California Center for Population Research
University of California - Los Angeles

Marshallian Localization Economies: Where Do They Come From and To Whom Do They Flow?

W. Mark Brown
David L. Rigby

CCPR-2009-020

September 2009
Last Revised: September 2009

California Center for Population Research
On-Line Working Paper Series

MARSHALLIAN LOCALIZATON ECONOMIES: WHERE DO THEY COME FROM AND TO WHOM DO THEY FLOW?[1]

W. Mark Brown[2] and David L. Rigby[3]

[1] This work was funded by a Canadian Studies Research Grant. The authors would like to acknowledge the research assistance of Des Beckstead and Bob Gibson of the Micro-Economic Analysis Division of Statistics Canada. They also thank John Baldwin for his comments on earlier drafts of this paper.
[2] Micro-Economic Analysis Division, Statistics Canada, Ottawa, Canada: Mark.Brown@statcan.gc.ca
[3] Department of Geography, UCLA, Los Angeles, USA: rigby@geog.ucla.edu

Abstract

Dense concentrations of economic activity are generally seen as giving rise to increasing returns that may be shared by business units that cluster in particular locations. What are the sources of these increasing returns and do they benefit all businesses or only some? Theories of the firm and strategic management argue that competitive advantage originates in the development and exploitation of firm-specific assets or capabilities that may be internal or external to the firm. The extent of firm heterogeneity suggests that businesses search for profit in many different ways. We might anticipate that older, larger, foreign-owned and multi-plant firms draw upon internal resources more readily than young, small, domestic, single-plant firms. Do the benefits of agglomeration vary among business establishments according to these characteristics? We examine this question using plant-level longitudinal micro-data from the Canadian manufacturing sector. We show that most manufacturing plants benefit from co-location, but that plants with different characteristics benefit in different ways.

Keywords: agglomeration, plant characteristics, micro-data, panel model

1. Introduction

How do firms organize their activities and compete in the market economy? Individual producers have to make a series of complex and interrelated choices regarding what to produce, how much to produce, what technology to employ, how to organize their operations, and where to locate. Facing uncertain levels of demand and competition, there is no simple calculus business owners can employ to ensure that they make profitable decisions. From Adam Smith (1776) to Stigler (1951) and through the work of Coase (1937) and Williamson (1975) we gain a general understanding of the factors that influence economies of scale and scope and the resultant tendencies for production to be internalized within a single firm or spread across networks of inter-dependent firms. Scott (1986, 1988) has synthesized much of this work, detailing the organizational and locational proclivities of firms operating in differentiated markets. In similar vein, Scherer et al. (1975) examine the decision of single-plant firms to adopt a multi-plant stance, while Kang and Sorenson (1999) focus on the relationship between ownership type and performance.

When we examine the structure of production within industries and across economies, we cannot fail to be struck by the heterogeneity that we observe. At least since the work of Penrose (1958), this heterogeneity has been employed to understand firm performance and strategy (see Melitz 2003 for a recent formal treatment). The existence of heterogeneity acknowledges that firm-specific assets—management skills, organization, behavioral routines, size, knowledge, technology, and even location—are highly variable and that the value of such assets may change rapidly in competitive markets. This resource-based vision of performance is more explicitly developed by Wernerfelt (1984) and Barney (1991), in contrast to the opportunities and threats model of industry attractiveness promoted by Porter (1985). The resource-based model of firm performance is generalized by Prahalad and Hamel (1990) in their discussion of firm competence and capabilities, and it is given an explicitly dynamic twist by Teece and Pisano (1994). Nelson and Winter (1982) ground their evolutionary model of economic growth on similar views of heterogeneity among competing agents in uncertain markets.

Over much of the last two decades a great deal of research has gathered empirical evidence of firm heterogeneity and how the characteristics of individual business establishments shape their own performance and, in aggregate, the dynamics of industries and regions (Baily et al. 1992; Baldwin 1995; Davis et al. 1996; Rigby and Essletzbichler 2006; Saxenian 1994; Storper 1997). Most of this research focuses on readily observable dimensions of business variability such as age, size, technology, organizational structure (single-plant or multi-plant firm) and ownership status (domestic or foreign). While these variables by no means capture the full-range of firm characteristics that shape performance, they do highlight the importance of variety and the range of competitive strategies pursued. What is also clear from much of this work is that firms search for efficiency in many different ways. A basic distinction can be drawn between those plants that have the internal capacity to generate competitive advantage and those that seek advantage through co-location with others.

Since the work of Marshall (1920), the potential benefits that individual businesses accrue by co-locating in space have generated considerable interest. Theoretical work on the returns to agglomeration is largely concerned with the mechanisms by which external economies are generated, on the means by which those economies flow between firms, and on the types of firms that benefit. Marshall (1920) outlined three primary sources of external economies: buyer-supplier networks that enhance the capacity of individual businesses to source the inputs that they require and sell the goods that they produce; labor market pooling that ensures the workplace skills required by firms are available; knowledge spillovers that result when the R&D efforts of firms are not fully appropriated and flow across firm boundaries to neighboring businesses. While older empirical studies of agglomeration focused largely on establishing a statistical relationship between firm concentration and performance (Moomaw 1983; Gerking 1994), more recent research tends to focus on the individual processes outlined by Marshall. Thus, Dumais et al. (1997), Rosenthal and Strange (2001), and Rigby and Essletzbichler (2002) use plant-level micro-data and linked plant and place-specific information to examine the relative strengths of Marshall's three forms of agglomeration. Rosenthal and Strange (2003) and Baldwin et al. (2008) push further to explore the distance across which spillovers flow. Rosenthal and Strange (2003), Henderson (2003), and Baldwin et al. (2009) use longitudinal techniques to control for omitted variable bias in their estimation of Marshall's agglomeration economies. Rather than limiting their analysis to specific industries, Baldwin et al. (2009) present results for all manufacturing activity and for a series of individual sectors. They also deal with questions of endogeneity bias by using instrumental variables (see also Duranton 2007). In just about all of this work, the theoretical claims of Marshall are roundly supported. Henderson (2003) also shows that single-plant firms benefit more from agglomeration economies than corporate firms. We take up this issue further in the analysis below.

Rigby and Essletzbichler (2002), Henderson (2003) and Baldwin et al. (2008) reveal that the strength of Marshall's different mechanisms of agglomeration operate unevenly across individual manufacturing industries. This likely reflects variations in production characteristics and potential sources of competitive advantage across industrial sectors. In this paper we seek to push investigation of this issue further, exploring the existence and the strength of Marshall's agglomeration economies across groups of firms distinguished broadly on the basis of their capacity to generate economies internally. Thus, we compare how agglomeration functions in single-plant versus multi-plant firms, in small versus large plants, in plants of different age, and in foreign versus domestic plants. We hypothesize that manufacturing establishments with diminished capacity to generate economies internally will rely more heavily on the benefits of agglomeration.

A good deal of research has looked at the performance of small plants or firms relative to their larger competitors (Pratten 1991). In general we know that smaller firms tend to have somewhat lower productivity than average, they have less access to capital, to technology and more highly qualified workers (Kleinknecht 1989). It is natural to ask, therefore, how smaller firms remain competitive. Acs and Audretsch (1990) note that most R&D is performed by large corporations and that innovative inputs in small firms usually take the form of spillovers. Models of industrial districts and clusters typically are developed around small firms whose very survival is seen to depend on the external economies co-location affords (Scott 1998). Somewhat surprisingly, perhaps, there is not a great deal of empirical work that examines whether small firms cluster more than large firms. In a carefully crafted study, Sweeney and Feser (1998) do not find a negative linear relationship between plant-size and clustering. Rather, they report that clustering increases with plant-size up to a limit and then decreases.

The plants of multi-unit firms tend to have higher productivity than plants of the single-unit firm (Baldwin and Gu 2006). This is usually explained by specialization and by the more efficient use of resources in the establishments of multi-plant firms. By drawing on the resources of the entire firm, we suspect that establishments of multi-plant firms will rely less on the benefits of agglomeration than single-plant firms.

