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Who Benefits from Agglomeration?

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RIGBY D. L. and BROWN W. M. Who benefits from agglomeration?, *Regional Studies*. Theories of the firm and strategic management argue that competitive advantage originates in the development and exploitation of assets or capabilities that may be internal or external to the firm. It might be anticipated 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 their characteristics? This question is examined using plant-level, longitudinal, micro-data from the Canadian manufacturing sector. It is shown that most manufacturing plants benefit from co-location, but that plants with different characteristics benefit in different ways.

Agglomeration Localization economies Panel data

RIGBY D. L. and BROWN W. M. 谁受益于集群？*区域研究*。企业与策略管理的理论主张竞争优势来自于发展与运用内在或外在于企业的资产或潜能。一般认为历史较为悠久、较大型或是外资及拥有众多工厂的企业，会较新成立、小型、国内与单一工厂的企业更容易运用内部的资源。集群效益对企业创立而言，会因企业的特色而有所差异吗？本研究透过加拿大制造业部门工厂层级、纵向的小型资料探讨上述问题。研究显示，大多数的制造业工厂受益于座落在同一区位，但有着不同特征的工厂受益的方式则有所不同。

集群 在地化经济 面板数据（平行数据）

RIGBY D. L. et BROWN W. M. Qui profite de l'agglomération?, *Regional Studies*. Les théories de l'entreprise et de l'organisation stratégique affirment que l'avantage compétitif s'explique par le développement et l'exploitation des actifs ou des capacités qui pourraient s'avérer intérieurs ou extérieurs à l'entreprise. On pourrait s'attendre à ce que les entreprises plus anciennes, plus grandes, à capitaux étrangers et à établissements multiples fassent appel plus facilement à des ressources internes que ne le font les petites entreprises naissantes nationales à un seul établissement. Est-ce que les avantages de l'agglomération varient d'une entreprise à une autre suivant leurs caractéristiques? On le remet en question auprès du secteur manufacturier canadien à partir des données longitudinales microéconomiques au niveau des établissements. On démontre que la plupart des usines de production profitent de la colocalisation mais que les établissements en profitent de manières différentes suivant leurs caractéristiques.

Agglomération Économies d'agglomération Données par panel

RIGBY D. L. und BROWN W. M. Wer profitiert von einer Agglomeration?, *Regional Studies*. Den Theorien des Firmen- und strategischen Managements zufolge liegen Wettbewerbsvorteile in der Entwicklung und Nutzung von Vorzügen oder Fähigkeiten begründet, die firmeninterner oder externer Natur sein können. Dementsprechend stünde zu erwarten, dass ältere und größere Firmen in ausländischem Besitz mit mehreren Werken interne Ressourcen stärker nutzen als junge, kleine und einheimische Firmen mit nur einem Werk. Fällt der Nutzen einer Agglomeration je nach den Merkmalen der jeweiligen Firma unterschiedlich aus? Diese Frage wird mit Hilfe von longitudinalen Mikrodaten auf Werksebene des produzierenden Sektors in Kanada untersucht. Wie sich zeigt, profitieren die meisten produzierenden Betriebe von einem gemeinsamen Standort, wobei sich aber Betriebe mit unterschiedlichen Merkmalen unterschiedlich verhalten.

Agglomeration Lokalisationsökonomien Paneldaten

RIGBY D. L. y BROWN W. M. ¿Quién se beneficia de una aglomeración?, *Regional Studies*. Las teorías de la gestión estratégica y comercial sostienen que la ventaja competitiva se origina en el desarrollo y la explotación de los bienes o las capacidades que pueden ser internas o externas a la empresa. Podríamos esperar que las empresas más antiguas, más grandes, de propiedad extranjera y de varias filiales obtienen recursos internos con más facilidad que las empresas recientes, pequeñas, nacionales y de una sola filial. ¿Varían los beneficios de una aglomeración entre los establecimientos comerciales en función de sus características? Analizamos esta cuestión con ayuda de datos micro longitudinales a nivel de filiales de empresas del sector manufacturero de Canadá. Demostramos que la mayoría de las filiales manufactureras se benefician de la ubicación conjunta pero las filiales con diferentes características se benefician de formas diversas.

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Aglomeración Economías de localización Datos de panel

JEL classifications: L6, O14, R12

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. When the structure of production within industries and across economies is examined, one cannot fail to be struck by the heterogeneity that is observed. At least since the work of PENROSE (1958) and CYERT and MARCH (1963), such variety has been employed to understand firm performance and strategy (for a recent formal treatment, see MELITZ, 2003). The existence of heterogeneity acknowledges that firm-specific assets – management skills, organization, behavioural 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 promoted by PORTER (1985). A resource-based model of firm performance is generalized by PRAHALAD and HAMEL (1990) in their discussion of firm competence and capabilities. KOGUT and ZANDER (1992) emphasized the critical role of knowledge within this framework, which 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; SAXENIAN, 1994; BALDWIN, 1995; STORPER, 1997; RIGBY and ESSLETZBICHLER, 2006; BOSCHMA and FRENKEN, 2011). Most of this research focuses on readily observable dimensions of business variability such as age, size, technology, location, organizational structure and ownership status. While these variables by no means capture the full range of firm characteristics that shape performance, they serve to highlight the importance of variety and hint at the range of competitive strategies possible. What is also clear from much of the work above is that firms search for efficiency in many different ways. A basic distinction can be drawn between those businesses that have the internal capacity to generate competitive advantage and those that seek advantage through co-location with others.

