & Lyubovnyi, 2011; Makhrova, Nefedova, & Treivish 2013), so our aim is to show that it is possible to test models used in western studies (especially from the USA) in the case of Russian small towns.

A number of authors believe that mostly larger urban centers generate economic agglomeration effects (without considering the clusters). According to Behrens et al. (2014), large cities produce more output per capita than small cities. This process is associated with agglomeration economies, with the opinion that large cities select more productive entrepreneurs and firms or even that talented individuals sort into large cities. Segal (1976), Moomaw (1981; 1983) and Tabuchi (1986) observed that labor productivity is generally higher in the larger cities. The most important advantage of economic density is the presence of agglomeration externalities. It means that productivity improves when firms are located near one another (Brinkman, 2016). According to Head and Mayer (2004), there are positive relationships between market size and wages, market size and migration and the importance of backward linkages. The same authors argue that there is also evidence of the productivity benefits derived from location in densely populated areas. Agglomeration is driven by the economy of scale. Most authors who support the idea that agglomeration effects are only linked to the big cities consider that agglomeration economies arise because of the production benefits of physical proximity. Physical proximity between firms, workers and consumers, may help firms in the day to day business of producing goods and services. Physical proximity may also facilitate the flow of knowledge, influence on firms to be more creative and innovative (knowledge spillovers).

However, agglomeration effects exist in small urban centers too. Empirical studies have confirmed that certain number of smaller cities have significant agglomeration effects. Carlino (1979) claimed that population scale has a negative effect on productivity, causing diseconomies rather than economies of agglomeration. Partridge et al. (2008) argued that small urban areas play a key role in the explanations for the development of urban systems, as markets, as resource bases, and as potential sources/causes of new urban centers. The same authors claim that small urban areas are neglected in agglomeration analysis. Their model included even distance penalties from “higher-tier” urban areas (mostly bigger cities) in the explanation of urban distance effects on small towns. They found that distance from agglomerated economic activity negatively affected local growth. According to Duranton and Puga (2001), technological shocks and differing sectoral propensities to innovate can spill over from urban areas into the small towns. This effect will impact on population growth. A number of authors consider that the transmission of agglomeration benefits to smaller urban centers from tier-specific urban places implies that distance has discontinuous effects (Eaton & Eckstein, 1997; Brülhart & Koenig, 2006). Ottaviano and Puga (1998) stated that economic agglomeration can be considered at different levels of aggregation. Starting from

the bottom, there are small scale agglomerations of finely defined sectors. In our opinion, some smaller cities have small scale agglomerations which defined their position in sector or market.

Bearing in mind transportation costs, Brinkman (2016) stated that increased capacity can lead to higher travel demand instead of lowering congestion appreciably. People respond to changes in transportation costs by changing location and their commuting behavior in cities. Rosenthal and Strange (2003), as well as their colleagues Arzaghi and Henderson (2008) argued that the production advantages of proximity can decline very rapidly across distances of a few miles or even a few city blocks (Jovanović, Vuković, & Zakić, 2012). Krugman (1980) in his model introduced the distance and transport costs. With both increasing returns and transport costs, there is an incentive to concentrate production of a good close to its largest market. By concentrating production in one place, scale economies can be realized, while by locating near the largest market, transport costs are minimized. The benefits of agglomeration ultimately reflect gains that occur when proximity reduces transport costs (Ellison, Glaeser, & Kerr, 2010). Marshall (1920) emphasized three different types of transport costs: the costs of moving goods, people, and ideas (that can be reduced by industrial agglomeration). Innovations depend on the quality of human capital, which are the main generator of economic development and agglomeration.

Small towns in Sverdlovsk region: Theoretical background

Sverdlovsk region is one of the most important regions in the overall development of Russia, with large economically developed territory, high level of business, cultural and public activity (Figure 1).