Foreign-owned manufacturing establishments tend to out-perform their domestic counterparts (Davie and Lyons 1991; Doms and Jensen 1995; Dimelis and Louri 2002; Baldwin and Gu 2005). Foreign-owned plants might be considered a special case of the multi-establishment firm, but where the headquarter plant is located in a foreign country. In this respect, foreign plants share the same sorts of advantages as the plants of multi-unit firms and we therefore expect they will rely less on the benefits of co-location. It is also supposed, from the literature on foreign direct investment, that foreign plant performance is bolstered by the firm specific assets of their parents.

The internal capacity of firms will also depend on their age. Entry can be viewed as an experiment where entrepreneurs discover their capabilities (Javanovic 1982). New firms also tend to start small, relative to incumbent firms in their industry, because their expectation of success is low and their investments are sunk (see Caves 1998). New firms, therefore, are small and are engaged in a process of learning-by-doing. By their very nature, they have relatively few internal resources to draw upon.

The objective of this paper is to test whether Marshallian localization economies help to compensate for the lack of internal resources, which we associate with smaller and newer firms. In particular, we want to test whether each of the three Marshallian economies—labor market pooling, buyer-supplier networks, and knowledge spillovers—differentially affect firms with differing internal capacities.

Beginning with *labor market pooling*, our expectation is that local labor markets will have a greater effect on the productivity of new firms because the geographic scope of their labor markets are potentially more limited. That is, because new firms, on average, pay lower wages than incumbent firms (Baldwin 1996) it will be more difficult for these firms to draw workers from outside the local labor market. Hence, in relative terms, new firms will tend to rely more on local labor markets and so they will be influenced more by variability in their underlying conditions.

Our expectations regarding *upstream suppliers* run, at least partially, counter to the broad thrust of the discussion to this point. New firms are often unsure of their production processes (Duranton and Puga 2001), which implies the relationship between output and costs is also uncertain. Therefore, it will be more difficult for new firms to determine which parts of their production processes can be more profitably outsourced to other firms (Stigler 1951). So it may be older, more established plants, whose production processes have become routine, that will benefit more from the presence of upstream suppliers. This is not the only potential expectation, however. It has been argued that smaller firms may benefit more from the presence of upstream suppliers if this represents an alternative to larger scale mass production (see Piore and Sable 1984 and Scott 1988). Still, while this argument might hold in certain circumstances, it does not constitute a broad theoretical claim that smaller firms should benefit more than larger firms from the localized presence of upstream suppliers.

We turn, finally, to *knowledge spillovers*. Our expectation is that spillovers are likely to be more important for new firms. As we have noted above, new firm entry can be viewed as an experiment (Jovanovic 1982) where post-entry entrepreneurs learn about their capabilities. Here we posit that post-entry learning will be more effective within an information rich environment where other firms are undertaking similar work. In contrast, for established firms, these localized forms of learning will not be as important because they have already successfully completed the uncertain initial stages of the entry process.

The remainder of the paper is organized as follows. In Section 2 we discuss the sources of our data, the variables employed and the modeling strategy adopted. The results of our analysis are presented in Section 3, beginning with a brief overview of past findings for all plants within our longitudinal data set. These findings provide a benchmark from which to examine how subsets of plants with different characteristics are impacted by the different types of agglomeration economies that we identify. Section 4 concludes with a summary of our findings and directions for future work.

2. Data, Methods and Background Findings

The variables used in our econometric models are readily separated into two groups, characteristics of individual business units or plants, and characteristics of particular locations. Table 1 lists the variables in our models and provides brief descriptions. The plant level information is developed from the Canadian Annual Survey of Manufactures (ASM) for 1989 and 1999. The panel techniques we employ require observations on individual establishments for at least two years.

Our place-specific data are derived from the ASM, from the Household Census in 1991 and 2001 and from Canadian input-output accounts. All data were geocoded to a constant 2001 census geography for census metropolitan areas (CMAs) and census agglomerations (CAs). In 2001, there were 141 CMAs/CAs in Canada ranging in size from Kitimat, BC with a population of about 10,000 to the Toronto CMA with a population of about 4.6 million. The 141 regions contained approximately 80% of the Canadian population in 2001 and roughly the same percentage of Canadian manufacturing establishments in 1999.

2.1 Plant-firm specific characteristics

The dependent variable in our analysis is labor productivity, measured as value added divided by the number of production workers. For each plant, we measure value added and production workers at their mean across three years. For 1989 these are the two adjacent years. Owing to the fact that 1999 is the last year on the longitudinal file, we take the mean level of value added and production workers for 1999 and the two previous years. Value added is measured in constant dollar terms using an industry-level deflator. We utilize three-year means for all plant-level characteristics, in order to reduce the year-over-year variability inherent to micro-data. Plants often encounter shocks that may obscure the relationship between plant-level inputs and output (e.g., because of labor hoarding). Using three-year means helps to reduce the effect of this variability on our estimates.

Labor productivity is expected to depend on several plant level characteristics. These include plant size, capital intensity and the ratio of non-production to production workers. It is expected that labor productivity will be higher in plants that are larger in size because they are able to take advantage of various forms of scale economies (e.g., those that result from longer production runs). Plant size is measured by the number of production workers. The productivity of production workers is also expected to rise as the amount of machinery and equipment with which they work increases. We would like to capture the effect of mechanization with a variable measuring the capital to labor ratio. Unfortunately, capital stock data are unavailable at the plant level and so we use a proxy variable to represent the capital-labor ratio. Production workers tend to generate higher levels of output if more non-production workers are contributing to the production process. For instance, more input from management and engineering functions can help to improve the organization of the production process. Hence, we expect labor productivity to be positively associated with the ratio of non-production to production workers.

We measure two types of firm characteristics in the model. First, we identify whether the plant is part of a multi-establishment firm. This is a binary variable where the reference group is single-plant firms. Our expectation is that multi-plant firms will be more productive than single plant firms. Multi-establishment status brings the benefit of firm-wide economies to the plant. For instance, multi-establishment firms may be better able to collect and analyze information that can improve management practices and thus raise productivity. Second, we identify whether plants are foreign controlled. Foreign controlled plants are expected to have higher level of productivity because they have access to a broader range of experiences and technologies (Baldwin and Gu, 2005). Foreign control is also a binary categorical variable where the reference group is domestically controlled plants.

2.2 Place-specific characteristics

The agglomeration variables that we develop in our productivity model, the local density of buyer-supplier networks, labor pooling and knowledge spillovers, can all be traced back to Marshall (1920). We outline below the variables employed to measure these Marshallian economies, along with indicators used to capture other types of agglomeration economies.

An area's labor pool supports the needs of a particular industry if the occupational distribution of an area corresponds to the distribution required by that industry. The labor mix for an industry within a metropolitan area is defined after Dumais *et al*. (1997) as:

$$LABMIX_i^m = \sum_o \left(L_{io} - \sum_{j \neq i} \frac{E_j^m}{E^m - E_i^m} L_{jo} \right)^2,$$

where o represents an occupation, i and j index industries and m refers to the metropolitan area. L measures the proportion of workers in a particular industry and occupation, while E measures the number of workers in a single industry or in all industries within a metropolitan area. This index is a sum of squared deviations that measures the degree to which the occupational distribution of employment in an industry is matched by the occupational distribution of the workforce in the metropolitan area as a whole, excluding the specified industry. The occupational distribution of industry workers is calculated at the national level and covers some 47 occupations at the 2-digit level using the 1991 Standard Occupational Classification, which is used for the 1991 and 2001 Censuses. We anticipate that a better match between the occupational distribution (demand) in an industry and the occupational distribution of the entire workforce of a metro area (supply) will boost productivity. Improved matches reduce the value of the squared term. Thus, we expect a negative coefficient on this variable in the following regressions.

