EXTERNAL ECONOMIES OF CITY SIZE AND TECHNOLOGY OF PRODUCTION OF MANUFACTURING INDUSTRIES

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ABSTRACT

In a highly competitive global market with rapidly changing technology and high demand for new products, transmission of know how, adaptation of new technology, competition for learning innovation and entrepreneurial skills and specialization and outsourcing are of crucial importance for survival of a competitive firm. Economic diversity and specialization of urban areas make the exchange of ideas, the transmission of knowledge and efficient production possible for firms in that area. The principal aim of this paper is to analyze the impact of external scale economies of city size on technology of production of industries.

The study takes a production function approach and examines the impact of external economies of urbanization on the elasticity of substitution. The study covers 19 two digit SIC level industries in 47 SMSAs in the United States. The findings show that the elasticity of substitution is significantly related to the urbanization economies in half of the industries. The analysis of the results reveals that the urbanization economies are a significant factor in affecting the organization and technology of production of industries within the city. The results confirm the relationship between economic diversity and growth of urban centers and technological innovation.

INTRODUCTION

The purpose of this paper is to examine the effects of urbanization economies on production technology of manufacturing industries. Agglomeration economies are external size factors which affect production costs and technology. Urbanization economies are external economies of scale to the firm and industry while localization economies are external economies of scale to the firm.

Most empirical research on agglomeration economies are based on a production function or a relationship derived from a production function. In this study the effects of urbanization economies on a labor demand equation derived from a production function have been measured. Measuring the effects of agglomeration economies directly from a production function is

problematic because of lack of data on capital stock, a labor demand equation resolves this problem because it does not require data on capital stock.

The research investigates the following question: Do external economies of city size affect the production technology of manufacturing industries within the city? It is hypothesized that agglomeration economies significantly affect elasticity of substitution parameter. In this study, urbanization economies have been defined by the extent of industrialization of each city, availability of business services and population of each city.

The extent of industrialization of a city has been measured by total manufacturing employment of each city. The number of business service firms measures the availability of the business services within the city. The least square regression analysis has been applied to the labor demand equation to test the effects of urbanization economies on the elasticity of substitution.

The data covers 19 two digit industries within 47 SMSAs for 1972, 1977 and 1982. The U.S. Census of Manufacturing publishes the industry data every five years, the latest available data is for the 2007 and the next conducted for the year ending December 2012, will be available in December 2013. One reason for use of the historical data for 1972, 1977 and 1982 was due to the lack of availability of data for 2012 at the time this research was conducted, the available data for 2007 was also considered outdated. Therefore the researcher decided to use the earlier years data to give room for structural changes from 1982 to 2012. This study is part of a broader study which will continue to test the model for 2012 when the data comes out in December 2013.

The study uses a production function and labor demand approach to test the impact of the city size on the parameters of a production function, e.g. elasticity of substitution. Although, the historical data of this paper pertains to earlier years, but the theoretical foundation of the study should confirm the validity of the results. However, the model will be also test for 2012 data to compare and contrast the results of 1982 and 2012. For the current study data has been collected from Census of Manufacturers, Census of Industry, Census of Population and State and Metropolitan Area Data Book.

The analysis of findings in this study allowed the following conclusions: In regards to the technology of production, the elasticity of substitution was found to be significantly affected by the urbanization economies variables in half of the industries. The study also reveals that total manufacturing size of each city and business service availability within each city are independently more important means of agglomeration economies than population.

REVIEW OF THE LITERATURE

Spatial agglomerations or clusters have external economies of same sector businesses and employees for firms within that industry that is called localization economies, while urbanization economies are external economies of total economic and social institutions size of a location

which decease production costs of all firms and industries in that location (Harrison, Kelley & Gant, 1996; Hoover, 1971; Isard, 1956; Weber, 1957).

