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# The Productive City Needs both

- localization and urbanization economies across spatial scales in the city

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## Abstract

This paper revisits a classical inquiry by addressing the question of localization and urbanization economies. We propose that specialization and diversity may offer externalities operating at different spatial scales. Using high-resolution geo-coded plant-level panel data for Swedish cities allowing us to observe neighborhoods of 1 km<sup>2</sup>, we estimate a firm-level production function to show that close proximity to employment density in the own industry, as well as city-wide diversity, positively contribute to productivity of firms. While localization economies appear to be bound to the immediate neighborhood level within cities, urbanization grow stronger at larger spatial scales. These results provide some support for that urbanization economies and localization economies not only co-exist but also co-depend.

**JEL:** R12, R11, R23, J24

**Keywords:** urbanization, localization, specialization, diversity, attenuation, externalities, productivity, innovation, neighborhood effects, external scale economies

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## 1. INTRODUCTION

Urban growth is commonly attributed to agglomeration economies. These are in turn described as external economies of scale arising from sharing, matching and learning effects (Duranton and Puga 2004, Glaeser 2000). There is still controversy concerning the actual nature and sources of these economies. A particular issue that has attracted attention regards the extent to which they are primarily associated with localization economies based on the theories of Marshall, Arrow and Romer (MAR) or are associated with urbanization economies and the theories of Jacobs (1970, 1984). This dichotomy is often framed as an issue of diversity versus specialization, and a large empirical literature assesses whether the growth and productivity of cities are primarily driven by industry specialization or economic diversity.

In this paper we approach the question of the roles of specialization and diversity from a different angle. We argue that localization and urbanization economies may operate simultaneously within a city or region, but at different spatial scales. As Desrochers (2001, p. 388) points out, “[t]he best setting for innovation would then seem to be a diversified city made up of many specialized clusters - which is historically what most important cities have been”.

The impact that specialization and diversity of business sectors has on city growth and productivity has been studied on a city-wide level (Glaeser 1992, Audretsch and Feldman 1996). The level and balance of diversity has been studied in terms of related and unrelated variety (Frenken et al 2007), relatedness (Neffke et al 2011) and different dimensions of proximity (Boschma 2005). The local plant-specific effects of specialization and diversity have been studied across different industry sectors (Henderson 2003, Combes 2000). According to a literature review by Beaudry and Schiffauerova (2009) there is also a variety of studies conducted on different granularities of industrial classifications, and geographical units of study. Although this problem of determining the drivers of urban growth has been cut in many different ways, there remains a gap in the research. To the best of our knowledge there has been no empirical study that coherently zooms in on the effects and relation between localization economies vis-a-vis urbanization economies across spatial scales.

The novelties of this paper are threefold: (1) The effects of localization economies and urbanization economies are compared across different spatial scales, (2) We employ new geocoded high-resolution data for Swedish cities which allows us to study “neighborhoods” the size of one square kilometer, and (3) we hypothesize that specialization and diversity may co-exist and even co-depend across spatial scales so that localization economies dominate on a neighborhood level whereas urbanization economies manifest primarily on a city-wide level.

There are two primary reasons for studying urban phenomena across different levels of spatial aggregation within the city. First, it contributes to deeper understanding of how urban factors differ across the city and also along different spatial scales. Second, it adds to our understanding of the relation between micro-level dynamics and macro-level outcomes. There are several contributions to this approach. Larsson (2014) demonstrates that the relationship between density and wage varies considerably across the city and that, consequently, an aggregated analysis risks underestimating the density-wage link in locally dense areas, such as the central business district. In a similar manner, Andersson et al. (2015) use panel data to map the sharp attenuation of the density-wage elasticity at the neighborhood level, and relate the results to the locality of social interactions and knowledge spillovers. Arzaghi and Hendersson (2008) documented considerable local externalities among advertising firms on Manhattan that dissipated beyond a distance of just 750 meters.