We calculate the benefits of the local density of buyer-supplier networks using national input-output data and indicators of the local concentration of production within specific sectors of the economy. These networks might convey additional benefits in the form of inter-industry spillovers embodied in material flows between industrial sectors. High correlation between estimates of the geographic concentration of upstream producers and downstream customers led us to focus on upstream activity only. To measure local variation in the density of upstream connections for each 4-digit industry and for each census metropolitan area in Canada, we identify an upstream supplier-weighted location quotient:

$$USXLQ_j^m = \sum_{i, i \neq j} w_{ij}^n \left(\frac{TVS_i^m / \sum_i TVS_i^m}{TVS_i^n / \sum_i TVS_i^n} \right).$$

The term in the parentheses is a location quotient for each industry i in metro area m. The location quotients are calculated using the total value of shipments (TVS) of each industry and measure the degree to which a particular city is specialized in an industry. A value less than one would indicate an industry is under-represented, while a value greater than one would indicate the industry was over-represented. The terms w_{ij} represents the weight of industry *i* as a supplier of industry *j*—that is, the proportion of all manufactured input purchases by industry *j* supplied by industry *i*. Supplier weights are estimated from inter-industry transactions and are derived from the Canadian national input-output tables. The subscripts *i* and *j* refer to each of the 236 4-digit SIC manufacturing industries, *m* refers to a specific metropolitan area and *n* refers to the nation. Note that we also removed the influence of the own-industry in these measures, by dropping the principal diagonal from the input-output direct coefficients matrix. Metropolitan areas whose economies are specialized in industries that are significant suppliers to industry *j* will have a relatively high *USXLQ* and this is expected to have a positive effect on labor productivity in plants in industry *j* within those areas.

Note that because the labor mix and buyer-supplier network measures are defined at the metropolitan level, the values for these variables for a given industry are constant for all plants in that industry and metropolitan area. As we have noted above, this necessitates adjustment of the standard errors in our model, for as Moulton (1990) demonstrates, they can be biased when merging aggregate variables across micro units of observation.

The third agglomeration effect arises from knowledge spillovers that are generated by the close proximity of producers in the same industry in the same urban area—intra-industry spillovers. Measuring knowledge spillovers is notoriously difficult, even impossible as Krugman (1991) claims, for they do not leave a paper trail. Jaffe *et al*. (2003) disagree, arguing that patent citations can track knowledge flows. Nevertheless, the linking of patent information to the plant-level data that are increasingly used to study agglomeration is surprisingly underdeveloped. Rigby and Essletzbichler (2002) show that flows of knowledge embodied in intermediate goods enhance the productivity of agglomerated plants, but that sheds little light on the role of disembodied information flows. We spent some time examining the influence of local own- and cross-industry patents, in industries of use and make, on plant labor productivity, but were discouraged by the results that were broadly insignificant. Our measures all used simple counts of patents within metropolitan areas and industries linked to the patent classification rather than citations. Raw patent counts for 1999, earlier years, or groups of years were not significantly related to productivity.

As a result, we follow Henderson (2003) and Rosenthal and Strange (2003) and use counts/densities of plants in specific geographical areas as a proxy for intra-industry knowledge spillovers. We exploit data on the latitude and longitude of individual plants to define concentric circles of varying distances around each, within which we count the number of plants within the same 2-digit (SIC) industry. Our past research has indicated that the productivity of an individual plant is influenced by the number of own-industry plant neighbors that are located within 5kms. Plant counts within concentric circles that are more than 5kms from a specific plant have no general influence on productivity. It is unclear to us why 5kms represents a significant distance threshold, though this does confirm other research that shows knowledge spillovers are highly localized (Rosenthal and Strange 2003).

We add metropolitan population size to our model as a proxy for urbanization economies that are not captured elsewhere in our model. The benefits of urban size are many. Large urban economies bring with them greater industrial and occupational diversity that facilitate the transfer of innovations across industries (Jacobs, 1969) and that are thought to help incubate new firms (Duranton and Puga 2001). Large population centers also create the demand for infrastructure that can enhance the productivity of all industries (e.g., highways, airports, ports and communications networks).

2.3 Model

The relationships between value added, plant size and capital intensity noted above can be formally derived from a production function using Cobb-Douglas technology where value added (VA) is expressed as:

$$VA = AK^{\alpha} L_{pw}^{\beta} L_{npw}^{\sigma}, \tag{1}$$

where K is a measure of capital input, L_{pw} is the number of production workers employed by the plant and L_{npw} is the number of non-production workers. With a little algebraic manipulation, equation (1) may be re-written such that labor productivity (LP) is a function of capital and labor inputs:

$$LP = \frac{VA}{L_{pw}} = A\left(\frac{K}{L_{pw}}\right)^{\alpha} \left(\frac{L_{npw}}{L_{pw}}\right)^{\sigma} L_{pw}^{\beta+\alpha+\sigma-1}. \tag{2}$$

The ASM does not provide plant level estimates of capital and therefore we need to develop a proxy $(\hat{K})$. We estimate $\hat{K}$ from the following expression for profit (π)

$$\pi = VA - wages = r\hat{K} \tag{3}$$

where r is the rate of return on capital. The profit to labor ratio $r\hat{K} / L_{pw}$ can be substituted into (2), and if we assume the rate of return is equalized across plants, then

$$LP = Ar^{\alpha}\left(\frac{\hat{K}}{L_{pw}}\right)^{\alpha} \left(\frac{L_{npw}}{L_{pw}}\right)^{\sigma} L_{pw}^{\beta+\alpha+\sigma-1}. \tag{4}$$

Given this formulation, variation in profits across industries and provinces can be accounted for by industry and province fixed effects.

One of the practical issues with equation (4) is that our proxy of the capital to labor ratio and our measure of productivity are very highly correlated because both contain value added in their numerator and labor in their denominator. To address this problem, we estimate a slightly different model. Multiplying (1) by VA^{α}/VA^{α} we obtain

$$VA = Ar^{\alpha}\left(\frac{\hat{K}}{VA}\right)^{\alpha} VA^{\alpha} L_{pw}^{\beta} L_{npw}^{\sigma}, \tag{5}$$

that implies

$$VA = A^{\frac{1}{1-\alpha}} r^{\frac{\alpha}{1-\alpha}} \left(\frac{\hat{K}}{VA}\right)^{\frac{\alpha}{1-\alpha}} L_{pw}^{\frac{\beta}{1-\alpha}} L_{npw}^{\frac{\sigma}{1-\alpha}}. \tag{6}$$

Labor productivity can then be defined as

$$LP = \tilde{A}\tilde{r}\left(\frac{\hat{K}}{VA}\right)^{\frac{\alpha}{1-\alpha}} \left(\frac{L_{npw}}{L_{pw}}\right)^{\frac{\sigma}{1-\alpha}} L_{pw}^{\frac{\beta+\alpha+\sigma-1}{1-\alpha}}, \tag{7}$$

where $\tilde{A} = A^{1/(1-\alpha)}$ and $\tilde{r} = r^{\alpha/(1-\alpha)}$. Equation (7) can be used to solve for the values of α, β, and σ. Hence, despite the fact that we do not examine the effect of the capital to labor ratio on productivity directly, we are able to recover an estimate.

In order to estimate (7) we include a multiplicative error term ε and use its logarithmic transformation:

$$\ln LP_{ijk} = \ln \tilde{A} + \ln \tilde{r} + \delta_1 \ln \frac{\hat{K}_i}{VA_i} + \delta_2 \ln \frac{L_{npw,i}}{L_{pw,i}} + \delta_3 \ln L_{pw,i} + \ln \varepsilon_i, \tag{8}$$

where $\delta_1 = \frac{\alpha}{1-\alpha}$, $\delta_2 = \frac{\sigma}{1-\alpha}$, and $\delta_3 = \frac{\beta+\alpha+\sigma-1}{1-\alpha}$. Note also that i indexes plants, j indexes firms and k indexes geographic locations.