Localization economies, referred by Harrison et al. (1996) as Static Agglomeration, are economies of scale in production resulting in availability of specialized inputs at lower costs (Harrison, et al. 1996).Urbanization or Dynamic Agglomeration Economies refers to spillover of know how and transmission of knowledge in locations with diverse economic activities that not only reduces the cost of general input but also facilitates technological change resulting in higher productivity and lowers average cost (Harrison et al., 1996; Marra, Carlei & Crociata, 2011).

Specialization, diversity, outsourcing, knowledge spillover and competition for learning and innovation lead to conglomeration of industries and firms and development of efficient growth centers which provide a site for small entrepreneurial firms to commercialize their new ideas and products (Cheshire & Malecki, 2003; Marra et al., 2011; Mittelstaedt, Ward & Nowlin, 2006; Rantisi, 2002). Growth of entrepreneurship and technological change lead to an ever increasing specialization, efficiency and growth of cities and regions with divers firms, organizations, knowledge centers (e.g. research universities) and infra-structure (Marra et al., 2011). According to Glaeser (1998) "96 percent of new products innovations occur in metropolitan areas."

Although, some might propose that with substitution of electronic for face to face communication and transactions the agglomeration economies effects of big cities are in decline. However, external economies of know how and technological innovation spillover of big cities could not be substituted by electronic. Moreover, the spatial economies of big metropolitan areas are big enough to out weigh negative factors such as pollution, congestion, crime and social and economic costs (Glaeser, 1998).

The positive relationship between the degree of urbanity and adaptation of new technology has it's roots in the higher degree of competition and faster exchange of ideas in bigger cities (Beeson, 1987; Glaeser, 1998; Harrison et al., 1996; Marra et al., 2011). Therefore, city size also lowers the cost of production by accelerating the rate of technological progress.

Agglomeration economies also change the organization of production of firms and industries by making supply of intermediate products possible through the market. When the firm or industry purchases intermediate products and drop the internal production, the shape of the total average cost of firm or industry changes (Stigler, 1951). This can also be an indication of technological change. In this study the effects of agglomeration economies on the organization and technology of the production will be tested.

Most of the empirical studies of agglomeration economies are based on measuring a production function, or measuring a relationship derived from a production function. Some of these works measure the effects of agglomeration economies on average productivity of labor by estimating a production function which includes the agglomeration economies variable (s)

(Aberg 1973; Greytak & Blackley, 1985; Henderson, 1986; Kawashima, 1975; Moomaw, 1981a, 1981b,1983a, 1983b; Segal, 1978; Shefer, 1973; Tabuchi, 1986).The present study is also based on a production function approach. It is based on a labor demand equation derived from a constant elasticity of substitution (CES) production function.

Carlino (1978) states that the spatial diffusion of innovation begins in the largest urban areas. Beeson (1987) shows that the rate of technical progress across states is affected by agglomeration economies. Harrison et al. (1996) examine the effects of localization and urbanization economies on the adaptation of new technology by manufacturing establishments. They find the economic diversity of the location is a more important factor "for promotion of adopting innovative firm behavior" than localization economy. Marra et al. (2011) examine the growth of 103 Italian provinces and show the relationship between economic diversity of Italian provinces and their economic growth rate.

The empirical work on effects of agglomeration economies on wages show that wages increase with population size. Sveikauskas (1975) analyzes the higher wages paid in large cities by regressing the overall wage rate of workers in manufacturing industries on the population of each city. He shows that money wages increase significantly with city size. Segal (1978) derives the marginal product of labor from a city level production function and show that city size increases the marginal product of labor and consequently the wage rate.

Fuches (1967) finds significant regional differences in the hourly wage rates which are not attributed to the differences in labor compositions. His results show that the ratio of actual to expected hourly earnings increases as the city size increases. Malpezzi, Kiat, and Shilling (2004) examine the relationship between agglomeration economies and the growth of earnings in U.S. metropolitan areas between 1970 to 1999 period. They find "strong evidence" that there is a positive relationship between growth of the metropolitan size, labor productivity and wages. Their results show urbanization economies as a more relevant factor explaining higher wages of bigger cities than localization economies.