These recent studies contribute to moving the scope of analysis beyond the aggregate city. Clearly, all parts of a city are not alike and some parts perform better than others, but at the same time all of them are also linked to each other. Manhattan might stand out in New York City, but what would happen if Manhattan was dropped in the middle of nowhere? Would it still be as attractive or productive? Most likely the answer to that question is no. Many, if not most, larger urban regions appear diversified if viewed as a holistic, integrated labor market. However, zooming in at the neighborhood level, most cities also have what could best be described as specialized parts, for instance financial districts, shopping districts, theatre districts or a car sales districts at the urban outskirts. From this perspective, city-wide diversity is a function of specializations at a more disaggregate spatial scale within the city. Specialized districts enjoy the benefits both of their local interactions and of being co-located with other districts and neighborhoods that contribute to city-wide interactions and agglomeration effects. This would be consistent with a different and sharper spatial decay in localization economies as compared to urbanization economies. It could for instance be explained by increased costs or frictions for social interactions across such districts (Becker and Murphy 1992; Lundblad 2015). Accordingly, New York City wouldn't be what it is without Manhattan, but neither would Manhattan be what it is without New York City.

In view of this, it could be claimed that the growth and productivity of cities is not a matter of cities being specialized *or* diversified, but rather about reaping the benefits of both localization economies and urbanization economies. Localization economies are typically defined as place- and industry-specific economies of scale. This is what makes Manhattan stand out in New York City. To some extent, it might prove to be easier to understand localization economies in terms of their spatial limitations than by determining the exact level of their specialization. In the same manner, urbanization economies are place-specific but *not* industry-specific economies of scale. This is what makes Manhattan and New York City stand out in the world. They operate on different spatial scales

and interact, but they do not compete. In short, we hypothesize that localization economies are industry- and neighborhood-specific, whereas urbanization economies are industry-external and region-specific.

We employ geocoded high-resolution data for Swedish cities. The data enable us to identify exogenously determined within-city 1 km<sup>2</sup> squares, which we refer to as “neighborhoods”. The main advantage of this approach is that we can measure variation in economic variables across such squares within a city. We set up a standard firm-level production function and test the respective importance of localization and urbanization economies at two spatial levels, i.e. the neighborhood and the region. In this way, we can test the hypothesis that localization economies operate at more fine-grained spatial resolution as compared to urbanization economies.

The rest of the paper is organized as follows: Section 2 presents the data and use the geo-coded data to illustrate the common phenomenon of concentration of industries to specific neighborhoods within cities and regions. Section 3 presents the empirical framework, defines variables and discusses the estimation procedure. The results are presented in Section 4 and Section 5 concludes.

## 2. DATA

### 2.1 A geo-coded firm-level panel dataset

We make use of audited firm-level register data for the period 1997-2010. These data are maintained by Statistics Sweden (SCB) and include balance-sheet information such as wages, employment, and book value of capital. A separate data file for the same time period contains plant-level data, where each plant is attached to a geo-code based on their physical address. The geo-code assigns each plant to a uniform and exogenously defined grid of squares covering the whole of Sweden. The fact that the area and location of the squares are exogenously determined alleviates issues of endogeneity with regard to geographic delineation, because their areal size and geographic positioning are unaffected by economic conditions. Every square is of equal size and covers an area of 1×1km, i.e. one square kilometer.

The plant-level file also includes a firm-level identifier, which makes it possible to assign each plant to a firm. Since our main objective is to analyze the influence the local environment has on firms, we focus our analysis single-plant firms, i.e. firms for which it is possible to define a unique location as given by the address of their plant. We restrict the analysis to firms with at least one employee in 2-digit NACE industries (15-74), which means that we exclude agriculture, fishing and mining as well

as services industries dominated by the public sectors, e.g. schools and healthcare. The dataset comprise 415,289 single-plant firms with a total of 1,526,296 firm-year observations.

## 2.2 Industry clusters within cities

The geo-coding of establishments allow us to move from the city- or region-level to a more fine-grained spatial scale, in order to analyze the influence that characteristics of the immediate within-city (or within-region) area has on firms' productivity, while controlling for economic characteristics of the wider city. To get a feel for the fine spatial level that these squares represents, we may consider the Stockholm local labor market region.<sup>1</sup> This region is the largest in Sweden in terms of population. The total area amounts to about 8,000 km<sup>2</sup>. In the geo-coded data, we identify about 3,500 squares that belong to Stockholm and that host at least one firm. The variance among these squares in terms of a standard measure like employment density is large. The difference between squares with low and high overall employment density amounts to a factor over around 10,000. This illustrates the significant differences in terms of the magnitude and the characteristics of the immediate local environment of firms located in the same region or city, but in different squares within the region or city. Put simply, there is substantial heterogeneity across squares within regions and cities which cannot be captured by aggregate spatial data. Henceforth, we will refer to a 1-by-1 km square as a 'neighborhood' within a city or region.