There is abundant evidence that many firms cluster together in space. In part, this may be explained by 'first nature geography' and by the desire of firms in natural resource processing sectors to locate close to their raw material sources. ELLISON and GLAESER (1999) estimated that at least 20% of firm co-location in the United States is driven by resource availability. Businesses outside the resource sector also tend to agglomerate, presumably because of the benefits they derive from close spatial association with one another. Indeed, ELLISON and GLAESER (1997) reported evidence of clustering across 446 of 459 four-digit Standard Industrial Classification (SIC) industries. While most reports of the agglomeration of economic activity tend to be rather crude, rigorous tests of the spatial clustering of establishments using distance-based methods were provided by FESER and SWEENEY (2000), MARCON and PUECH (2003), and DURANTON and OVERMAN (2005, 2008).

Two frameworks that help explain agglomeration were outlined by MARSHALL (1920) and JACOBS (1969). MARSHALL (1920) was long interested in the development of industry-towns, local specialization in labour skills, buyer–supplier networks, and how knowledge spillovers generate and sustain place-specific competitive advantages within industrial sectors. JACOBS (1969), by contrast, was a champion of diversity, imagining the city as a dense assemblage of different knowledge pools, providing fertile ground out of which flow innovation and growth. More formal treatments of aggregate increasing returns, generated by the gains from a wider variety of intermediate inputs, from labour specialization, and by labour pooling were offered by ABDEL-RAHMAN and FUJITA (1990), BECKER and HENDERSON (2000), and KRUGMAN (1991), respectively. DURANTON and PUGA (2001) developed a model of an urban system comprising both diverse and specialized urban centres. They linked process innovation in new firms to the diversity of existing production arrangements within 'nursery cities', while specialized urban centres offer mature firms with fixed techniques cost reductions through sharing intermediate suppliers. DURANTON and PUGA (2004) provided a detailed overview of these arguments.

Early empirical research sought evidence of agglomeration through the influence of industry scale and population size, the urban proportion of state population, or employment density on productivity levels or productivity growth (SVEIKAUSKUS, 1975; MOOMAW, 1981; BEESON, 1987; MOOMAW and WILLIAMS, 1991; CICCONE and HALL, 1996). More sophisticated efforts to separate the influence of industry specialization and diversity, in dynamic form Marshall–Arrow–Romer (MAR) and Jacobs externalities, were offered by GLAESER *et al.* (1992) and HENDERSON *et al.* (1995). GLAESER *et al.* (1992) examined employment growth for a sample of large industries in US cities between 1956 and 1987. They reported that local competition and industrial diversity accelerate growth, while regional industrial specialization has no significant effect. In line with JACOBS (1969), they hypothesized that knowledge spillovers flow between industries rather than within them. HENDERSON *et al.* (1995) reported results from an analysis of urban employment growth in five mature, capital-goods sectors and in three high-technology sectors between 1970 and 1987. MAR externalities exerted a positive and significant influence on employment growth in the mature industries, while MAR and Jacobs externalities drove employment growth in new, high-technology industries. These results are broadly consistent with HENDERSON (2003). A huge literature that tries to disentangle the relative importance of localization and urbanization economies has followed. BEAUDRY and SCHIFFAUEROVA (2009) provided a comprehensive review.

Both GLAESER *et al.* (1992) and HENDERSON *et al.* (1995) showed that the life cycle of products/industries is critical in determining whether (and what kinds of) agglomeration externalities enhance economic fortunes within urban industrial groupings. In this respect they provided evidence consistent with the nursery cities model of DURANTON and PUGA (2001). MCCANN and FOLTA (2008) pushed this argument further, questioning whether all firms benefitted equally from spatial clustering. They developed a knowledge-based view of the firm, after KOGUT and ZANDER (1992), and hypothesized that the learning ability of firms and their organizational flexibility would moderate the influence of agglomeration externalities. Evidence from a sample of US biotechnology firms confirms that younger firms and those with larger knowledge stocks gain most from cluster membership. ALCACER (2006) and KNOBEN *et al.* (2010) advanced related arguments about firm characteristics and agglomeration; while POTTER and WATTS (2011) and NEFFKE *et al.* (2011, 2012) examined agglomeration within an explicitly evolutionary framework, showing how the life cycle of industries regulates the form and even the existence of benefits from co-location.

Running alongside the theoretical search for the micro-foundations of agglomeration, newer empirical papers seek not only to differentiate localization and urbanization economies, but also to distinguish the precise mechanisms through which returns to agglomeration are generated. DUMAIS *et al.* (1997), RIGBY and ESSLETZBICHLER (2002), ROSENTHAL and STRANGE (2001, 2003), and BALDWIN *et al.* (2008, 2010) all keyed on MARSHALL (1920), seeking evidence of the relative benefits of labour pooling, buyer–supplier networks, and knowledge spillovers across different industries and regions.

The present paper responds to the recent calls of MCCANN and FOLTA (2008, 2011) and KNOBEN *et al.* (2010) to explore how different types of firms benefit from agglomeration. The work advances the research on agglomeration showing, first, that not all firms gain from co-location and, second, that businesses with different internal capabilities capture different forms of geographical externalities. For contrasting groups of firms, panel models are employed and firm-level labour productivity is regressed on both firm-specific and place-specific characteristics. Using a panel specification allows one to control for plant-level unobserved heterogeneity that might exert a confounding influence in many of the cross-sectional studies reported above. In this regard, the results are potentially more robust than those recently offered by KNOBEN *et al.* (2010). The analysis also differs from that of MCCANN and FOLTA (2011) in that it explores how different mechanisms of agglomeration exert asymmetric effects across plants/firms with varying characteristics. The place-specific characteristics examined represent varying types of agglomeration economies after MARSHALL (1920) and JACOBS (1969). The present paper differentiates the impacts of those externalities on small plants versus large plants, on establishments that are part of multi-unit and foreign firms, and those that comprise single-plant firms. It distinguishes how different economies of agglomeration benefit younger plants from older plants, and how place-specific attributes influence the performance of plants born to incumbent firms vis-à-vis those born to new firms. The empirical analysis focuses on Canadian manufacturing establishments operating over the period 1989–1999.