Figure 1. Russian territory with highlighted Sverdlovsk region (with black color) (Retrieved from: http://www.investinginrussia.ru/upload/mipim/regions/map/map44.jpg)

It is included into the top of 10 most important Russian regions by the majority of the main socio-economic indexes (Federal State Statistics Service 2015; N. Vuković, Zalesov, & D. Vuković, 2017). This region has unique location. It is located in 2000 km to the East from Moscow, on continental border between Europe and Asia, on crossing of transcontinental streams of raw materials, goods, financial, labor and information resources. As all industrial regions in the period of crises, Sverdlovsk region has a great socio-economical problem with the development of cities with industries based on old technologies. In our research we analyzed three towns in Sverdlovsk region: Verkhnyaya Salda, Nevyansk and Verkhoturye. The selection of these towns was not random, because they are well-known in Russia and abroad due to their unique cultural and historical values and/or industrial achievements. We analyzed data from two industrial centers: Nevyansk and Verkhnyaya Salda and one cultural center: Verkhoturye. Verkhnyaya Salda is small town specialized in the production of titanium. JSC Corporation VSMPO-AVISMA is one of the world largest producer and exporter of titanium. Historically, all economic activities of the town are based on industrial production of titanium. Nearby this town there is a free economic zone "Titanium Valley" which we consider as significant for the process of town agglomeration. This town is close to industrial bigger town Nizhny Tagil (Figure 2).

Figure 2. The position of the analyzed settlements (Source: https://www.google.rs/maps/@57.6240062,59.7172726,8z)

Nevyansk is small industrial town, located between Yekaterinburg (the main city of Sverdlovsk region) and Nizhny Tagil (Figure 2). It was founded as a town-plant in 1701. Nowadays, the town has several middle-size industrial enterprises, which are not strong as titanium factory in Verkhnyaya Salda. Nevyansk has implemented a new strategy of socio-economic development of the town which is aimed at the development of tourism, small business and attraction of young people. The strategy of the town is concentrated on the changing the main trend from industrial production to tourism and services development. The tendency of changing economy from traditional industry to modern small business and tourism does not give more significant results (Figure 3), so the authors of this paper found that this is an important reason why this town should be chosen for the analysis. Both Verhnyaya Salda and Nevyansk belong to Gornozavodskaya agglomeration (Mining and metallurgical agglomeration), which is based on historically formed production and technological relationship between small towns and the center – town of Nizhny Tagil. These relations are mostly caused by using natural resources of small towns and supplying raw materials for the biggest enterprise of Nizhny Tagil — EVRAZ Nizhny Tagil Metallurgical Plant. However, for Nevyansk these connections are rather weak first of all due to far location of Nevyansk from Nizhny Tagil and new trend of socio-economic development of the town. Today, Nevyansk has more close relations with Yekaterinburg, which can give them extra impulses for development (Figure 2).