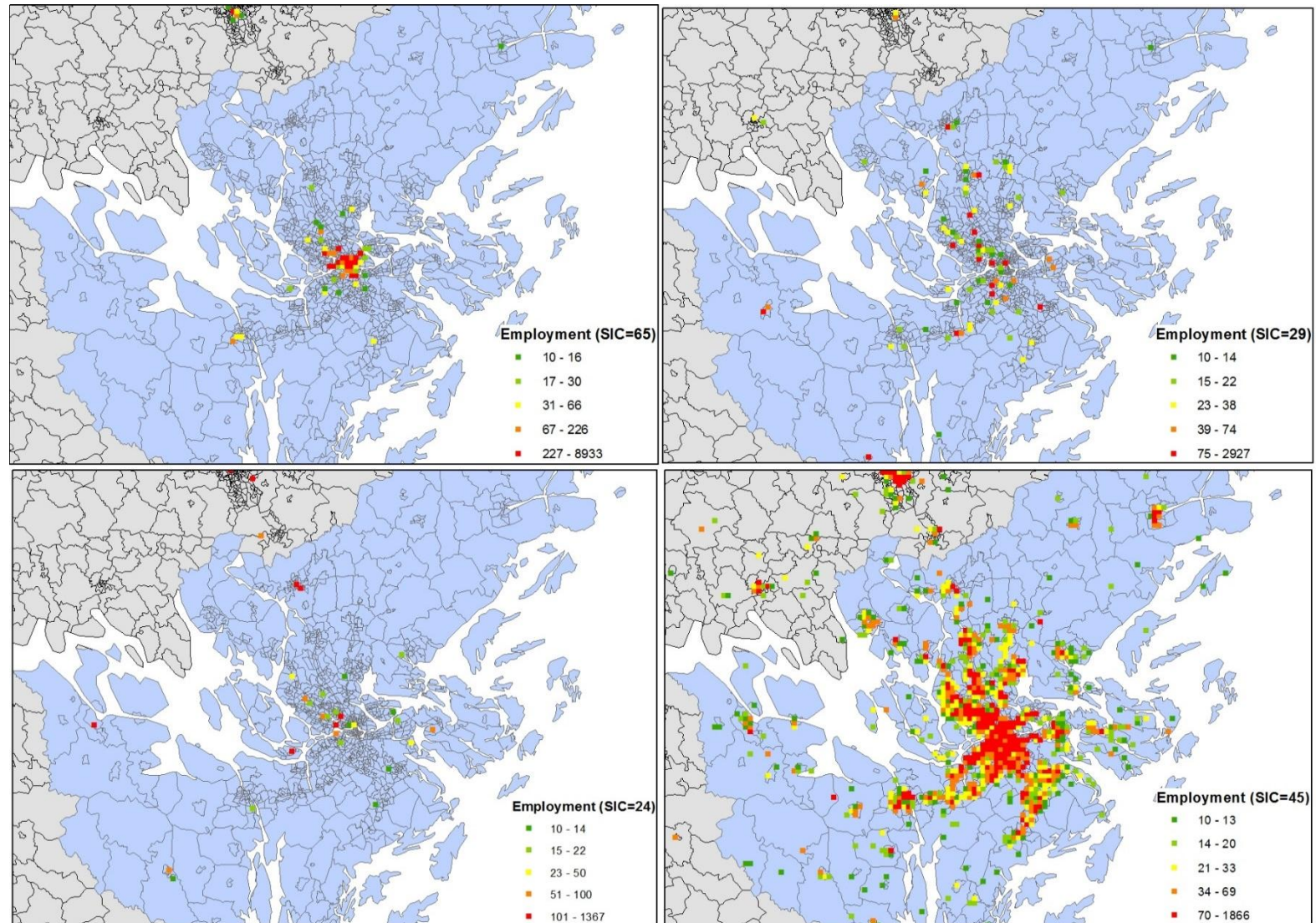
To illustrate the point made in the introduction that industries tend to be concentrated to specific neighborhoods we present Figure 1. In this figure we plot the within-city employment density distributions for four industries in the Stockholm metropolitan labor market region. The figure displays two service dominated industries (financial services and construction) and two manufacturing industries (chemicals and machinery). The figure plots employment density, divided into quintiles, in all neighborhoods with at least 10 employees per km<sup>2</sup> in the relevant industry.