The paper is structured as follows. The second section discusses the sources of the data, the variables employed and the modelling strategy adopted. The results of the analysis are presented in the third section, beginning with a brief overview of past results generated from cross-sectional and panel models. 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 identified. The fourth section concludes with a summary of the findings and directions for future work.

DATA, METHODS AND BACKGROUND FINDINGS

The variables used in the econometric models were readily separated into two groups: characteristics of

Table 1. Description of variables

Variables	Description
Plant characteristics	
Labour 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	
Labour mix	Defined in the second section of the paper
Local density of upstream suppliers	Defined in the second section of the paper
Plants within 5 km	Number of plants within 5 km in the same two-digit Standard Industrial Classification (SIC)
Population	Population of the census metropolitan area (CMA) or census agglomeration (CA) where the plant is located

individual business units or plants; and characteristics of particular locations. Table 1 lists the variables in the models and provides brief descriptions. The plant-level information was developed from the Canadian Annual Survey of Manufactures (ASM) for 1989 and 1999. The panel techniques employed require observations on individual establishments for at least two years.

The place-specific data were derived from the ASM, from the Household Censuses in 1991 and 2001, and from Canadian input–output accounts. All data were geo-coded 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 in British Columbia, 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.

Plant-firm specific characteristics

The dependent variable in the analysis was labour productivity, measured as value added divided by the number of production workers. For each plant, value added and production workers were measured at their mean across three years. For 1989, these were the two adjacent years. Owing to the fact that 1999 is the last year on the longitudinal file, the mean level of value added and production workers for 1999 and the two previous years were taken. Value added was measured in constant Canadian dollar terms using an industry-level deflator. Three-year means for all plant-level characteristics were utilized 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 (for example, because of labour hoarding). Using three-year means helps to reduce the effect of this variability on the estimates.

Labour productivity was 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 labour productivity will be higher in plants that are larger in size because they can take advantage of various forms of scale economies (for example, those that result from longer production runs). Plant size was measured by the number of production workers. The productivity of production workers was also expected to rise as the amount of machinery and equipment with which they work increases. The authors wanted to capture the effect of mechanization with a variable measuring the capital to labour ratio. Unfortunately, capital stock data were unavailable at the plant level and so a proxy variable was used to represent the capital to labour 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, labour productivity is expected to be positively associated with the ratio of non-production to production workers.

Two types of firm characteristics were measured in the model. First, it was identified whether the plant was part of a multi-establishment firm. This is a binary variable where the reference group is single-plant firms. The expectation, informed by considerable past research, is that multi-plant firms will be more productive than single-plant firms (BAILY *et al.*, 1992). 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 analyse information that can improve management practices and thus raise productivity. Second, it was identified 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. Note that the set of plant/firm controls detailed above is considerably richer than that found in most empirical studies of agglomeration.

Place-specific characteristics

The agglomeration variables developed in the productivity model, the local density of buyer–supplier networks, labour pooling and knowledge spillovers can all be traced back to MARSHALL (1920). The paper outlines below the variables employed to measure these Marshallian economies, along with indicators used to capture other types of agglomeration economies.

An area's labour pool supports the needs of a particular industry if the occupational distribution of an area corresponds to the distribution required by that industry. The labour 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 are 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 forty-seven occupations at the two-digit level using the 1991 Standard Occupational Classification (SOC), which is used for the 1991 and 2001 censuses. It is anticipated 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, a negative coefficient on this variable is expected in the following regressions.

The benefits of the local density of buyer–supplier networks were calculated 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 to a focus on upstream activity only. To measure local variation in the density of upstream connections for each four-digit industry and for each CMA in Canada, an upstream supplier-weighted location quotient was identified:

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

The term in parentheses is a location quotient for each industry i in metro area m. The location quotients were calculated using the total value of shipments (TVS) of each industry and the degree to which a particular city is specialized in an industry was measured. A value less than 1 would indicate an industry is under-represented; a value greater than 1 would indicate the industry was over-represented. The term 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 were estimated from inter-industry transactions and derived from the Canadian national input–output tables. The subscripts i and j refer to each of the 236 four-digit SIC manufacturing industries; m refers to a specific metropolitan area; and n refers to the nation. Note that the influence of the own industry was also removed 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 labour productivity in plants in industry j within those areas.

Note that because the labour 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 noted above, this necessitates adjustment of the standard errors in the model, for as MOULTON (1990) demonstrated, they can be biased when merging aggregate variables across micro-units of observation. In all the regressions below, standard errors are clustered by metropolitan area.

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) claimed, for they do not leave a paper trail. JAFFE *et al.* (2003) disagreed, 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) showed 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. The present authors spent some time examining the influence of local own- and cross-industry patents, in industries of use and make, on plant labour productivity, but were discouraged by the results that were broadly insignificant. The 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, this paper follows HENDERSON (2003) and ROSENTHAL and STRANGE (2003) and uses counts/densities of plants in specific geographical areas as a proxy for intra-industry knowledge spillovers. It exploits data on the latitude and longitude of individual plants to define concentric circles of varying distances around each one, within which the number of plants within the same two-digit (SIC) industry are counted. Past research has indicated that the productivity of an individual plant is influenced by the number of own-industry plant neighbours that are located within 5 km. Plant counts within concentric circles that are more than 5 km from a specific plant have no general influence on productivity. It is unclear why 5 km represents a significant distance threshold, though this does confirm other research that shows knowledge spillovers are highly localized (ROSENTHAL and STRANGE, 2003).