Carlino (1985) states that since the 1970s, the manufacturing sector has been growing more rapidly in smaller cities. Carlino (1985) and Moomaw (1983a) use different ways to test the hypothesis that the bigger cities have become less attractive as locations for manufacturing industries. Their results show less favorable position for bigger cities as location for manufacturing industries. However, Black and Henderson (1999) show that "industries are still highly agglomerated" in the bigger cities. They show that there are different types of "manufacturing cities, service centers and market-center cities".

Black and Henderson (1999) suggest that the urban re-concentration in the biggest cities could be the result of transformation of the U.S. economy from manufacturing to financial and high-tec service economy. They examine 15 industries in high-tec and capital goods for 1963-1992 period and show that all industries are agglomerated and the bigger cities have the largest

share of employment of those industries. They report the high-tec industries as the most agglomerated industries.

The current study is concerned with the relationship between urbanization economies and the characteristics of production represented by the elasticity of substitution. Although the sample is the manufacturing industries, but the results could be tested for the service or high-tec sectors in the future.

METHODOLOGY

To measure the effects of agglomeration economies on the production characteristics a general form of CES production function has been chosen. The choice of a general form of CES production function allows for an elasticity of substitution different from one or zero.

To measure the effects of agglomeration economies on elasticity of substitution the parameters of a labor demand equation derived from the production function have been estimated. The labor demand approach allows us to measure the effects of agglomeration economies on the production function parameters without need for capital data. The effects of agglomeration economies on elasticity of substitution have been tested by inclusion of variables measuring urbanization economies. The CES production function in its general form can be written as following:

$$Q = A\,[dL^{-B} + (1-d)K^{-B}]^{-H/B}$$

Where Q is the output, L is labor input, K is capital input, A is an efficiency parameter or Hick's neutral parameter which changes output proportionally for given quantities of input, d($0 \le d \le 1$) is a distribution parameter and B is related to δ the elasticity of substitution parameter, as follows,

$$\delta = 1/(1+B) \qquad -1 \le B \le \infty \text{ since } 0 \le \delta \le \infty$$

and finally, H is the returns to scale parameter.

The following labor demand equation was derived from the CES production function:

$$L = CW^{-\delta}Q^{\beta}$$

Where C is collection of constant terms and $\delta = 1/(1+B)$ is elasticity of substitution.
The agglomeration economies variables have been incorporated into the production function parameter of the elasticity of substitution. The derived demand equation formulation of the production function with agglomeration variables is as follow:

$$L = C\, w^{-(1+a\ln s+b\ln u)/(B+1)} Q^{H(1+a\ln s+b\ln u)+(B-a\ln s-b\ln u)/H(B+1)}$$

Or,

$$L = C\, w^{-\Upsilon} Q^{\beta 1} Q^{\beta 2 \ln Q} Q^{\beta 3 \ln u} \qquad (1)$$

Where,

$$\Upsilon = (1 + a \ln s + b \ln u)/(B+1)$$

$$\beta 1 = \Upsilon + \beta/[H(B +1)]$$

$$\beta 2 = - a/[H(B +1)]$$

$$\beta 3 = - b/[H(B +1)]$$

and,

Elasticity of substitution is,

$$\delta = \Upsilon = (1 + a \ln s + b \ln u)/(B+1)$$

Where s stands for localization economies and u stands for urbanization economies. In (1) elasticity of substitution has been allowed to be affected by agglomeration economies.

Urbanization Economies Variables

Urbanization economies result from the general level of economic activity in an area. The general level of economic activity of a city is a broad concept. We divide it into two main categories: manufacturing sector and service sector. In this way we will be able to study the effects of total manufacturing size and the size of service sector of each city separately on manufacturing industries. In addition to the size of the manufacturing sector and the size of services sector in each city, the population of each city will be also used as a surrogate for city size.

The importance of interrelations between manufacturing industries are in terms of availability and lower price of intermediate inputs, therefore an external spatial size factor reduces cost of production of manufacturing industry (Czamanski & Czamanski, 1976; Carlino 1978). Kelly (1977), Moomaw (1983) and Czamanski and Czamanski (1976) measure the total manufacturing size by total employment of manufacturing sector in an urban area. This study has also used the total employment of manufacturing sector as a measure of the manufacturing size of an urban area.