Throughout the analysis we assume that other characteristics of the firm and the characteristics of the location of the firm are transmitted through the multifactor productivity term $\tilde{A}$. Hence,

$$\ln \tilde{A} = a + \varphi' \mathbf{lnX}_j + \theta' \mathbf{lnG}_k + \gamma_i + \eta_j + \lambda_k \tag{9}$$

where **X** is a vector of characteristics related to the firm that controls plant i and **G** is a vector of characteristics that are associated with location k. These locational characteristics are related either to the metropolitan area associated with k or are calculated based on a set distance from k, where k can be thought of as a point in space. Unobserved fixed effects associated with plant i, its related firm j, and location k are represented in equation (9) by γ_i, η_j, and λ_k, respectively.

The primary econometric issue associated with estimation of equation (8) is the potential correlation of the error term with one or more independent variables. This correlation may stem from the presence of unobserved fixed effects and/or endogeneity (reverse causality). To remedy the possibility of omitted variable bias, we substitute (9) into (8) and take the first difference across periods:

$$\ln \Delta LP_{ijk} = \Delta a + \delta_1 \Delta \ln \frac{\hat{K}_i}{VA_i} + \delta_2 \Delta \ln \frac{L_{npw,i}}{L_{pw,i}} + \delta_3 \Delta \ln L_{pw,i} + \varphi^t \Delta \mathbf{lnX_j} + \theta^t \Delta \mathbf{lnG_k} + \Delta \ln \varepsilon_i \tag{10}$$

In so doing, we eliminate the plant-, firm- and location-level fixed effects that might be correlated with other independent variables. For simplicity, we assume that the rate of return on capital is constant within plants across our two time periods and so this term is dropped in equation (10). Elsewhere (see Baldwin et al. 2009), we have used instrumental variables techniques to examine potential problems of endogeneity. The results we provide appear robust to such concerns.

2.4 Sample Characteristics

Descriptive statistics for all place-specific variables and for plant variables that are continuous are reported in Table 2. The values in Table 2 are shown for the two years over which we have drawn our observations, 1989 and 1999. These values are not logged. Along with the mean, median and standard deviation for all variables, we report the number of observations across which the descriptive statistics were calculated. There were 11,323 plants present in 1989 that were in business in 1999. The mean labor productivity of plants present in 1989 and 1999 increased from $82,775 to $87,298. Other plant level characteristics remained relatively stable over the period. The profit to value added ratio remained essentially constant. Average and median plant sizes increased marginally, while non-production to production worker ratios fell modestly. Correlation coefficients for all pairs of continuous variables are reported in Baldwin et al. (2008).

Plant characteristics are measured across individual manufacturing establishments. We limited our sample in several ways. By construction, plants in rural areas are excluded from the study. Furthermore, only plants with a three-year average level of employment above zero are included as labor productivity with zero employment is undefined. The sample is also restricted to plants with positive value added and positive returns to capital. For the latter, this implies value added minus wages is greater than zero. As a practical matter these restrictions are imposed because logarithmically transformed variables with a value of zero or less are mathematically undefined. They are also imposed because plants with negative value added or negative returns to capital are likely undergoing significant economic shocks. Again, this may blur the relationship between inputs and output. Also excluded are plants that change location and industry.

Due to the longitudinal nature of the analysis, the most significant restriction to our set of plants is that they must have remained in business at least ten years. In 1999, this restriction, plus all of the others noted above, reduced the number of plants in the sample from about 29,000 to 11,300. The loss of so many observations raises questions about sampling bias. However, note that the results reported below are very similar to those published earlier on a much larger cross-section of plants from 1999.

Shifting to our geographical or place-specific variables, for each establishment, counts of the number of plants in the same 2-digit (SIC) industry within 5 kms were generated. All establishments, not just those that form part of our sample, are included in these counts. Population values are reported for approximately 140 census metropolitan areas (CMAs) or census agglomerations (CAs) that comprise the geographical units of analysis. The labor mix and upstream location quotient are calculated at the 3-4 digit level of the Canadian Standard Industrial Classification for each CMA/CA, yielding 3,204 observations.

3. Plant Characteristics and the Benefits of Agglomeration

3.1 All plants

Table 3 shows the results of estimating equation (10) across our entire balanced panel of 11,323 plants. This model was estimated using ordinary least squares after differencing between years. All standard errors are robust and corrections have been made for the potential correlation of errors between manufacturing establishments found in the same region (Moulton 1990).

The baseline model estimates are broadly consistent with our theoretical expectations. All plant and firm characteristics exert a significant influence on productivity in the anticipated direction. Labor productivity tends to be significantly higher in plants where the profit to value added ratio, our proxy for the capital to labor ratio, is high. The elasticity on the profit to value added ratio is largest for all independent variables—a 10% increases in the profit to value added ratio would increase labor productivity by approximately 7.5%. Increases in the ratio of non-production to production workers inside plants also raises productivity, with an elasticity about half that of the profit to value added ratio. The negative sign on plant size reflects the value of the exponent in equation (7), $\delta_3 = (\beta + \alpha + \sigma - 1)/(1-\alpha) = -0.109.$ Solving for β implies, trivially, that value added increases with the number of production workers (β = 0.425), but since $\beta + \alpha + \sigma - 1 = -0.062$ plants experience moderate decreasing returns to scale.

Within a first-difference framework, the nature of the multi-plant and foreign-plant status variables requires some explanation. The effect of multi-plant status is captured through the effect of switches between single-plant and multi-plant status. The same holds true for foreign-plant status. As we measure multi-plant and foreign-plant status at the end of the period, a switch from single- to multi-plant status, or from domestic- to foreign-plant status, will result in a positive value (+1), while the reverse will result in a negative value (-1). The coefficient on both variables will reflect the weighted average of these bi-directional switches across plants. Turning to the results, the positive and significant coefficients for multi-plant status and foreign-plant status suggest establishments that become part of a multi-plant or a foreign controlled enterprise tend to have higher productivity than single, domestic plants.

The influence of agglomeration economies on plant productivity is also indicated in Table 3 for all plants that comprise our balanced panel. Our labor mix variable exerts the largest impact of all agglomeration factors on productivity. Thus, plants located in urban areas where the supply of labor more closely matches the occupational demands of the plant's industry enjoy higher productivity than plants located in urban areas where there is a greater disconnect between the demand for labor within specific occupations and available supply. The local density of upstream suppliers raises plant productivity, but its elasticity is only about one-fifth that of labor mix. Knowledge spillovers are also shown to improve plant performance, with our proxy for spillovers, the number of plants in the same 2-digit (SIC) industry within 5kms of a specific plant, significantly raising that establishment's productivity, albeit by a relatively small amount. This spillover effect was insignificant for establishment counts at distances greater than 5kms, confirming the results of Rosenthal and Strange (2003) who report a strong distance gradient with respect to intra-industry spillovers. Our measure of urbanization economies, population size, exerts a significant, though negative influence on plant productivity. We provide an interpretation of this result at the end of this section.

3.2 Domestic single-plant firms and foreign/multi-plant firms

We turn now to examine how these agglomeration factors operate across subsets of plants identified on the basis of plant/firm characteristics that are commonly regarded as indicators of internally available resources/competencies. Table 4 separates our baseline sample into domestic, single-plant firms and establishments that are part of multi-plant/foreign-controlled organizations. Establishments connected to multi-plant firms and foreign firms were combined because tests of the data indicated that the effects of plant and place characteristics on the productivity of these two groups are qualitatively similar, and statistically indistinguishable. Most plants, some 73% of the original balanced panel, are domestic, single-plant firms.

Table 4 reveals that individual plant characteristics have both similar and differential effects on labor productivity across single- and foreign/multi-plant firm establishments. Plant size and the ratio of non-production to production workers tend to have similar effects on labor productivity across the two types of firms, while the coefficient on the profit to value added ratio tends to be smaller for single-plant firms. For domestic, single-plant firms, switching from multi-plant to single plant status is negatively associated with labor productivity growth, while switching from foreign to domestic status is not significantly associated with changes in productivity. For foreign/multi-plant firms the effects of multi-plant and foreign-plant status were positive and significant.