Metropolitan population size was added to the model as a proxy for urbanization economies that are not captured elsewhere in the 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 which are thought to help incubate new firms (DURANTON and PUGA, 2001). Large population centres also create the demand for infrastructure that can enhance the productivity of all industries. At the same time, congestion costs suggest that there are limits to the net benefits of urban size.

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:

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

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 rewritten such that labour productivity (LP) is a function of capital and labour inputs:

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

The ASM does not provide plant-level estimates of capital and therefore a proxy ($\hat{K}$) is needed. $\hat{K}$ is estimated from the following expression for profit (π):

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

where r is the rate of return on capital. The profit to labour ratio $r\hat{K}/L_{\text{pw}}$ can be substituted into equation (2), and if it is assumed that the rate of return is equalized across plants, then:

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

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 the proxy of the capital to labour ratio and the measure of productivity are very highly correlated because both contain value added in their numerator and labour in their denominator. To address this problem, a slightly different model is estimated. Multiplying equation (1) by VA^{α}/VA^{α} yields:

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

which implies:

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

Labour productivity can then be defined as:

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

where:

$$\tilde{A} = A^{1/(1-\alpha)} \quad \text{and}$$

$$\tilde{r} = r^{\alpha/(1-\alpha)}$$

Equation (7) can be used to solve for the values of α, β and σ. Hence, despite the fact that the effect of the capital to labour ratio on productivity is not examined directly, an estimate can be recovered.

In order to estimate (7), a multiplicative error term ε is included and its logarithmic transformation is used:

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

where:

$$\delta_1 = \frac{\alpha}{1-\alpha},\ \delta_2 = \frac{\sigma}{1-\alpha},\ \text{and}\ \delta_3 = \frac{\beta+\alpha+\sigma-1}{1-\alpha}$$

Note also that i indexes plants, j indexes firms, and k indexes geographic locations.

Throughout the analysis it is assumed that other characteristics of the firm and the characteristics of the location of the firm are transmitted through the multi-factor productivity term $\tilde{A}$. Hence:

$$\ln \tilde{A} = a + \varphi' \ln \mathbf{X}_j + \theta' \ln \mathbf{G}_k + \gamma_i + \eta_j + \lambda_k \quad (9)$$

where $\mathbf{X}$ is a vector of characteristics related to the firm that controls plant i; and $\mathbf{G}$ is a vector of characteristics that are associated with location k. These locational characteristics are either related 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 the 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, equation (9) is substituted into equation (8) and the first difference across periods is taken:

$$\begin{aligned} \ln \Delta LP_{ijk} = {} & \Delta a + \delta_1 \Delta \ln \frac{\hat{K}_i}{VA_i} + \delta_2 \Delta \ln \frac{L_{\mathrm{npw},i}}{L_{\mathrm{pw},i}} \\ & + \delta_3 \Delta \ln L_{\mathrm{pw},i} + \varphi^t \Delta \ln \mathbf{X}_j \\ & + \theta^t \Delta \ln \mathbf{G}_k + \Delta \ln \varepsilon_i \end{aligned} \quad (10)$$

In so doing, the plant-, firm- and location-level fixed effects that might be correlated with other independent variables are eliminated. For simplicity, it is assumed that the rate of return on capital is constant within plants across the two time periods and so this term is dropped in equation (10). Elsewhere (BALDWIN *et al.*, 2010) instrumental variables techniques have been used to examine potential problems of endogeneity resulting from simultaneity bias. The results provided appear robust to such concerns.

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 the observations were drawn, 1989 and 1999. These values are not logged. Along with the mean, median and standard deviation for all variables, the number of observations across which the descriptive statistics were calculated are reported. There were 11 323 plants present in 1989 that were in business in 1999. The mean labour productivity of plants present in 1989 and 1999 increased from C$82 775 to C$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 by BALDWIN *et al.* (2008).

Plant characteristics were measured across individual manufacturing establishments. The sample was limited in several ways. By construction, plants in rural areas were excluded from the study. Rural Canada covers an extremely large land area and with relatively few plants it is unlikely that any significant agglomerations of manufacturing plants are missing. Furthermore, difficulties in constructing place-specific data for rural areas also suggests that adding observations from such regions would be largely impractical. Only plants with a three-year average level of employment above zero were included in the study as labour productivity with zero employment is undefined. The sample was also restricted to plants with positive value

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

	1989				1999			
	Mean	Median	SD	Number of observations	Mean	Median	SD	Number of observations
Plant characteristics								
Labour 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								
Labour mix	5.1	4.3	2.4	3204	5.5	4.8	2.5	3204
Local density upstream suppliers	6.0	1.2	24.5	3204	6.9	1.2	29.0	3204
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

Note: SD, standard deviation.
Source: Annual Survey of Manufactures, 1989 and 1999.

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 were imposed because logarithmically transformed variables with a value of zero or less are mathematically undefined. They were 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 were plants that change location and industry. While plants that switch industries may not be of great interest, those that change location certainly are of interest. These plants exerted a good deal of noise in the general results, particularly on the impact of the different measures of agglomeration. Unfortunately, however, plants that changed location over the period 1989–1999 moved in many directions and their numbers were not large enough for distinct effects associated with such changes to be identified.

Due to the longitudinal nature of the analysis, the most significant restriction to the 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, the results reported below are very similar to those published earlier (and reported in Table 3) on a much larger cross-section of plants from 1999. Furthermore, the authors' concern in this paper is with differences in the effects of agglomeration across plants/firms with varied characteristics. The fact that all the plants/firms examined are 'survivors' suggests that they share a common bias. The results are not separated by industry in the analysis that follows. It is entirely possible that results for individual industries might look somewhat different from the general findings presented. Unfortunately, there are not enough observations on individual industries over the study regions to estimate the panel models for different sectors of the economy.