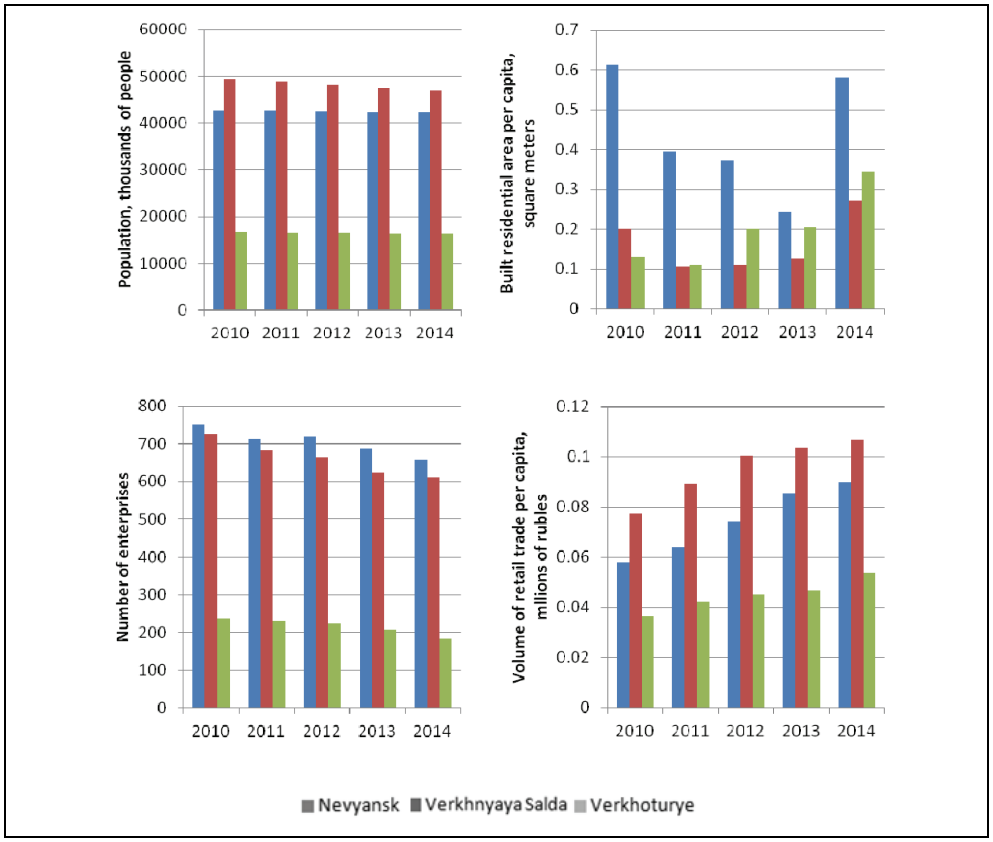

Figure 3. The data represent: a) Population (in thousands of people), b) Built residential area per capita (m^2), c) Number of enterprises, d) Volume of retail trade per capita (millions of rubles) (Source: Federal State Statistics Service, 2015)

Verkhnyaya Salda has independent position due to its town-forming enterprise. Nevertheless, the closeness to the center of agglomeration gives additional advantages for socio-economic development. For example, one of the biggest international exhibitions of Russian and foreign-made armaments takes place in Nizhny Tagil. It attracts about 20,000 people from more than 50 countries, so this is good chance for promotion of not only production of VSMPO-AVISMA, but the region overall. Verkhoturye is non-industrial town, located far away from the bigger cities (Figure 2). This little town is the cultural-religiously oriented and mainly occupied in services and education. The main strategy of the municipal administration is to develop infrastructure of the town and create economic conditions for small business. It requires investments and state support to save unique architecture monuments on their territory. Industrial scenario is

not appropriate for this town, because of long distance from all nearest industrial cities, low level of business activity and industrialization, and very low level of infrastructure development.

Methodology

Methodological background

The degree of agglomeration economies can be measured by the degree of increasing returns to scale of the estimated production function. Avinash Dixit and Josef Stiglitz (1977) contributed to the disputes on the optimality of product diversification by developing a model in which the monopolistically competitive equilibrium coincides with the social optimum. They used Cobb-Douglas utility function to explain the model of monopolistic competition with optimum product diversity. In the following years, many authors (Krugman, 1979; Krugman, 1980; Krugman, 1991; Krugman, 1992; Venables, 1993; Yang & Heijdra, 1993; Romer, 1994; Fujita et al., 1999; Lugovskyy, 2003; Fujita & Thisse, 2009) have used or modified Dixit-Stiglitz model according to the purpose of their research. The model has become extremely popular as a basic framework in the fields of industrial organization, international economics, macroeconomics, development and growth (Lugovskyy, 2003), as also for the explanation of the process of agglomeration. The integrated model based on Dixit-Stiglitz preferences and a specified production function even gives predictions about the exact functional forms of the relations between bilateral trade flows, factor endowments and country sizes (Prize Committee of the Royal Swedish Academy of Sciences, 2008).