When we turn to the gains from agglomeration, plants controlled by domestic, single-plant firms and foreign/multi-plant firms benefit from all three Marshallian economies. Moreover, the magnitude of these effects are similar, with the exception being the density of upstream suppliers, whose elasticity for foreign/multi-plant firms is almost three times greater than that of domestic, single-plant firms. Taken on its own, this result suggests plants that we expect to benefit the least from agglomeration economies, foreign and multi-plant firms, benefit as much, and in at least one respect, even more than domestic, single-plant firms from localization economies. However, before resting with this conclusion, further analysis is warranted.

The industrial structures of these two subsets of plants are quite different and, as we show in Baldwin, Brown and Rigby (2008), the estimated effect of the three Marshallian economies do vary across broad industrial sectors. Like in Baldwin, Brown and Rigby (2008), we define sectors based on a classification derived from the Organisation for Economic Co-operation and Development (OECD) (1987), which was modified for Canadian data by Baldwin and Rafiquzzaman (1994). These sectors include natural resource-based industrial, labor-intensive industries, scale-based industries, product-differentiated industries, and science-based industries and are defined primarily on the basis of the factors that influence the competitive process. For example, in the case of scale-based industries, competition hinges on the length of production runs.

Dividing the dataset into these five aggregate sectors confirms that single-plant firms and plants that belong to multi-unit/foreign firms tend to be found in quite different economics sectors. Natural resource-based, scale-based and science-based industries tend to be overrepresented in the foreign/multi-plant subset, while labor intensive and product differentiated industries are underrepresented, compared to the domestic, single-plant subset.

To account for the effect of industry composition we undertook a sensitivity analysis, where we re-estimated the model for the domestic, single-plant and foreign/multi-plant subsets five times, with one of the five OECD sectors excluded each time. Excluding these sectors one-by-one from the sample proved the results to be very stable, with the notable exception of scale-based industries. Tables 4a and 4b present the estimates with scale-based industries excluded from the sample and scale-based industries on their own, respectively.

With scale-based industries excluded, the resulting parameter estimates are similar to the all-industry model for the domestic, single-plant subset, but they are very different for the foreign/multi-plant subset (see Table 4a). For the latter, the effect of labor mix and knowledge spillovers (plants within 5 km) is no longer significant. The density of upstream suppliers remains significant, but its parameter estimate is reduced. So for this more restricted industrial subset, we see that a better labor mix and a greater potential for knowledge spillovers have a positive and significant association with labor productivity for single-plant firms, but this is not the case for the foreign/multi-plant firm subset. Plants in the later group, however, still benefit more from a stronger presence of upstream suppliers. This is a finding that is broadly consistent with our expectations.

For scale-based industries (see Table 4b), we observe the mirror image of the subset of industries that excludes this OECD sector. It is plants that are controlled by foreign/multi-plant firms that benefit the most from localization economies. Domestic, single-plant firms appear not to benefit from these spillovers, with the exception of labor mix whose parameter estimate is still weaker than the foreign/multi-plant classified plants. Why scale-based industries behave so differently is open to question. It may be that there is a qualitative difference between domestic single-plant and foreign/multi-plant firms in this sector. Often large scale, multi-plant firms are exceptionally complicated to run. For these firms locations with the right mix of labor, a strong presence of upstream suppliers, and the potential for knowledge spillovers, despite their strong internal capacities, may result in a significant pay-off. In effect, there may be a complementarity between the significant internal resources of these firms and their local economic environment.

For a broad subset of industrial sectors, Marshallian economies, as captured by labor mix and plant counts within 5 km, more strongly influence domestic, single-plant firms, which we posited would be more reliant on localized external economies than foreign/multi-plant firms. The exception to this pattern is the local density of upstream suppliers, which tends to have a stronger effect on the productivity of foreign/multi-plant firms, regardless of whether scale-based industries are in or out of the sample. Still, even across domestic, single-plant firms their reliance on localization economies may vary. Smaller and, in particular, younger plants may be more reliant on these economies than those plants that are larger and that have been in operation for a longer period of time. It is to these two sub-samples that we now turn.

3.3 Domestic, single-plant firms: Plant size

Table 5 takes the sample of domestic, single-plant firms and splits it into two groups based on plant size.[4] The first of these groups, the small firm group, comprises 5,825 manufacturing establishments each with fewer than 20 production workers, on average, between 1988 and 1990. The second group of relatively large businesses comprises 2,451 establishments each of which employs 20 or more production workers. Unlike the domestic, single-plant and foreign/multi-plant subsets, the industrial composition of large and small domestic, single-plant firms are quite similar, and this also holds when we cross-tabulate plants by their age, which we do in the next sub-section.

Again we see that individual plant characteristics impact productivity in similar ways across both these groups. Both groups also benefit from all three types of Marshallian localization economies, with the only statistically significant difference being the advantageous labor market conditions in terms of the right occupational mix of workers—smaller firms benefit more from labor market pooling. Following trends in the previous section, the small firm group, with fewer internal resources, reveals significant reductions in productivity associated with increasing urban size.

---

[4] We utilize the full sample of domestic, single-plant firms, rather than excluding plants in scale-based industries, for this analysis. We do so because the point estimates of the parameters for domestic, single-plant firms in scale-based industries, albeit at times insignificant, were qualitatively similar to those of plants found in industries found outside of this OECD sector. Subsequent analyses will also use this complete subset of plants.

3.4 Domestic, single-plant firms: Plant age

In Table 6, we examine the impacts of plant characteristics and agglomeration economies on relatively new plants. That is, those born in the 1980s in comparison to older plants, those born prior to 1980.[5] The vast majority of plants born in the 1980s were created by new firms (greenfield entrants).[6] In general, we posit that these new plants will have fewer internal resources than older plants and so will be more reliant on agglomeration economies.

Turning immediately to the agglomeration economies, entrants born in the 1980s benefit the most from an appropriate labor mix. The parameter estimate for 1980s plants is significantly larger that that of plants born prior to 1980. Also consistent with our expectations, knowledge spillovers also raise the productivity of new entrants. So for these two measures of Marshallian economies, it is new plants that benefit the most. This is, however, not the case for upstream suppliers.

The productivity of new plant entrants is not significantly related to the local supplier network, while the density of that network raises productivity of plants born prior to the 1980s. In fact, the estimated effect of upstream suppliers on productivity of there plants and foreign/multi-plant firms, with scale-based industries excluded, are about the same. It is the age of the plant that matters, not its size or the nature of its firm. Why might this be so? As we noted in the introduction, new, single-plant domestic firms may initially produce a large proportion of their inputs in-house, but as their production processes become standardized different stages of the production process become more amenable to outsourcing. This is a similar argument to that put forward by Duranton and Puga (2001) that new firms are experimenting with their production processes.

3.5 Domestic, single-plant firms: Plant size and plant age

Finally, we cross tabulate our panel of establishments by plant size and plant age (see Table 7). We do so to both test whether the plant age results are robust to controlling for plant size, but also to test explicitly whether it is new, small plants that benefit the most from knowledge spillovers.

Moving through each Marshallian localization economy in order, labor mix has a particularly strong effect on the productivity of small, new plants. Productivity in these plants appears to be more reliant than others on local labor markets, consistent with our expectations.

The effect of upstream suppliers on productivity is independent of plant size. Its effect is the same across small and large plants when looking across each age class. It is across

[5] We explored dividing plants born prior to 1980 into two groups, those born prior to 1970 and those born in the 1970s. Tests of the regression equations for structural differences indicated that the subsets of plants indicated they were statically indistinguishable.
[6] Regression estimates with only 'green entrants' were qualitatively similar.

plants of different ages that we see a differential effect. Once again, it is only the older plants that benefit from these economies of agglomeration.