Shifting to the geographical or place-specific variables, for each establishment, counts of the number of plants in the same two-digit (SIC) industry within 5 km were generated. All establishments, not just those that form part of the sample, were included in these counts. Population values are reported for approximately 140 CMAs or CAs that comprise the geographical units of analysis. The labour mix and upstream location quotient were calculated at the three- to four-digit level of the Canadian Standard Industrial Classification for each CMA/CA, yielding 3204 observations.

PLANT CHARACTERISTICS AND THE BENEFITS OF AGGLOMERATION

All plants

The second column of Table 3 shows the results of estimating equation (10) across the entire balanced panel of 11 323 plants. This model was estimated

Table 3. General model results

	Single cross-section, 1999		Fixed effects panel, 1989–1999		Fixed effects panel, 1989–1999 (two-stage least squares (2SLS))	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Plant characteristics						
Profit to value added ratio	0.813	< 0.001	0.750	< 0.001	0.730	< 0.001
Production workers	–0.031	< 0.001	–0.109	< 0.001	–0.120	< 0.001
Non-production to production workers	0.274	< 0.001	0.384	< 0.001	0.400	< 0.001
Multi-plant status (Reference = single plant)	0.190	< 0.001	0.086	0.002	0.060	0.041
Foreign plant status (Reference = domestic)	0.103	< 0.001	0.094	< 0.001	0.070	0.001
Place characteristics						
Labour mix	–0.838	< 0.001	–0.508	< 0.001	–1.190	< 0.001
Local density upstream suppliers	0.014	< 0.001	0.100	< 0.001	0.380	0.049
Plants within 5 km	0.013	< 0.001	0.021	< 0.001	0.100	0.032
Plants within 200 km					–0.240	0.055
Population	0.079	< 0.001	–0.149	< 0.001	–0.200	0.055
Constant	12.19	< 0.001	0.044	< 0.001	–0.014	0.656
Number of observations	20 424		11 323		10 615	
R^2	0.661		0.466		0.360	
Root mean square error (MSE)	0.290		0.430		0.470	

Note: All continuous variables are logged. The first column reports results from a single cross-section of plants in 1999. The second and third columns report results from panel models estimated over the two years 1989 and 1999. The second column results are from a fixed effects regression model. The third column results are from a fixed effects regression model incorporating instrumental variables to control for potential endogeneity. In all regressions, standard errors are corrected for heteroskedasticity and potential correlation of errors across plants within the same census metropolitan area (CMA)/census agglomeration (CA).
Source: Annual Survey of Manufactures, 1989 and 1999.

using ordinary least squares after differencing between years. All standard errors were robust and clustered by metropolitan area, thereby adjusting for the potential correlation of errors between manufacturing establishments found in the same region (MOULTON, 1990). For purposes of comparison and to show that most of the results were robust to a variety of econometric specifications, the first column of Table 3 reports the results of estimating a cross-sectional form of the model for the year 1999. The third column shows that the signs and significance of the coefficients in the panel model are consistent as instrumental variables techniques are employed to address potential concerns with endogeneity. It is important to note that the coefficient for population, the measure of urbanization economies, changes from positive to negative in the move from a single cross-section to a longitudinal panel. The negative sign on the urbanization measure was found consistently across all subsamples of manufacturing plants that are detailed in the results that follow.

The model estimates shown in Table 3 are broadly consistent with theoretical expectations. All plant and firm characteristics exert a significant influence on productivity in the anticipated direction. Labour productivity tends to be significantly higher in plants where the profit to value added ratio, the proxy for the capital to labour ratio, is high. 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). For the fixed effects panel results in the second column, $\delta_3 = (\beta + \alpha + \sigma - 1)/(1 - \alpha) = -0.109$. 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.

The cross-section results shown in Table 3 indicate that establishments of multi-plant firms and foreign-owned plants are more productive. 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- and multi-plant status. The same holds true for foreign plant status. As multi-plant and foreign plant status were measured 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 bidirectional 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 both the cross-sectional sample and all plants that comprise the balanced panel. The labour mix variable exerts the largest impact of all agglomeration factors on productivity. Thus, plants located in urban areas where the supply of labour 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 labour 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 the labour mix. Knowledge spillovers are also shown to improve plant performance, with the proxy for spillovers (the number of plants in the same two-digit (SIC) industry within 5 km of a specific plant) significantly raising productivity, albeit by a relatively small amount. This spillover effect was insignificant for establishment counts at distances greater than 5 km, confirming the results of ROSENTHAL and STRANGE (2003) who reported a strong distance gradient with respect to intra-industry spillovers.

Domestic versus foreign firms

This section now turns 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. All the tables that follow report results from the fixed effect panel model. The baseline results for all plants in the panel are those shown in the second column of Table 3. Given the caveats noted above, the models are estimated across the population of Canadian manufacturing plants that were in operation in 1989 and 1999. Thus, on the one hand, differences in regression coefficients reported for different subsets of the population can be regarded as meaningful. On the other hand, the plants that were examined may be interpreted as a sample drawn from some broader population. This latter interpretation demands establishment of the significance of differences in regression coefficients across the samples that are compared. This is done by regressing a base sample on the independent variables of equation (10) and then interacting a second sample of plants with each of those variables and establishing, via *t*-tests, whether the partial regression coefficients in the second sample differ significantly from those of the base sample. The body of every table below reports *p*-values for each partial regression coefficient that establish the significance of variables within each model. Next to the variable labels, the first column of each table below uses asterisks to denote whether the coefficients on a variable are significantly different across the sample models estimated.