It is clear from the figure that there are rather distinct within-region clusters in the sense that the scale of the industry varies substantially between neighborhoods. Furthermore, the two service industries are located in significantly denser neighborhoods, in terms of employment in the own industry. Particularly in the financial services sector (top left), almost all employment is concentrated to a few blocks in the city center; presumably reflecting the importance of close proximity in this particular industry (cf. Andersson et al., 2015). Construction (bottom right) on the other hand, is more evenly spread out across the map, whereas the manufacturing industries are dispersed in their own clusters along the main highways leading in and out of the city center.

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<sup>1</sup>Local labor market regions constitute a common unit of analysis in studies of spatial externalities (see e.g. Beaudry and Schiffauerova 2009).





**Figure 1.** Neighborhood level concentration per industry in the Stockholm labor market region (blue shaded area). The selected industries are banking and financial services (65), manufacture of chemical products (24), manufacture of machinery and equipment (29), and construction (45).



### 3 EMPIRICAL STRATEGY

#### 3.1 Model

Our main hypothesis is that localization and urbanization economies operate concurrently within cities and regions, but at different spatial scales. In particular, localization economies are expected to operate at a finer spatial scale than urbanization economies.

To test this, we employ a firm-level production function framework which includes variables reflecting the two types of external scale economies at two different levels of spatial resolution, i.e. the immediate neighborhood level and the level of the wider region. The baseline is a Cobb-Douglas production function:

$$(1) \quad Y_{its,nR} = A_{its,nR} L_{it}^{\alpha} K_{it}^{\beta}$$

where  $Y_{its,nR}$  denotes the value-added of firm  $i$  in year  $t$  operating in sector  $s$ . Subscript  $n$  refers to the neighborhood the firm is located in and  $R$  the wider region.  $L_{it}$  is the labor force and  $K_{it}$  the capital stock of the same firm  $i$  in year  $t$ .  $A_{its,nR}$  is total factor productivity. Dividing both sides by  $L_{it}^{\alpha}$  and taking logs leave us with a simple expression for value-added per employee in log form ( $y_{its,nR} = Y_{its,nR} / L_{it}^{\alpha}$ ):

$$(2) \quad \ln y_{its,nR} = \ln A_{its,nR} + \beta \ln K_{it}$$

We assume that total factor productivity of each firm,  $A$ , is a function of six components. The first two are localization and urbanization economies operating at the level of the neighborhood. We denote these by  $N_{its,n}^{LOC}$  and  $N_{t,n}^{URB}$ . The next two are the same type of economies operating at the level of the wider region,  $R_{ts,R}^{LOC}$  and  $R_{t,R}^{URB}$ . External economies of scale at both spatial levels are in this formulation assumed to ‘shift’ the production function of the firms to which they pertain.

$$(3) \quad \ln A_{ist,nR} = \phi_1 \ln N_{its,n}^{LOC} + \phi_2 \ln N_{ts,n}^{URB} + \theta_1 \ln R_{ts,R}^{LOC} + \theta_2 \ln R_{ts,R}^{URB} + \mathbf{X}'\boldsymbol{\beta} + \varepsilon_{ist,nR}$$

In addition to the external scale economies, we assume that productivity depends on firm-, sector- and year-specific effects, which are contained in matrix  $\mathbf{X}$ . The final component,  $\varepsilon_{ist,nR}$ , captures

unobserved stochastic productivity shocks,  $\varepsilon_{ist,nR} \sim IID(0, \sigma_\varepsilon^2)$ . Substituting  $\ln A_{it,nR}$  in (2) for the six components in (3), we get an estimating equation with which we can assess the respective influence of localization and urbanization economies at the two spatial levels.