Another factor changing the price of intermediate products for manufacturing industries is the size of business services in each city. Business services include advertising, computer services, auditing, consulting, telephone answering, janitorial work and provision of temporary office help. The larger the size of business services in a city the more the specialization in the production of these services and the lower their prices. Therefore, the size of business services in a city affects the availability and price of these intermediate products for manufacturing firms

and industries. Thus, the size of business services in each city is an external size factor which affects the costs of manufacturing industries.

The number of business service firms in each city has been used to measure the size of the service sector in each city. Finally, population has been used as a surrogate to capture the effects of any missing urbanization economies variable if there are any.

Empirical Models for Industry

The labor demand in (1) has been estimated at industry level. For an industry, the industry size is an internal factor. Therefore, at industry level the external size factors are the urbanization economies measured by total manufacturing employment, number of business service firms and population of each city. Therefore, the labor demand equation in (2) has been estimated at industry level:

$$\ln T_{ij} = \ln C_1 - Y \ln W_{ij} + \beta_1 \ln Q_{ij} + \beta_2 \ln Q_{ij} \ln M_{ij} + + \beta_3 \ln Q_{ij} \ln BN_j + \beta_4 \ln Q_{ij} \ln POP_j \quad (2)$$

Where, L is ith industry employment in jth city, W is ith industry wage rate in jth city, Q is ith industry output in jth city, M is total manufacturing employment in jth city, BN is number of business service firms in jth city and POP is population of jth city.

Where:

i = 1……..19

j = 1…….47

Ordinary least square regression has been conducted and (2) has been estimated cross section of 47 cities for 19 separate manufacturing industries for three separate years, 1972, 1977 and 1982. The following hypothesis will be tested:

H *It is hypothesized the estimated values of* β_1 *and/or* β_2 *and/ or* β_3 *in (2) are significantly different from zero. If they are, then urbanization economies affect elasticity of substitution.*

Data

Cross sectional analysis over 47 SMSAs for 19 two digit SIC industries have been conducted. Data covers 3 separate years of 1972, 1977 and 1982. The U.S. Census of Manufacturing publishes the industry data every five years, the latest available data is for the 2007 and the next conducted for the year ending December 2012, will be available in December 2013. One reason for use of the historical data for 1972, 1977 and 1982 was due to the lack of availability of data for 2012 at the time of this research, the available data for 2007 was also

considered outdated. Therefore the researcher decided to use the data for earlier years to give room for structural changes in composition of the U.S. cities and industries from 1982 to 2012. But, the fact that the study uses a theoretical foundation and takes a production function and labor demand approach to test the impact of the city size on the parameters of a production function, e.g. elasticity of substitution, should confirm the validity of the results. However, the study will continue and the 2012 data will be also applied and tested for the current model to compare and contrast the results of 1982 and 2012.

The data on labor employment, wage rate, output, number of firms within each industry, industry sales, the total manufacturing employment of each SMSA, the number of business service firms in each SMSA, the population of each SMSA and density of each SMSA have been collected. Data on labor, wages, output and number of firms were at industry level.

All manufacturing industries data were from the U.S. Census of Manufacturers. The total manufacturing employment of each SMSA collected from the U.S. Bureau of the Census, State and Metropolitan Area Data Book. The number of business service firms in each SMSA collected from the U.S. Census of Service Industry. The population data were either from the U.S. Census of Population or the U.S Bureau of the Census, State and metropolitan Area Data Book. The data on density were from the U.S. Bureau of the Census, State and metropolitan Area Data Book or calculated from population data.