Table 4 separates the baseline sample into domestic and foreign-controlled firms. Most plants, some 73%

Table 4. Domestic versus foreign plants

	Domestic		Foreign	
	Coefficient	p-value	Coefficient	p-value
Change in plant characteristics				
Profit to value added ratio*	0.718	< 0.001	0.960	< 0.001
Production workers	–0.107	< 0.001	–0.119	< 0.001
Non-production to production worker ratio	0.385	< 0.001	0.447	< 0.001
Multi-plant status**	0.115	< 0.001	0.036	0.237
Foreign plant status***	–0.027	0.449	0.110	< 0.001
Change in place characteristics				
Labour mix	–0.497	< 0.001	–0.491	< 0.001
Local density upstream suppliers**	0.076	< 0.001	0.203	< 0.001
Plants within 5 km	0.021	< 0.001	0.022	0.094
Population	–0.169	0.015	0.033	0.819
Constant	0.037	0.002	0.061	0.017
Number of observations	9704		1619	
R^2	0.477		0.431	
Root mean square error (MSE)	0.410		0.520	

Note: The determination of foreign plant status was made in 1999. Over the period 1989–1999, foreign plant status can change, hence foreign plant status also appears as an independent variable. Asterisks indicate whether there are significant differences between the samples for the specified variable: *significant at the 0.1 level, **significant at the 0.05 level, and ***significant at the 0.01 level.

of the original balanced panel, are controlled by domestic firms. Plant size, the ratio of non-production to production workers, and the profit-value added ratio, the proxy for capital intensity, are all significant, with the same sign, for domestic and foreign firms. The coefficients on these plant characteristics are slightly larger for foreign-controlled establishments, though only in the case of the profit-value added ratio is the difference in coefficients significant between the two sets of plants. A change to multi-plant status raises the productivity of domestic establishments while it has no significant impact on foreign firms. The authors suspect that this is because foreign controlled plants are de facto part of a multi-unit firm. Takeover by a foreign firm raises plant productivity, while foreign-owned plants that switch to domestic control see no significant change in labour productivity. Differences in partial regression coefficients for multi-plant and foreign plant status are statistically significant between domestic and foreign manufacturing establishments.

Turning to the benefits of agglomeration, plants controlled by domestic and foreign firms gain from all three kinds of Marshallian economies. Differences in agglomeration coefficients between domestic and foreign controlled plants are only significant in the case of the local density of upstream suppliers where foreign plants gain more from such spatial association. The paper returns to this finding below. Productivity in domestic plants falls as urban population size increases, though the authors cannot claim with any statistical significance that the size of the urban population impacts the efficiency of domestic and foreign firms differently. The authors caution that some of the results shown in Table 4 might be driven by the sectoral and locational bias of foreign-owned firms in relation to domestic firms. Foreign firms are over-represented in resource-, scale- and science-based industries in Canada.

Domestic, single- versus multi-plant firms

Table 5 takes the 9704 domestic plants from Table 4 and splits them into two groups: those that represent independent firms and those that are part of a multi-establishment firm. Approximately 85% of Canadian domestic manufacturing plants are independent firms. It is expected that these plants will make more extensive use of agglomeration possibilities than plants of multi-unit firms that should be able to draw upon a more extensive set of firm-specific resources. Plant characteristics influence productivity in single-plant and multi-unit firms in similar ways, with increases in plant size, the profit to value added ratio, and the ratio of non-production to production workers all leading to gains in productivity. The productivity of domestic establishments that are part of a multi-unit firm as opposed to a single-unit firm increases significantly faster with respect to the profit to value added ratio, and significantly slower with respect to the ratio of non-production to production workers.

Table 5 shows that single-plant firms experience significant productivity benefits from all three localization economies and that they are negatively impacted by urbanization economies. Examination of Marshall's agglomeration measures for the plants of multi-unit firms shows the positive benefits of labour market pooling and the local density of the supplier network. Multi-unit plants do not appear to gain from close spatial association with other establishments in the same broad industry. Statistical tests reveal that only in the case of the labour mix and the upstream supplier

Table 5. Domestic, single- versus multi-plant firms

	Single		Multi	
	Coefficient	*p*-value	Coefficient	*p*-value
Change in plant characteristics				
Profit to value added ratio***	0.678	< 0.001	1.040	< 0.001
Production workers	–0.102	< 0.001	–0.121	0.001
Non-production to production worker ratio**	0.424	< 0.001	0.272	< 0.001
Multi-plant status	0.120	0.011	0.095	< 0.001
Foreign plant status	–0.043	0.607	–0.008	0.861
Change in place characteristics				
Labour mix***	–0.510	< 0.001	–0.384	< 0.001
Local density upstream suppliers*	0.059	0.017	0.129	< 0.001
Plants within 5 km	0.019	0.002	0.028	0.104
Population	–0.157	0.057	–0.047	0.834
Constant	0.031	0.043	0.036	0.136
Number of observations	8276		1428	
R^2	0.477		0.501	
Root mean square error (MSE)	0.406		0.415	

Note: The determination of foreign plant status and multi-plant status were made in 1999. Over the period 1989–1999, foreign plant status and multi-plant status can change, hence foreign plant status and multi-plant status also appear as independent variables. Asterisks by the variable name indicate significant differences across samples: *significant at the 0.1 level, **significant at the 0.05 level, and ***significant at the 0.01 level.

network are the regression coefficients between the two plant-type samples significantly different. Thus, single-plant firms tend to gain more from an advantageous labour market mix, while plants of multi-unit firms gain more from a dense, local supplier network.

Domestic, single-plant firms: small versus large

Table 6 splits the sample of domestic, single-plant firms into two groups based on plant size. The first of these, the small firm group, comprises 5825 manufacturing establishments each with fewer than twenty-one production workers, on average, between 1988 and 1990. The second group of relatively large businesses comprises 2451 establishments each of which employs twenty-one or more production workers at the start of the study period. Again it can be seen that individual plant characteristics impact productivity in similar ways across both these groups. Large plants gain significantly more than small plants from higher levels of capital.