Testing our main hypothesis in this framework rests on a comparison of the estimates of the parameters associated with the variables reflecting neighborhood and region-wide external scale economies, i.e.  $\phi_1, \phi_2, \theta_1$  and  $\theta_2$ .<sup>2</sup> The idea is as follows: if  $\phi_1, \theta_2 > 0$  and  $\theta_1 = \phi_2 = 0$ , then we can infer that localization and urbanization economies operate simultaneously but at different scales. Such a pattern would indeed favor the idea that localization economies operate at a spatial scale finer than the whole city or region, whereas urbanization economies pertain to the region or city as a whole. This is indeed our baseline hypothesis. If, on the other hand,  $\phi_1 = \phi_2 = 0$  but  $\theta_1, \theta_2 > 0$ , then neighborhood level matters little. Instead, both localization and urbanization economies would appear to operate primarily at the region level. If there are no effects of localization economies but only region-wide urbanization economies, then we would expect that  $\phi_1 = \phi_2 = \theta_1 = 0$  but  $\theta_2 > 0$ . This outlines the main idea of the empirical framework.

### 3.2 Variables

#### *Localization economies*

To measure localization economies we follow Martin et al. (2011) and compute, for each firm, the number of other employees working in the same industry and in the same neighborhood and region, respectively. Same industry is here taken to mean the same 2-digit NACE code, i.e.  $s$  refers to a unique 2-digit NACE code. For firm  $i$  in sector  $s$ , in year  $t$  and located in neighborhood  $n$  our measure of neighborhood localization economies,  $N_{its,n}^{LOC}$ , is:

$$(4a) \quad N_{its,n}^{LOC} = Emp_{st,n} - L_{it} + 1$$

where  $Emp_{st,n}$  is the total number of employees in sector  $s$  in neighborhood  $n$  in year  $t$ .<sup>3</sup> The measure for localization economies at the level of the wider region,  $R_{is,R}^{LOC}$ , for the same firm  $i$  in sector  $s$ , in year  $t$  and located in neighborhood  $n$  is then:

<sup>2</sup>A similar set-up is used by Andersson et al (2015) to assess attenuation of externalities associated with employment density.

<sup>3</sup>In the previous section we stated that our empirical analysis on single-plant firms for which we can identify a unique address in space. While this is true for the sample of firms used in the econometric analysis, the variables

$$(4b) \quad R_{is,R}^{LOC} = Emp_{st,R} - Emp_{is,n} + 1$$

This measure informs about the total number of employees working in sector  $s$  outside neighborhood  $n$  but in the same region  $R$  to which neighborhood  $n$  belongs. Region refers to local labor market regions. We employ the definition of local labor markets defined by Statistics Sweden which distinguish between 81 regions.<sup>4</sup>

This way of measuring localization economies captures the classic idea that they are *external to the firm but internal to the industry and the geographic area* and depends on the *absolute scale of the industry* in the area (Ohlin 1933, Hoover 1937). While many studies use relative measures to assess localization economies (Beaudry and Schiffauerova 2009), there are in fact several arguments to use more straightforward absolute measures (Kemeny and Storper 2014). Theoretically, absolute measures come closer to the core theoretical arguments, which emphasize the scale. For small regions, relative measures can in principle be high even though the underlying scale of the industry in the regions is very limited. Empirically, shares or ratios are also more difficult to interpret as it is not clear to what extent a change in localization is driven by the denominator or numerator.<sup>5</sup> This is an issue that is relevant in analyses involving changes over time. Changes over time in absolute measures of localization, as in (4a) and (4b), have a clear meaning and interpretation.

Although localization economies are often framed as dealing with specialization rather than diversity, it needs to be recognized that our measure of localization economies is not detached from diversity. We base our measures on 2-digit NACE industries, and each such industry often comprise a plethora of firms and activities. Firms in a given 2-digit industry may employ different business models, focus on different customers or sub-markets and employ workers with different education and experience profiles, and so on.<sup>6</sup> Therefore, measures of localization economies to some extent reflect within-industry diversity (cf. Frenken et al. 2007).

### Urbanization economies

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reflecting the external environment of firms are based on ‘complete’ data and thus include all activities. For example,  $Emp_{st,n}$  include employment of plants that do belong to firms with many plants in different locations.

<sup>4</sup>Local labor market regions are delineated based on commuting flows and consists of municipalities that form an integrated labor market.

<sup>5</sup>This is an issue that is particularly relevant in studies employing location quotients (LQ) to measure localization economies. LQs are in essence the ratio of two ratios, making interpretation of changes very difficult.

<sup>6</sup>This argument holds even if one would consider a more fine-grained industry-level. Think for example of standard models of agglomeration based on the monopolistic competition model of Dixit and Stiglitz (1977). In this framework firms sell differentiated varieties such that each firm faces its ‘own’ downward-sloping demand curve implying diversity in the product market. Ample studies also document significant inter-firm heterogeneity even within fine-grained sectors (Griliches and Mairesse 1995).