Even small towns may have effects of agglomeration, if there are certain conditions. Marshall (1920) recognized that "agglomeration of economic activity is driven by economies of scale, while assuming that the scale economies are external to the individual firm but internal to the industry or the town, and hence consistent with perfect competition" (Prize Committee of the Royal Swedish Academy of Sciences, 2008, p. 12). NEG has a different assumption. Krugman (1980) broke with this tradition by assuming internal economies of scale and imperfect competition. Agglomeration is then driven by pecuniary externalities interfere beyond market prices as a large market allows greater product diversity and lower costs. The presence of scale economies and of monopolistic competition implies a market imperfection, so that the externality can be marked to these basic performances of the economy. Ten years later he created *The Core-periphery Model* (Krugman, 1991). The Cobb-Douglas function is again used for one of the most significant economic models of the twentieth century.

At this point, we do not have the aim to present the Krugman model (1991), but we will point out on very important conclusion of the model*:* "The comparative-statics results in Krugman's analysis allow us to understand why urbanization, and the move towards a core-periphery structure, would tend to result if transport costs fell or technologies with increasing returns became more prevalent. Arguably, such trends were important during the process of industrialization" (Prize Committee of the Royal Swedish Academy of Sciences, 2008, p. 16). We believe that industrialization is essential in the creation of agglomeration effects in small cities. Most models based on the theory of NEG focus on labor (Krugman, 1991; Krugman & Venables, 1995; Ottaviano, Tabuchi, & Thisse, 2002; Puga, 1999). These are unsuited to the study of growth. The key to all sustained growth is the accumulation of human capital, physical capital and/or knowledge capital — with the accumulation of knowledge capital, i.e. technological progress having a privileged position (Baldwin & Martin, 2004).

The model for the research

In the analysis of the process of agglomeration of small towns we used the *Cobb-Douglas production function*. This function allows estimating elasticities of supply of labor and capital. The calculations were made in comparable prices derived to 2010, using known inflation rates. We expect that the industrial centers will achieve better production results in relation to the cultural center. The *Cobb-Douglas production function* is used to show the relationship between the level of production and input factors and tells how much output can be produced given any number of inputs. As agglomeration economies are external to the firm, it remains possible to continue to assume that the individual firm's production function is subject to constant returns to scale and perfect competition. As the data for individual firms are often unavailable, it is miss-assumed that because there are constant returns to scale may be summed across firms. First of all, we analyzed the correlation and regression model. After determining the significance of statistics, we analyzed the *Cobb-Douglas production function*. This function is the particular production function that takes the form:

$$Y = a_0 K^{a_1} L^{a_2} \qquad (1)$$

where Y stands for output (total production), K for capital (investments in fixed assets), L for labor (person-hours worked in a year) and a_0 is a productivity parameter (a higher value of a_0 means producing more with the same inputs).

The exponents a_1 and a_2 are the output elasticities of capital and labor, respectively. They are found from empirical data.

If $a_1 + a_2 = 1$, the production function shows constant returns to scale: $Y(qK, qL) = qY(K, L)$;

If $a_1 + a_2 > 1$, it has increasing returns to scale $Y(qK, qL) > qY(K, L)$;

If $a_1 + a_2 < 1$, it has decreasing returns to scale $Y(qK, qL) < qY(K, L)$.

Positive coefficients indicate the degree of increasing returns to scale in small towns production and represent the elasticity of urban agglomeration. The percentage increases in small towns production due to a unit increase in labor force in an urban area. In the absence of agglomeration economies, however, the production function is homogeneous of degree one with respect to capital and labor. The econometrics specification of equation is the following:

$$\ln(Y) = \ln(a_0) + a_1 \ln(K) + a_2 \ln(L) \tag{2}$$

Using the following variable substitution:

$\ln(Y) = Y'$

$\ln(a_0) = a_0'$

$\ln(K) = K'$

$\ln(L) = L'$

The function can be expressed as:

$$Y' = a_0' + a_1 K' + a_2 L' \tag{3}$$

The mean effectiveness of resources can be calculated from:

$$\mu_K = \frac{Y}{K} = \frac{a_0 K^{a_1} L^{a_2}}{K} = a_0 K^{a_1 - 1} L^{a_2} \tag{4}$$

$$\mu_L = \frac{Y}{L} = \frac{a_0 K^{a_1} L^{a_2}}{L} = a_0 K^{a_1} L^{a_2 - 1} \tag{5}$$