Small and large plants benefit from Marshallian localization economies, but in somewhat different ways. Though only the coefficient on the labour mix variable can be shown to be significantly different across the two samples, the data shown in Table 6 nevertheless are suggestive of broader differences in the relative benefits of agglomeration. Small manufacturing establishments do not appear to benefit from the local density of upstream suppliers as much as larger plants, even though it cannot be claimed that the differences in coefficients are significant. Small and large, domestic, single-plant firms enjoy productivity benefits from their association with local clusters of own-industry plants.

Small plants face significant reductions in productivity that are associated with increasing urban size. The influence of urban size on large plant productivity is ambiguous and measured with relatively little precision so that the coefficients on the urban size effect cannot be said to be different between small and large plants.

Domestic, single-plant firms by age

Table 7 examines the impacts of plant characteristics and agglomeration economies by age of manufacturing establishments. The plants identified in the panel were born prior to 1989. In total, 822 plants born before 1960 cannot be aged precisely and so they are not included in the results presented. The oldest plants in the sample, domestic single-plant firms born in the 1960s, experience significantly larger productivity gains from a higher profit to value added ratio and from larger size than do younger plants, though all benefit from these characteristics. All plants are more productive when the non-production to production worker ratio is higher, though the oldest plants gain significantly less. The effects of changing ownership status and multi-plant status are more variable across plants of different age.

Turning to the agglomeration effects, it is anticipated that the youngest plants, those born in the 1980s, will rely most heavily on external resources. Entrants born in the 1980s benefit significantly more from an appropriate labour mix than do older plants. Consistent with the expectations, knowledge spillovers also raise the productivity of the newest plants significantly more than the productivity of the oldest plants.

Table 6. Domestic, single-plant firms by size

	Small		Large	
	Coefficient	*p*-value	Coefficient	*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	0.032	0.141	0.004
Foreign plant status*	0.150	0.226	–0.102	0.246
Change in place characteristics				
Labour mix***	–0.525	< 0.001	–0.367	< 0.001
Local density upstream suppliers	0.044	0.328	0.074	0.064
Plants within 5 km	0.021	0.004	0.021	0.074
Population	–0.251	0.005	0.039	0.777
Constant	0.017	0.314	0.060	0.003
Number of observations	5825		2451	
R^2	0.473		0.470	
Root mean square error (MSE)	0.406		0.389	

Note: Small plants are defined as employing fewer than twenty-one production workers and large plants are defined as employing more than twenty-one production workers. Asterisks by the variable name indicate significant differences across samples: *significant at the 0.1 level, **significant at the 0.05 level, and ***significant at the 0.01 level.

Table 7. Domestic, single-plant firms by decade of birth

	1960s		1970s		1980s	
	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value
Change in plant characteristics						
Profit to value added ratio**	0.804	< 0.001	0.702	< 0.001	0.661	< 0.001
Production workers***	–0.176	< 0.001	–0.110	< 0.001	–0.101	< 0.001
Non-production to production worker ratio*	0.292	0.018	0.532	< 0.001	0.418	< 0.001
Multi-plant status*	0.021	0.802	0.044	0.315	0.227	0.003
Foreign plant status	–0.110	0.457	0.119	0.402	–0.335	0.217
Change in place characteristics						
Labour mix***	–0.450	< 0.001	–0.472	< 0.001	–0.556	< 0.001
Local density upstream suppliers	0.113	0.022	0.099	0.002	0.035	0.300
Plants within 5 km***	–0.032	0.059	0.003	0.778	0.026	0.018
Population	–0.141	0.300	–0.298	0.083	–0.211	0.026
Constant	–0.020	0.369	0.033	0.221	0.061	0.001
Number of observations	850		1547		4950	
R^2	0.504		0.539		0.466	
Root mean square error (MSE)	0.376		0.370		0.424	

Note: Asterisks by the variable name indicate significant differences across samples: *significant at the 0.1 level, **significant at the 0.05 level, and ***significant at the 0.01 level. The text identifies between which of the three samples those differences are found.

The own-industry count of plants within 5 km has no statistical influence on the productivity of plants born in the 1970s, and it has a negative impact on the productivity of older plants, those born in the 1960s. The productivity of new plant entrants is not significantly related to the local supplier network, while the density of that network raises the productivity of plants born prior to the 1980s. This finding is consistent with the results presented above, although the differences in the regression coefficient on the upstream network are not statistically significant across the plant age groups. Still, what might explain this pattern? The authors suspect that new, single-plant domestic firms initially produce a large proportion of their inputs in-house, but as they learn over time, and as their production processes become more standardized, different stages of production become more amenable to outsourcing. The youngest plants shown in Table 7 appear more negatively impacted by urban size, though the coefficients on this variable are not significantly different across the three plant age samples.

Table 8. Domestic, single-plant firms, new entrants versus plants born to incumbents, and by decade of birth

					Green entrants by decade of birth			
	Born to incumbents		Green entrants		1970s		1980s	
	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value
Change in plant characteristics								
Profit to value added ratio**	0.762	< 0.001	0.646	< 0.001	0.660	< 0.001	0.642	< 0.001
Production workers	–0.112	< 0.001	–0.101	< 0.001	–0.089	< 0.001	–0.105	< 0.001
Non-production to production worker ratio	0.373	< 0.001	0.443	< 0.001	0.567	< 0.001	0.419	< 0.001
Multi-plant status	0.107	0.017	–0.013	0.882	0.046	0.336	–0.015	0.886
Foreign plant status*	–0.067	0.461	–0.245	< 0.001	–0.006	0.757	–0.517	< 0.001
Change in place characteristics								
Labour mix**	–0.453	< 0.001	–0.543	< 0.001	–0.467	< 0.001	–0.559	< 0.001
Local density upstream suppliers	0.091	0.002	0.042	0.142	0.095	0.044	0.036	0.267
Plants within 5 km**	0.015	0.343	0.020	0.050	–0.012	0.338	0.025	0.037
Population*	–0.036	0.737	–0.232	0.017	–0.211	0.309	–0.238	0.020
Constant	–0.007	0.650	0.050	0.010	0.011	0.729	0.058	0.004
Number of observations	2572		5704		986		4718	
R^2	0.480		0.480		0.539		0.470	
Root mean square error (MSE)	0.398		0.408		0.373		0.414	

Note: Asterisks by the variable name indicate significant differences across samples: *significant at the 0.1 level, **significant at the 0.05 level, and ***significant at the 0.01 level. The text identifies between which samples those differences are found.