We use two measures of urbanization economies. The first is similar to the measure of localization economies, though it is based on employment outside the industry a firm belongs to. For firm  $i$  in sector  $s$ , in year  $t$  and located in neighborhood  $n$  our measure of neighborhood urbanization economies,  $N_{ts,n}^{URB}$ , is given by:

$$(5a) \quad N_{ts,n}^{URB} = Emp_{t,n} - Emp_{ts,n} + 1$$

where  $Emp_{t,n}$  is total employment in neighborhood  $n$  in year  $t$ . This is thus a measure of the scale of economic activities in the neighborhood as the firm is located in outside its own industry. The same measure at the level of the wider regions,  $R_{ts,R}^{URB}$  is:

$$(5b) \quad R_{ts,R}^{URB} = Emp_{t,R} - Emp_{ts,R} - Emp_{t,n} + 1$$

which reflects the scale of economic activities in other sectors outside the neighborhood to which firm  $i$  belongs. The two measures in (5a) and (5b) captures the idea that *urbanization economies are external to the firm but internal to the geographic area*. They are thus not bound to any specific industry. The logic with these measures is that if urbanization economies are important, then we should observe that it is not necessarily the scale of the industry that matters, as reflected by  $N_{ts,n}^{LOC}$  and  $R_{ts,R}^{LOC}$ , but rather the scale of economic activities in general. It is this that (4a) and (4b) aim to capture by representing the scale economic activities outside the industry the firm belongs to.

Our second measure of urbanization economies is an index of industry diversity as used by Martin et al (2011).<sup>7</sup> For firm  $i$  in sector  $s$ , in year  $t$  and located in region  $R$  the industry diversity measure is given by:

$$(6a) \quad Div_{ts,R} = \frac{1}{H_{ts,R}}$$

where  $H_{ts,R}$  is defined as:

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<sup>7</sup>Because many neighborhoods only have a few sectors, we only calculate this index at the level of the wider region.

$$(6b) \quad H_{is,R} = \sum_{s' \neq s} \left( \frac{Emp_{s',R}}{Emp_{s',R} - Emp_{st,R}} \right)^2$$

For each firm in a given region and year,  $Div_{is,R}$  measures the regional diversity in industries *outside* the 2-digit industry in which it operates, and is in all essence the inverse of a Herfindahl-index based on industry employment shares. The rationale for including this measure of ‘extra-industry diversity’ is that it complements the other measure of urbanization economies. Since at least Jacobs (1970) there has been frequent arguments that one important part of urbanization economies is precisely diversity, which is argued to foster cross-fertilization of ideas and knowledge.  $Div_{is,R}$  is intended to capture this aspect of urbanization economies. The higher the value of  $Div_{is,R}$ , the greater the extra-industry diversity.

#### *Control variables*

The matrix  $\mathbf{X}$  in (3) contains firm-, sector- and year-specific effects assumed to influence  $A$  of each firm. More precisely, we first include measure of human capital in the firm defined as the number of employees with a university education of at least three years as a fraction of the total number of employees. It is well established in the literature that skilled workers are important for firms’ capacity of develop as well as absorb new technologies, i.e. a capacity crucial for firm’s productivity (Bartel and Lichtenberg 1987, Cohen and Levinthal 1990). Second, as there are many unobserved factors that could influence firms’ productivity, such as managerial practices and routines, we also account for time-invariant unobserved firm heterogeneity through firm-specific effects. Being able to account for unobserved heterogeneity among firms is indeed one of the main virtues of using panel data (Hsiao 2002). Controlling for firm-specific factors is important as it alleviates the risk that our estimates of the influence of external scale economies at the neighborhood and region level reflect that ‘better’ firms sort themselves to more favorable neighborhoods and regions. Recent work on agglomeration economies with heterogeneous firms point to that spatial sorting of firms as well as workers, where more productive firms and workers self-select to more favorable locations, are theoretically as well as empirically an important phenomenon in explaining different levels of productivity across regions (Baldwin and Okubo 2006, Combes et al 2008).