The first formula defines the output per capital unit and the second one shows the output change per capita. The marginal product of a factor is the extra amount of output that is produced when one unit of the factor is added, holding all other inputs constant. If the production function has constant returns to scale in capital and labor, it exhibits decreasing returns to capital alone and decreasing returns to labor alone. In a *Cobb-Douglas production function*, the marginal product of an input is equal to the product of the factor's exponent times the average amount that each unit of the factor produces. The marginal effectiveness of the resources is given by:

$$\nu_K = \frac{\partial \mathrm{Y}}{\partial \mathrm{K}} = a_0 a_1 K^{a_1 - 1} L^{a_2} \tag{6}$$

$$\nu_L = \frac{\partial \mathrm{Y}}{\partial \mathrm{L}} = a_0 a_2 K^{a_1} L^{a_2 - 1} \tag{7}$$

The output elasticities with respect to capital and labor are measured by:

$$\delta_K = \frac{\partial \mathrm{Y}}{\partial \mathrm{K}} \cdot \frac{\mathrm{K}}{\mathrm{Y}} = \frac{a_0 a_1 L^{a_2} K^{a_1 - 1} \mathrm{K}}{a_0 L^{a_2} K^{a_1}} = a_1 \tag{8}$$

$$\delta_L = \frac{\partial \mathrm{Y}}{\partial \mathrm{L}} \cdot \frac{\mathrm{L}}{\mathrm{Y}} = \frac{a_0 a_2 L^{a_2 - 1} K^{a_1} \mathrm{L}}{a_0 L^{a_2} K^{a_1}} = a_2 \tag{9}$$

This gives the percentage change in the production function in respond to a change of the levels of both resources:

$$\gamma_{KL} = \frac{\nu_L}{\nu_K} = \frac{\partial Y}{\partial L} \div \frac{\partial Y}{\partial K} = \frac{a_0 a_2 L^{a_2 - 1} K^{a_1}}{a_0 a_1 L^{a_2} K^{a_1 - 1}} = \frac{a_2 K}{a_1 Y} \tag{10}$$

The replacement rate of resources is defined by the relationship of the above performances.

Results and discussion

Verkhnyaya Salda is the most developed town among those we took into consideration. It can be attributed to single-industry town which development is fully determined by the economic growth of an industrial enterprise on its territory. Therefore, the main factors of socio-economic development such as

average wage, revenue of enterprises p/c, labor per capita and volume of investment are sufficiently high (Figure 4a, 4b, 4c, 4d).