Domestic, single-plant firms born to incumbents versus greenfield entrants, and by age

The manufacturing establishments examined in Table 7 were all domestic, single-plant firms in 1999, at the end of the panel. Some of these firms were born as new or greenfield entrants to the economy, and some of them were born as the plants of established or incumbent firms. Plants from the latter group might be able to draw on a different internal resource mix than greenfield entrants, and this possibility is now analysed.

Table 8 displays the results from estimating the model of the productivity benefits of agglomeration over domestic, single-plant firms. The first two columns distinguish those plants born to incumbent firms (becoming independent single-plant firms by 1999) and those plants born as new firms (most remaining independent single-plant firms through 1999). The third and fourth columns divide the latter group into those plants born in the 1970s and those born in the 1980s.

Focusing on the influence of agglomeration, plants born to incumbents and those born as new firms enjoy a boost in productivity from an advantageous labour mix. For green entrants, this efficiency boost is significantly larger. Plants born to incumbents gain from the local density of upstream suppliers and experience no benefits from co-location. Conversely, greenfield entrants do not benefit from the local density of the upstream supply network but they do benefit from co-location with own-industry plants. However, for both of these processes of agglomeration, the differences in coefficients between plants born to incumbents and those that are greenfield entrants are not significant.

At least in part, these results suggest that the origins of new plants impact their organization and structure, and the potential benefits of agglomeration. Results shown in Table 8 also reveal that urban size negatively impacts greenfield entrants, though it has no influence on the productivity of plants born to incumbents. This finding is significant across the two groups.

Separating the greenfield entrants by decade of birth, the youngest plants gain slightly more from the right kind of labour mix, they gain nothing from the local upstream supply network, and they benefit from co-location with plants in the same industry within a radius of 5 km. Older greenfield entrants gain little from co-location with plants in the same industry, but they have learned to exploit the upstream supply network. Comparing the agglomeration coefficients between these two samples of establishments indicates that the influence of labour mix and co-location are significantly different.

Finally, the section turns to the effect of urbanization economies measured through changes in the population of the urban areas in which plants are located. Manufacturing establishments that are assumed to have fewer internal resources, that is, small, young and domestic plants that are not part of multi-establishment firms, are all negatively impacted (in terms of productivity) by urban size. Why there should be negative urbanization economies for these 'more vulnerable' plants is open to question. One would expect congestion effects to impact all plants. The authors do know that wages tend to be higher in urban versus non-urban areas and higher in larger urban centres than in smaller ones. If smaller, younger, domestic and single-plant firms have lower productivity than their rivals, these firms will experience difficulties attracting labour in urban areas because they cannot provide competitive wages. There is also a dynamic explanation for the urbanization effects. 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 the data are being differenced, the effect of urbanization economies is being measured through the change in urban population. Therefore, while the change in population is being used as an estimator of the effect of urbanization economies on productivity, this is simultaneously a measure of local economic growth.

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. It is anticipated 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 place-based economies that are generated in particular locations. This paper has attempted to identify the sources of these external resources and to examine whether they benefit all businesses or only some.

It is shown that virtually all plants reap productivity benefits from being located in places where the occupational distribution of workers matches the demand for labour by occupation. However, these benefits tend to be larger for small and young businesses. Knowledge spillovers, measured by own industry plant counts within a radius of 5 km, also generate productivity gains for smaller and younger establishments, those that are not part of multi-establishment firms and that were born to greenfield entrants rather than incumbent firms. It is less clear how the co-location of plants born to incumbent and greenfield entrants impact productivity. The local density of upstream suppliers does not benefit the firms that were supposed to have few internal resources. 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 of local supplier–buyer networks. It is suspected 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.

The initial exploration of agglomeration within the Canadian economy, in the context of a cross-sectional model, reported a positive influence of urban size on plant productivity. That general finding was reversed in the shift to a fixed effect format to combat unobserved heterogeneity. The results from this paper now cast further light on the relationship between urban size and manufacturing plant performance. Urban size has a significant negative impact on productivity in plants that are small, relatively young, domestically controlled, and that comprise single-establishment firms. For larger plants, older plants, those that are foreign controlled, and for plants that comprise part of multi-establishment firms, urban size has no significant effect on productivity.

Recent analysis, making use of micro-data, has been able to identify the gains from co-location much more accurately than in the past. This paper shows that not all manufacturing plants benefit from localization and urbanization economies, and it is shown what kinds of businesses are able to exploit different forms of external economies. However, much remains to be done to understand precisely how and where the benefits of agglomeration are produced and how they are distributed across firms and regions within the space economy. Of particular interest is the evolutionary dynamics of agglomerations. How do clusters of firms and other economic agents grow? What are the ties that bind economic actors to particular locations, and how do these change over time and space? How do the characteristics of clusters and the characteristics of the economic agents they embody co-evolve? Are the dynamics of firm entry, exit, and growth different inside and outside the agglomeration? And how does the geographical mobility of economic agents into and out of clusters shape their fortune? 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.

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