We further include year and industry, as well as year-industry effects. The former two are intended to capture trends over time as well as characteristics of industries that may be relevant for productivity. The year-industry effects aims to capture industry-specific shocks over time. These are relevant to account for. For example, if an industry that is concentrated to a specific region or neighborhood is subject to a shock that increase productivity and employment, our measures of localization economies

of that industry in a could pick up that shock, rather than reflecting a ‘true’ effects from localization economies.

### *Descriptives*

Basic descriptive statistics for the variables included in the empirical analysis are presented in Table 1. These figures are based on 415,829 single-plant firms operating in 2-digit NACE sectors 15-74. The table also reports basic information on how the single-plant firms in the sample are distributed across broad industry categories and size-classes of firms in terms of employees. We see that about 15 % of the single-plant firms in the sample are active in manufacturing sectors. About 40 % of the firms are active in sectors that are classified as High-tech manufacturing or knowledge-based services. As in most firm-level datasets, the vast majority (> 80 %) of the single-plant firms is either micro or small.

**Table 1.** Descriptive statistics, panel data 1997-2010

	Mean	Std. deviation
Value-added per employee (log)	5.99	0.73
Capital (log)	5.74	2.15
Fraction of skilled workers	0.19	0.33
Localization neighborhood (log)	3.13	2.51
Urbanization neighborhood (log)	5.53	2.49
Localization region (log)	8.47	2.02
Urbanization region (log)	11.31	1.59
Diversity region (log)	2.67	0.12
Manufacturing	14.8 %	
High-tech or knowledge-based industries	40.7 %	
Micro (<10 employees)	70.4 %	
Small (10-49 employees)	10.6 %	
Medium-sized (50-249 employees)	1.2 %	
Large ( $\geq 250$ employees)	17.8 %	

**Note:** The table reports descriptive statistics for 415,289 single plant firms in 2-digit NACE sectors 15-74 with at least one employee for years 1997-2010. The numbers are based on a total of 1,526,296 firm-year observations. Manufacturing refers to 2-digit NACE sectors 15-36. The rest is services. High-tech or knowledge-based industries refers to sectors classified as High-tech, medium-high-tech or knowledge intensive services after Eurostat’s *High-tech aggregation* by NACE rev 1.1. The definition of micro, small, medium-sized and large firms follow the size-classification developed by DG for Enterprise and Industry at the European Commission.

### 3.3 Estimation

The full empirical model including all variables discussed above is presented in equation (7), where  $\lambda_i$  denotes the time-invariant firm-specific effect and  $H_{it}$  is human capital as defined above. We estimate the model with the panel fixed effects (FE) estimator, which exploits within variation in the data. The

FE estimator estimate parameters based on the so-called within-transformation, which means that all variables, in each year, are expressed in terms of deviations from their mean value over the whole period. Parameters are thus identified based on changes in variables over time. Consequently, any permanent heterogeneity at the firm-, industry-, neighborhood- or region-level is wiped out.<sup>8</sup>

$$\begin{aligned}
 \ln y_{its,nR} = & \underbrace{\delta + \lambda_i + \beta \ln K_{it} + \delta H_{it}}_{\text{Firm-level characteristics}} + \underbrace{\phi_1 \ln N_{its,n}^{LOC} + \phi_2 \ln N_{is,n}^{URB}}_{\text{Neighborhood external scale economies}} + \dots \\
 (7) \quad & \underbrace{\dots + \theta_1 \ln R_{is,R}^{LOC} + \theta_2 \ln R_{is,R}^{URB} + \theta_3 \ln DIV_{is,R}}_{\text{Region-level external scale economies}} + \dots \\
 & \underbrace{\dots + \sum_{t=1}^T \gamma_t D_t + \sum_{s=1}^S \sigma_s D_s + \sum_{st=1}^{ST} \varphi_{st} (D_s \times D_t)}_{\text{Industry, year and industry-year effects}} + \varepsilon_{it}
 \end{aligned}$$

Estimation of the model in (7) with the FE estimator then implies that the parameters for our five key variables for external scale economies are identified from how their changes over time correspond to changes in the labor productivity (value-added per employee) of the firms to which they are assumed to apply. A statistically significant and positive estimate of  $\phi_1$ , for example, suggests that an expansion of the number of employees in an industry in a given neighborhood induce an increase in the labor productivity of firms belonging to the same industry and neighborhood, even if other variables (including the firms' own characteristics such as capital and fraction of skilled workers) are held constant. Such results would be consistent with localization economies operating at the level of neighborhoods.