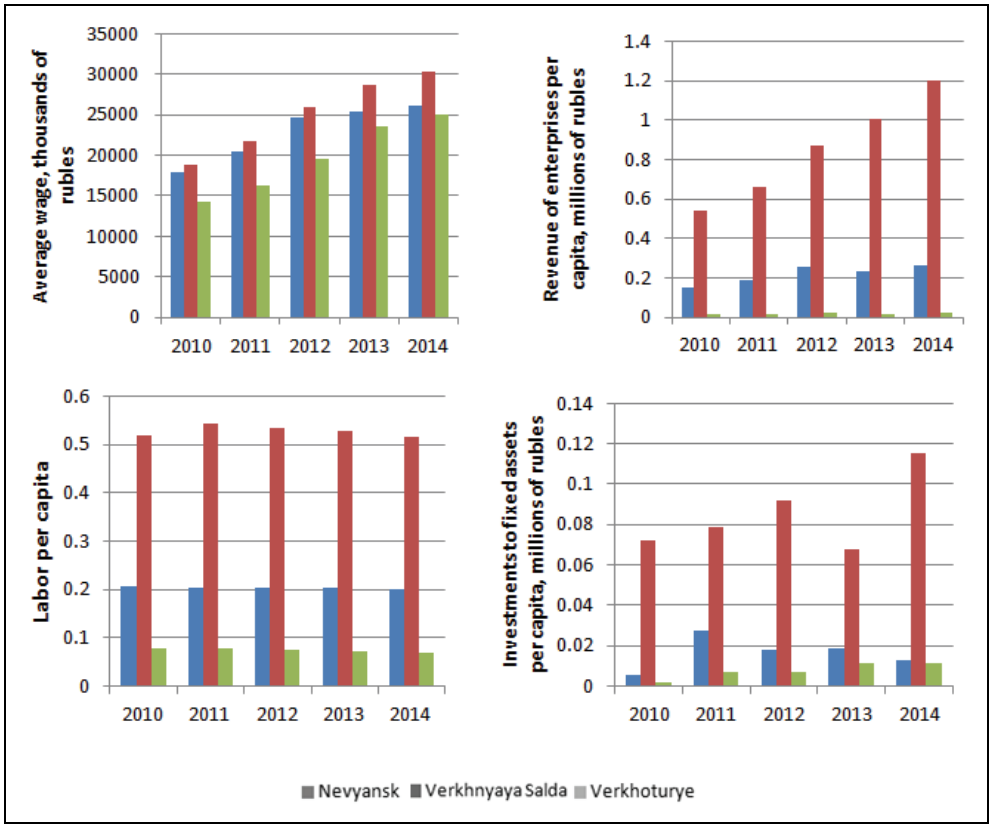

Figure 4. The data represent: a) Average wage (in thousands of rubles), b) Revenue of enterprises per capita (millions of rubles), c) Labor per capita (relative units), d) Investments in fixed assets per capita (millions of rubles) (Source: Territorial body of the Federal Service of the State Statistics, 2015)

These data are well described by *Cobb-Douglas production function*, which allows estimating elasticities of supply of labor and capital. We got the elasticity of labor equal to 0.2878 and elasticity of capital equal to 0.7186 (Table 1). The determination coefficient is 0.979 and the F-test of significance of regression coefficients is good enough.

Table 1. Productivity parameter, elasticity of capital, elasticity of labor, determination coefficient and F-test of *Cobb-Douglas production function*

Name of the observed town	α_0	α_1	α_2	R^2	F	s
Verkhnyaya Salda	1.5129	0.7186	0.2878	0.9790	46.65	0.0394
Nevyansk	$2.8\ 10^{-18}$	0.1890	5.2910	0.7189	2.56	0.1036
Verkhoturye	$1.28\ 10^{4}$	0.0172	-0.4900	0.2977	0.42	0.0925

It is important to notice that the sum of elasticity coefficients is equal to 1. This means that the single-industry town as Verkhnyaya Salda is characterized by constant returns to scale. The growth of total production is mainly determined by increasing of capital. The mean and marginal effectiveness of resources and replacement rate of resources are presented in the Table 2.

Table 2. The mean effectiveness, marginal effectiveness of resources and output elasticities of production function for Verkhnyaya Salda

Period	μ_K	μ_L	ν_K	ν_L	δ_K	δ_L	γ_{KL}
2010	1.8125	1.1938	1.3024	0.3435	0.7185	0.2877	0.2637
2011	1.72422	1.3575	1.2389	0.3906	0.7185	0.2877	0.3152
2012	1.62674	1.5745	1.1689	0.4530	0.7185	0.2877	0.3876
2013	1.56918	1.7257	1.1275	0.4965	0.7185	0.2877	0.4404
2014	1.49262	1.9596	1.0725	0.5639	0.7185	0.2877	0.5257

The Table 2 shows that effectiveness (mean and marginal) of labor constantly increases whereas the mean effectiveness of capital falls. Taking into account almost permanent value of labor resources, we can conclude that the increase of the production function is fully determined by the capital increase. This leads to an increase in the replacement rate of resources.

The same cannot be said for Nevyansk, where a decrease in annual investments in fixed assets is observed (Figure 4d). The total production function is slightly increasing (Figure 4) whereas the labor parameter is becoming constant (Figure 4c). The analysis in the framework of Cobb-Douglas model has shown that this situation cannot be described by the simple production function (Figure 5). We have got low significance of the regression coefficients and high standard errors (Table 1).