The effect of knowledge spillovers on productivity is most apparent for new, small plants. For older, small plants, there is no significant effect, although it is important to keep in mind that if these plants were this small after more than ten years in operation, it is likely that they are lagging plants whose ability to increase productivity may be limited. This is confirmed when we observe that the constant term is negative and significant, suggesting negative multifactor productivity growth for these plants, after controlling for the effect of agglomeration economies and other correlates. Also large plants born in the 1980s do not benefit from knowledge spillovers. But, in contrast, large plants born prior to the 1980s do appear to benefit, albeit the coefficient is marginally significant. So it is new, and in particular, new, small plants that appear to benefit the most from knowledge spillovers.

Finally, we turn to the effect of urbanization economies, which we measure through changes in the population of the urban areas in which plants are located. It is small plants, regardless of age, that appear to be negatively affected by urbanization economies. For larger plants the parameter estimates are positive but not significant. This holds not only for larger single, domestic plants, but also for foreign/multi-plant firms. Why there are negative urbanization economies for smaller plants is open to question. We would expect congestion effects to affect all plants. More promising, perhaps, is a more dynamic explanation. That is, the option value of entry is higher in larger urban areas because of expected growth opportunities for less skilled/experienced entrepreneurs. They are able to survive, even if their productivity growth is lagging, because of expanding local markets. It is important to keep in mind that because we are differencing our data, we are measuring the effect of urbanization economies through the change in urban population. So while we are using the change in population as an estimator of the effect of urbanization economies on productivity, it is important to keep in mind that this is simultaneously a measure of local economic growth.

4. Conclusion

Dense concentrations of economic activity are generally seen as giving rise to increasing returns that may be shared by business units that cluster in space. Theories of the firm and strategic management argue that competitive advantage originates in the development and exploitation of firm-specific assets or capabilities that may be internal or external to the firm. We anticipate that older, larger, foreign-owned and multi-plant firms have greater internal resources upon which they might build advantage. Young, small, domestic and single-plant businesses cannot draw upon these same resources and are more likely to develop strategies for survival that rest on the external resources generated in particular locations. Here we have attempted to identify the sources of these external resources and to examine whether they benefit all businesses or only some.

We show that most manufacturing plants benefit from co-location, but that plants with different characteristics benefit in different ways. Small, and in particular, relatively new plants benefit the most from two of the three Marshallian economies: knowledge spillovers and labor market pooling. Knowledge spillovers are particularly important for new, small businesses. Labor market pooling is positively associated with higher productivity in most types of firms, be they small or large, young or old. The exception is foreign/multi-plant firms outside the scale-based sector. The productivity gains associated with a favorable labor market are strongest for small, new plants. Overall, these results confirm that locational considerations are more important for those establishments unable to generate economies internally.

When we turn to the density of upstream suppliers, we do not observe firms with the smallest capacity to generate internal resources benefitting the most. Rather, older firms, regardless of size or complexity, derive the largest benefit from having upstream suppliers nearby. This is consistent with the argument that older firms, whose production processes have been standardized, are better able to exploit the advantages that a high local density of upstream suppliers provides. We suspect that younger plants have less information about internal versus external production possibilities and/or have not yet learned how to configure their production possibilities in an optimal fashion.

Recent analysis, making use of micro-data, has been able to identify the gains from co-location much more accurately than in the past. Yet, there remains much to be done to understand precisely how and where the benefits of agglomeration are produced and how they are distributed over the economic landscape. For example, how does the quality of the labor force vary in businesses that are agglomerated and in businesses that are not? How does labor mobility between firms account for changes in productivity, and how does the mobility of skilled (and unskilled) workers spill knowledge across firm boundaries? We might also ask how the geographical mobility of individual business units affects performance, particularly the movement of plants into and out of clusters of firms, and how cluster performance is influenced by the movement of particular kinds of firms? These questions speak to the geography of economic performance, to the ways that knowledge and other key resources are generated and captured in place, if only temporarily, and to the processes that control the movement of these resources. Increasingly, we have the data to answer these questions.

References

Acs, Z. and D. Audretsch 1990. *Innovation and Small Firms*. Cambridge, MA: MIT Press.

Baily, M., Hulten, C. and D. Campbell 1992. Productivity dynamics in manufacturing plants. *Brookings Papers on Economic Activity*: Microeconomics: 187-267.

Baldwin, J. 1995. *The Dynamics of Industrial Competition*. Cambridge, MA: Cambridge University Press.

Baldwin, J. 1996. Productivity growth and plant turnover and restructuring in the Canadian manufacturing sector. In D. Mayes (ed.) *Sources of Productivity*. Cambridge: Cambridge University Press, 245-262.

Baldwin, J., L. Bain, R. Dupuy and G. Gellatly. 2000. *Failure Rates for New Canadian Firms: New Perspectives on Entry and Exit*. Ottawa: Statistics Canada.

Baldwin, J., Beckstead, D, Brown, W. and D. Rigby 2008. Agglomeration and the geography of localization economies in Canada. Forthcoming, *Regional Studies* 42: 117-132.

Baldwin, J.R., Brown, W.M. and D.L. Rigby. 2009. Agglomeration economics: Micro-data panel estimates from Canadian manufacturing. *Economic Analysis Research Paper Series*. Paper no. 049. Ottawa: Statistics Canada.

Baldwin, J.R. and W. Gu. 2003. Participation in export markets and productivity performance in Canadian manufacturing. *Canadian Journal of Economics* 36(3): 634-657.

Baldwin, J.R. and W. Gu. 2005. Global Links: Multinationals, Foreign Ownership and Productivity Growth in Canadian Manufacturing. *The Canadian Economy in Transition*. No. 9. Ottawa: Statistics Canada.

Baldwin, J.R. and M. Rafiquzzaman. 1994. *Structural Change in the Canadian Manufacturing Sector (1970-1990)*. Analytical Studies Branch Research Paper Series. Catalogue no. 11F0019MIE1994061. Ottawa: Statistics Canada.

Barney, J. 1991. Firm resources and sustained competitive advantage. Journal of Management 17: 99-120.

Carlson, B. and G. Eliasson 1994. The nature and importance of economic competence. *Industrial and Corporate Change* 3: 687-711

Carruth, A., A. Dickerson, and A. Henley. 2000. What do we know about investment under uncertainty? *Journal of Economic Surveys*. 14(2): 119-153.

Caves, R.E. 1998. Industrial organization and new findings on the turnover and mobility of firms. *Journal of Economic Literature*. 36: 1947-1982.

Caves, R. and T.A. Pugel 1980. ‘Intraindustry differences in conduct and performance. *Monograph Series* 1980-2. NY: Graduate School Bus. Admin., NYU.

Coase, R. 1937. The nature of the firm. *Economica* 4: 386-405.

Davies, S. and B. Lyons 1991. Characterising relative performance: the productivity advantage of foreign-owned firms in the UK. *Oxford Economic Papers* 43: 684-595.

Davis, S., Haltiwanger, J. and S. Schuh 1996. *Job Creation and Destruction*. Cambridge MA: MIT Press.

Dimelis, S. and H. Louri 2002. Foreign ownership and production efficiency: a quantile regression approach. *Oxford Economic Papers* 54:449-469.

Dumais, G. Ellison, G. and E. Glaeser 1997. Geographic concentration as a dynamic process. Center for Economic Studies Working Paper 98-3. Center for Economic Studies, US Bureau of the Census. Washington, DC.

Duranton, G. 2007. California dreamin': the feeble case for cluster policies. Unpublished manuscript, Department of Economics, University of Toronto.

Duranton, G. and D. Puga. 2001 Nursery cities: Urban diversity, process innovation, and the life cycle of products. *American Economic Review*. 91(5): 1457-1477.

Gerking, S, 1994. Measuring productivity growth in U.S. regions: a survey. *International Regional Science Review* 16: 155-185.

Henderson, V. 2003. Marshall's scale economies. *Journal of Urban Economics* 53: 1-28.

Jacobs, J. 1969. *Economy of Cities*. New York: Vintage.

Jaffe, A, M. Trajtenberg and R. Henderson. 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. *The Quarterly Journal of Economics.*108(3): 577–598.