Industry labor employment has been measured by all employees of each industry in each SMSA. Industry output has been measured by value added of each industry. The wage rate was computed by dividing total payroll of each industry in each SMSA by all employees of each industry in each SMSA as follows:

W_{ij} = Total payroll of the ith industry in the jth SMSA/All employees of the ith industry in the jth SMSA

RESULTS OF EMPIRICAL INVESTIGATION

Regression analysis was applied to equation (2) to test for non-zero β_2 and/or β_3 and/ or β_4 measuring the effects of city size on the elasticity of substitution parameter of the manufacturing industry. The industry labor demand equation in (2) was estimated for 19 manufacturing industries across 47 SMSAs for three separate years 1972, 1977 and 1982. The number of tables containing the results of estimated values of Υ, β_1, β_2, β_3, β_4 are too long to be listed in this paper. In general, the results were quite good. That is the R^2s were high and the F-test indicated that the specified relations were significant.

As explained earlier, agglomeration economies increase the availability and lower the price of intermediate products, consequently firms and industries drop the internal production of

intermediate products. This changes the organization of the production. It has been also supported by the literature that the rate of technological change is affected by city size. Theoretically, the change in elasticity of substitution of labor and capital is indicative of technological change (Hildebrand & Liu, 1957).

The results of regression analysis of estimating labor demand equation in (2) for 1982 indicated that β_2 , the coefficient of total manufacturing size, was significantly different from zero for five industries, β_3 , the coefficient of business service size was significantly different from zero for two industries and β_4 , coefficient of population in each city, was significantly different from zero for one industry. All together β_s were significantly different from zero for eight industries in 1982.

For 1977, β_2 was significantly different from zero for one industry, β_3 for two industries and β_4 for three industries. Altogether β_s were significantly different from zero for six industries. Results of regression analysis of estimating demand equation in (2) for 1972 showed that β_2 was significantly different from zero for six industries. β_3 was significantly different from zero for one industry and β_4 for three industries. All together 3s were significantly different from zero for eight industries.

The above results indicate that urbanization economies affect the elasticity of substitution of labor and capital for some industries. This could be indicative of the relationship between city size and technological change for some industries. Also, the size of total manufacturing of each city was a more significant variable than the size of business services and population of each city in affecting the elasticity of substitution. The later result could be related to the availability of general intermediate products, out sourcing, transmission of new knowledge, adaptation of new technology and the role of inter industry relationship in each industry's production technology.

The above argument also holds for business services. With city provision of business services internal production is abandoned. Further, the inter industry relationships requires adaptation of each industry to any technological changes arising in another industry. In other words, it could show spread of know how from one industry to another. Population size affected elasticity of substitution for only a few industries. This could also show the effects of bigger cities on technological change.

Table (1) is a summary of results of this paper.

Table 1
SUMMARY OF RESULTS

Year	β_2	β_3	β_4
1982	5	2	1
1977	1	2	3
1972	6	1	3

*Number of β's different from zero. Nonzero β means agglomeration economies affect the elasticity of substitution. β_2 is the coefficient of total manufacturing size, β_3 is the coefficient of business service size and β_4 is coefficient of population.

SUMMARY AND CONCLUSION

Agglomeration economies have been an issue in urban economies and location theory since Van Thunen (1926) and Weber (1957). Discussion of these economies was primarily conceptual until the late 1950s. At that time Vernon (1960) completed the detailed analysis of inter-industry relations and external factor influencing manufacturing in New York States. Later Chinitz (1961) contrasted Pittsburgh's and New York's economies in a way which clearly revealed many of the links between the character and growth of cities and their industrial structures. The next wave of empirical work on agglomeration economies appeared in the 1970s and has continued to this day. The purpose of this research has been to extend this line of research.

The analysis builds on its predecessors in a number of ways. First, production function in which measure of various agglomeration factors were included were estimated for a cross-section of 45 large U.S. cities. Second, the estimates were obtained for two digit SIC manufacturing industries at three different time periods.

The elasticity of substitution was found to be significantly related to one or another of the agglomeration variables in half of the industries in all time periods. Related findings also suggest that there is biased in the use of population as a summary surrogate measure of agglomeration economies. The introduction of the business service availability variable and the incorporation of the localization variable provide a means of considering the use of population as a surrogate variable. In general, the analysis indicates that industry size and business service availability were independently more important than population size.

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