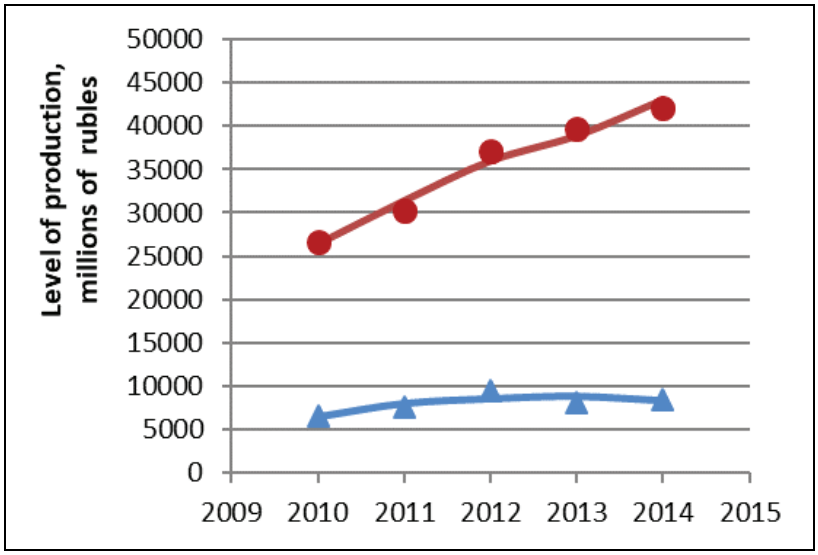

Figure 5. Cobb-Douglas production function — the level of production (millions of rubles) for Verkhnaya Salda (line with the circles) and (Nevyansk (line with the triangles).

The reason can be in the crisis in the machinery industry that mostly influences the economic situation in Nevyansk where the main enterprises belong to this branch. Now Nevyansk has lost its historical status of town-plant. The strategy of town development is being changed. New alternative industry branches are developed, such as production of reinforced concrete structures and construction mixtures. One of the key strategies is development of tourism that can give new breath for economic growth. Moreover, Nevyansk has close economic interrelations with big urban centers of the Sverdlovsk region (e.g. Yekaterinburg and Nizhny Tagil). Verkhoturye is far from big industrial city, because its development is not determined by the economic growth of enterprises. The correlation analysis has shown that the production function does not depend on the labor and capital parameters at all.

Conclusion

The wide range of literatures showed that industrial cities have a better chance to realize the economic effects of agglomeration (Marshall, 1920; Duranton & Puga, 2001; Otsuka, Goto, & Sueyoshi, 2010). In our case study, analysis confirmed this theory. The results showed that only the town with a strong industry achieved constant returns to scale and the growth of total production. However, there is the limitation in our analysis. The sample included three small towns with different industrial level. Also, as a constraint we can specify that the

social-economic weakness of the non-industrialized town could be caused by the large distance from the regional centers and is less connected with the degree of industrialization. "Administrative status", "transport connection" or "communications network" are not measured in our production function.

The result of *Cobb-Douglas production function* showed that small industrial towns in Sverdlovsk region realized economy of agglomeration. Moreover, Cobb-Douglas model is appropriate to use considering agglomeration based on innovation (constant returns to scale and production growth). Russian cities mostly developed economic strategy based on industry (especially in the industrial region such as the observed one).

Finally, it is important to note that an agglomeration exists not only in big cities. Despite numerous theories (that we discussed in the previous section), some studies have shown that the effects of agglomeration exist in small towns too (Carlino, 1979; Duranton & Puga, 2001; Brülhart & Koenig, 2006). Agglomeration effects can be observed at different levels of aggregation. Large cities provide greater opportunity for economies of scale, availability of quality human capital, cluster effects, innovation processes and knowledge spillover, but under certain conditions smaller towns can also achieve some of the effects of agglomeration.

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