Jovanovic, B. 1982. Selection and the evolution of industry. *Econometrica*. 50(3): 649-670.

Kang, D. and A. Sorenson. 1999. Ownership information and firm performance. *Annual Review of Sociology* 25: 121-144.

Kleinknecht, A. 1989. Firm size and innovation: observations in Dutch manufacturing industry. *Small Business Economics* 1: 215-222.

Krugman, P. 1991. Increasing returns and economic geography. *The Journal of Political Economy.* 99(3): 483–499.

Marshall, A. 1920. *Principles of Economics* (8th ed.). London: Macmillan.

Melitz, M. 2003. The impact of trade on intra-industry reallocation and aggregate industry productivity. *Econometrica*. 71(6): 1695-1725.

Moomaw, R. 1983. Spatial productivity variations in manufacturing: a critical survey of cross-sectional analyses. *International Regional Science Review* 8: 1-22.

Moulton, B. 1990. An illustration of the pitfall in estimating the effects of aggregate variables on micro-units. *The Review of Economics and Statistics*. 72(2): 334-338.

Nelson, R. and S. Winter 1982. *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.

Organisation for Economic Co-operation and Development (OECD). 1987. *Structural Adjustment and Economic Performance.* Paris: Organisation for Economic Co-operation and Development.

Penrose, E. 1958. *The Theory of the Growth of the Firm*. New York: Wiley.

Piore, M and C. Sable. 1984. *The Second Industrial Divide: Possibilities for Prosperity*. New York: Basic Books.

Porter, M. 1985. *Competitive Advantage*. New York: Free Press.

Prahalad, C. and G. Hamel 1990. The core competence of the corporation. *Harvard Business Review* (May-June): 79-91.

Pratten, C. 1991. *The Competitiveness of Small Firms*. Cambridge, MA: Cambridge University Press.

Rigby, D. and J. Essletzbichler 2002. Agglomeration and productivity differences in US cities. *Journal of Economic Geography* 2: 407-432.

Rigby, D.L. and J. Essletzbichler. 2006. Technological variety, technological change and a geography of production techniques. *Journal of Economic Geography* 6: 71-89.

Rosenthal, S. and W. Strange 2001. The determinants of agglomeration. *Journal of Urban Economics* 50: 191-229.

Rosenthal, S. and W. Strange 2003. Geography, industrial organization and agglomeration. *Review of Economics and Statistics* 85: 377-393.

Rosenthal, S. and W. Strange 2004. Evidence on the nature and sources of agglomeration economies. In Henderson, V. and J. Thisse. (eds.) *Handbook of Regional and Urban Economics*, vol. 4. Amsterdam: North-Holland, 2119-2171.

Saxenian, A. (1994): *Regional Advantage*. Cambridge, MA: Harvard University Press.

Scherer, F., Beckenstein, A., Kaufer, E. and R., Murphy 1975.*The Economics of Multi-Plant Operation: An International Comparisons Study*. Cambridge, MA: Harvard University Press.

Scott. A. 1986. Industrial organization and location: division of labor, the firm, and spatial process. *Economic Geography* 63: 215-231.

Scott, A. 1988. *Metropolis: From the Division of Labor to Urban Form*. Berkeley: University of California Press.

Smith, A. 1776. *The Wealth of Nations: Books I-II*. London: Penguin Group.

Stigler, G. 1951. The division of labor is limited by the extent of the market. *Journal of Political Economy* 59: 185-193.

Storper, M. 1997. *The Regional World: Territorial Development in a Global Economy*. New York: Guilford.

Sweeney, S. and E. Feser 1998. Plant size and clustering of manufacturing activity. *Geographical Analysis* 30: 45-64.

Teece, D. and G. Pisano 1994. The dynamic capabilities of firms: an introduction. *Industrial and Corporate Change* 3: 537-556.

Wernerfelt, B. 1984. A resource based view of the firm. *Strategic Management* 5: 171-180

Williamson, O. 1975. *Markets and Hierarchies*. New York: The Free Press.

Table 1. Description of variables

Variables	Description
Plant Characteristics	
Labor productivity	Value added divided by the number of production workers in the plant
Profit to value added ratio	Value added minus wages divided by value added
Production workers	Number of production workers in the plant
Non-production to production worker ratio	Number of non-production workers divided by the number of production workers in the plant
Place Characteristics	
Labor mix	Defined in Section 2 of the paper
Local density of upstream suppliers	Defined in Section 2 of the paper
Plants within 5 km	Number of plants within 5 km in the same 2-digit SIC
Population	Population of the census metropolitan area or census agglomeration where the plant is located

Table 2. Descriptive statistics: panel of plants present 1989-1999

	1989				1999			
	Mean	Median	Std Dev	Obs	Mean	Median	Std Dev	Obs
Plant Characteristics								
Labor productivity	82,775	57,910	113,862	11,323	87,298	55,644	112,083	11,323
Profit to value added ratio	0.58	0.58	0.16	11,323	0.58	0.58	0.18	11,323
Production workers	53	15	230	11,323	59	21	198	11,323
Non-production to production worker ratio	0.46	0.37	0.52	11,323	0.42	0.33	0.53	11,323
Place Characteristics								
Labor mix	5.1	4.3	2.4	3,204	5.5	4.8	2.5	3,204
Local density upstream suppliers	6.0	1.2	24.5	3,204	6.9	1.2	29.0	3,204
Plants within 5 km	41	17	74	11,323	31	13	54	11,323
Population	159,220	37,932	463,249	138	178,011	39,992	535,224	138

Source: Statistics Canada, Annual Survey of Manufactures, 1989 and 1999.

Table 3. Labor productivity as a function of plant and place characteristics: General model results

	All plants, 1989-1999	
Change in plant Characteristics	Coeff.	*p*-value
Profit to value added ratio	0.750	<0.001
Production workers	-0.109	<0.001
Non-production to production workers	0.384	<0.001
Multi-plant status (reference = single plant)	0.086	0.002
Foreign-plant status (reference = domestic)	0.094	<0.001
Change in place Characteristics		
Labor mix	-0.508	<0.001
Local density upstream suppliers	0.100	<0.001
Plants within 5km	0.021	<0.001
Population	-0.149	<0.001
Constant	0.044	<0.001
# obs.	11,323	
R^2	0.466	
Root MSE	0.430	

Notes: All variables are log transformed, with the exception of the binary variables, and differenced between the years 1989 and 1999. In all regressions, standard errors are corrected for heteroskedasticity and the potential correlation of errors within census metropolitan areas and census agglomerations.
Source: Statistics Canada, Annual Survey of Manufactures, 1989 and 1999.

Table 4. Labor productivity as a function of plant and place characteristics: Domestic, single-plant and foreign/multi-plant firms

	Single-Plant		Foreign/Multi-Plant	
	Coeff	*p*-value	Coeff	*p*-value
Change in Plant Characteristics				
Profit to value added ratio	0.678	<0.001	0.989	<0.001
Production workers	-0.102	<0.001	-0.120	<0.001
Non-production to production worker ratio	0.424	<0.001	0.372	<0.001
Multi-plant status	0.120	0.011	0.057	0.002
Foreign-plant status	-0.043	0.607	0.089	<0.001
Change in Place Characteristics				
Labor mix	-0.510	<0.001	-0.439	<0.001
Local density upstream suppliers	0.059	0.017	0.170	<0.001
Plants within 5 km	0.019	0.002	0.026	0.031
Population	-0.157	0.057	-0.002	0.990
Constant	0.031	0.043	0.063	0.001
# obs.	8,276		3,047	
R^2	0.477		0.431	
Root MSE	0.406		0.455	

Note: The determination of multi-plant and foreign-plant is made in 1999. Over the period 1989 to 1999, foreign-plant and multi-plant status can change, and so multi-plant and foreign-plant status also appears as an independent variables. All variables are log transformed, with the exception of the binary variables, and differenced between the years 1989 and 1999. In all regressions, standard errors are corrected for heteroskedasticity and the potential correlation of errors within census metropolitan areas and census agglomerations.
Source: Statistics Canada, Annual Survey of Manufactures, 1989 and 1999.

Table 4a. Labor productivity as a function of plant and place characteristics: Single-plant and foreign/multi-plant firms (less Scale-based industries)

	Single-Plant		Foreign/Multi-Plant	
	Coeff	*p*-value	Coeff	*p*-value
Change in Plant Characteristics				
Profit to value added ratio	0.708	<0.001	1.095	<0.001
Production workers	-0.102	<0.001	-0.101	<0.001
Non-production to production worker ratio	0.364	<0.001	0.437	<0.001
Multi-plant status	0.188	<0.001	0.074	0.002
Foreign-plant status	-0.040	0.638	0.095	<0.001
Change in Place Characteristics				
Labor mix	-0.372	<0.001	-0.095	0.177
Local density upstream suppliers	0.050	0.088	0.126	<0.001
Plants within 5 km	0.017	0.011	0.005	0.756
Population	-0.113	0.086	0.192	0.111
Constant	0.049	<0.001	0.068	0.002
# obs.	6,529		2,249	
R^2	0.452		0.495	
Root MSE	0.408		0.464	

Note: The determination of multi-plant and foreign-plant is made in 1999. Over the period 1989 to 1999, foreign-plant and multi-plant status can change, and so multi-plant and foreign-plant status also appears as an independent variables. All variables are log transformed, with the exception of the binary variables, and differenced between the years 1989 and 1999. In all regressions, standard errors are corrected for heteroskedasticity and the potential correlation of errors within census metropolitan areas and census agglomerations.
Source: Statistics Canada, Annual Survey of Manufactures, 1989 and 1999.

Table 4b. Labor productivity as a function of plant and place characteristics: Domestic, single-plant and foreign/multi-plant firms (Scale-based industries)

	Single-Plant		Foreign/Multi-Plant	
	Coeff	*p*-value	Coeff	*p*-value
Change in Plant Characteristics				
Profit to value added ratio	0.567	<0.001	0.773	<0.001
Production workers	-0.096	<0.001	-0.166	0.002
Non-production to production worker ratio	0.657	<0.001	0.096	0.467
Multi-plant status	-0.156	0.054	0.011	0.756
Foreign-plant status	-0.176	0.451	0.060	0.115
Change in Place Characteristics				
Labor mix	-0.463	<0.001	-0.621	<0.001
Local density upstream suppliers	0.086	0.160	0.272	<0.001
Plants within 5 km	0.012	0.390	0.056	0.037
Population	-0.324	0.077	-0.221	0.411
Constant	-0.015	0.696	0.063	<0.001
# obs.	1,747		798	
R^2	0.513		0.408	
Root MSE	0.385		0.476	

Note: The determination of multi-plant and foreign-plant is made in 1999. Over the period 1989 to 1999, foreign-plant and multi-plant status can change, and so multi-plant and foreign-plant status also appears as an independent variable. All variables are log transformed, with the exception of the binary variables, and differenced between the years 1989 and 1999. In all regressions, standard errors are corrected for heteroskedasticity and the potential correlation of errors within census metropolitan areas and census agglomerations.
Source: Statistics Canada, Annual Survey of Manufactures, 1989 and 1999.

Table 5. Labor productivity as a function of plant and place characteristics: Domestic, single-plant firms by plant size

	Plant size: Less than 20		Plant size: 20 or more	
	Coeff	*p*-value	Coeff	*p*-value
Change in Plant Characteristics				
Profit to value added ratio	0.604	<0.001	0.861	<0.001
Production workers	-0.100	<0.001	-0.074	<0.001
Non-production to production worker ratio	0.464	<0.001	0.358	<0.001
Multi-plant status	0.146	0.033	0.141	<0.001
Foreign-plant status	0.150	0.226	-0.103	0.246
Change in Place Characteristics				
Labor mix	-0.525	<0.001	-0.367	<0.001
Local density upstream suppliers	0.044	0.044	0.074	0.064
Plants within 5 km	0.021	0.004	0.021	0.073
Population	-0.251	0.032	0.039	0.777
Constant	0.018	0.314	0.060	0.003
# obs.	5,825		2,451	
R^2	0.473		0.470	
Root MSE	0.406		0.389	

Notes: Small plants are defined as employing fewer than 20 production workers and large plants are defined as employing 20 or more production workers. All variables are log transformed, with the exception of the binary variables, and differenced between the years 1989 and 1999. In all regressions, standard errors are corrected for heteroskedasticity and the potential correlation of errors within census metropolitan areas and census agglomerations.
Source: Statistics Canada, Annual Survey of Manufactures, 1989 and 1999.

Table 6. Labor productivity as a function of plant and place characteristics: Domestic, single-plant firms by decade of birth

	Pre-1980s		1980s	
	Coeff	*p*-value	Coeff	*p*-value
Change in Plant Characteristics				
Profit to value added ratio	0.706	<0.001	0.661	<0.001
Production workers	-0.126	<0.001	-0.101	<0.001
Non-production to production worker ratio	0.419	<0.001	0.418	<0.001
Multi-plant status	0.046	0.331	0.228	0.003
Foreign-plant status	0.016	0.898	-0.335	0.217
Change in Place Characteristics				
Labor mix	-0.444	<0.001	-0.556	<0.001
Local density upstream suppliers	0.104	<0.001	0.035	0.300
Plants within 5 km	0.002	0.882	0.026	0.018
Population	-0.153	0.173	-0.211	0.026
Constant	-0.007	0.669	0.033	0.221
# obs.	3,326		4,950	
R^2	0.509		0.466	
Root MSE	0.373		0.424	

Notes: Plants are cross-classified based on their date of birth, pre-1980 and post-1980. All variables are log transformed, with the exception of the binary variables, and differenced between the years 1989 and 1999. In all regressions, standard errors are corrected for heteroskedasticity and the potential correlation of errors within census metropolitan areas and census agglomerations.
Source: Statistics Canada, Annual Survey of Manufactures, 1989 and 1999.

Table 7. Labor productivity as a function of plant and place characteristics: Domestic, single-plant firms by plant size and decade of birth

	Plant size: Less than 20				Plant size: 20 or more			
	pre-1980s		1980s		pre-1980s		1980s	
	Coeff	p-value	Coeff	p-value	Coeff	*p*-value	Coeff	*p*-value
Plant Characteristics								
Profit to value added ratio	0.628	<0.001	0.594	<0.001	0.830	<0.001	0.876	<0.001
Production workers	-0.140	<0.001	-0.098	<0.001	-0.092	<0.001	-0.063	0.001
Non-production to production worker ratio	0.408	<0.001	0.468	<0.001	0.434	<0.001	0.256	0.059
Multi-plant status	0.088	0.518	0.173	0.045	0.078	0.052	0.303	0.027
Foreign-plant status	0.288	0.071	-0.036	0.715	-0.032	0.728	-0.793	0.054
Place Characteristics								
Labor mix	-0.436	<0.001	-0.564	<0.001	-0.341	<0.001	-0.396	<0.001
Local density upstream suppliers	0.089	0.007	0.024	0.421	0.123	0.002	0.042	0.441
Plants within 5 km	-0.015	0.270	0.031	0.007	0.022	0.075	0.013	0.327
Population	-0.278	0.057	-0.281	0.043	0.002	0.989	0.062	0.774
Constant	-0.038	0.028	0.045	0.056	0.034	0.192	0.111	<0.001
# obs.	1,914		3,911		1,412		1,039	
R^2	0.525		0.458		0.479		0.470	
Root MSE	0.364		0.422		0.372		0.403	

Note: Plants are cross classified by size and decade of birth. All variables are log transformed, with the exception of the binary variables, and differenced between the years 1989 and 1999. In all regressions, standard errors are corrected for heteroskedasticity and the potential correlation of errors within census metropolitan areas and census agglomerations.
Source: Statistics Canada, Annual Survey of Manufactures, 1989 and 1999.