## 4. RESULTS

### 4.1 Baseline model

Table 2 reports results from an estimation of equation (6) using the full dataset of single-plant firms 1997-2010 operating in 2-digit NACE industries 15-74. Starting with the firm-level control variables, i.e. capital and human capital, they have the expected sign and are statistically significant. Increasing

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<sup>8</sup>The parameters for the industry dummies, for example, will be identified based on those firms that change industry over time.

fractions of skilled workers and growing capital are associated with rising levels of labor productivity, all else equal.

**Table 2.** Estimated influence of neighborhood and region external scale economies on labor productivity of single-plant firms 1997-2010, panel FE estimates.

Variables	Estimated parameters
<b><i>Firm-level characteristics</i></b>	
Capital (log)	0.0454*** (0.000475)
Human capital (fraction of skilled workers)	0.0428*** (0.00420)
<b><i>Neighborhood</i></b>	
Localization economies, within 2-digit industry (log)	0.00252*** (0.000618)
Urbanization economies, outside 2-digit industry (log)	0.00361*** (0.000645)
<b><i>Region</i></b>	
Localization economies, within 2-digit industry (log)	0.00118 (0.00212)
Urbanization economies, outside 2-digit industry (log)	0.0161*** (0.00329)
Extra-industry diversity (log)	0.0247* (0.0143)
Firm fixed effects?	Yes
Year effects?	Yes
Industry effects?	Yes
Year-industry effects?	Yes
No. firm-year observations	1,526,296
No. firms	415,289

**Note:** The table reports the estimated influence of neighborhood- and region-level external scale economies on the labor productivity in 415,289 single-plant firms in Sweden operating in 2-digit NACE industries 15-74. The underlying data is panel data comprising 1,526,296 firm-year observations. Standard errors are presented within brackets. Variables are defined in section 3.2. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

The estimated influence of the variables aimed to capture external scale economies are also in line with expectations. At the neighborhood level, we see that localization economies as well as urbanization economies are both positive and significant at the one percent level. This means that an expansion in neighborhood employment in the same industry as a firm is active in as well as in other industries is positively associated with an increase in the firm's labor productivity, all else equal. We thus find evidence of both localization and urbanization economies operating simultaneously at the level of neighborhoods. Accordingly, firms benefit from being located in a neighborhood within a region (or city) in which the scale of the industry in which they are active is large (localization economies) at the same time as the neighborhood also show a large scale of activities in other industries (urbanization economies).



Turning to the region-level it is clear that localization economies is insignificant, while the estimated parameter associated for the variable aimed to capture urbanization economies is still significant at the 1% level. This result is consistent with the idea that localization economies primarily operate at fine spatial scale within regions (or cities), whereas urbanization economies span whole regions. We thus find empirical support for our main conjecture. One explanation for this is that localization economies at the neighborhood level pertains to knowledge and information spillover phenomena related to local social interactions that are subject to sharp spatial attenuation. Such an interpretation is consistent with the study by Arzaghi and Hendersson (2008) who found that local externalities among advertising firms on Manhattan (localization economies) dissipated beyond a distance of just 750 meters. The fact that urbanization economies pertain to wider area could reflect that they capture more general effects such as gains from sharing infrastructure and variety of service providers, i.e. effects that may not necessitate as close proximity. In addition, extra-industry diversity is positive but only significant at the 10 % level rendering some support for that being located in a diversified region stimulate productivity (Jacobs 1970, Glaeser et al 1992).

### 3.2 Robustness

To probe the robustness of the main results in Table 2 we perform separate estimations for (i) high-tech and knowledge-intensive industries (ii) Low-tech and low knowledge-intensive industries, (ii) small firms (<50 employees) and large and medium-sized firms (>50).

As regards the distinction between industries, it is often argued that diversity is more relevant for high-tech and knowledge-intensive industries that may draw on cross-fertilizations between activities (Duranton and Puga 2001, Feldman and Audretsch 1999). In their survey of the literature Beaudry and Schiffauerova (2009) indeed claim that many studies find that urbanization economies or diversity appear to matter more for knowledge-based industries. In view of this, we perform separate estimations for (i) and (ii) to test whether our main result holds up for the two groups of industries.

The split between small and large firms is motivated by the rather common argument that small firms are more dependent on the local environment than large firms (Rigby and Brown 2013). The reason is that small firms often have weaker internal resources and capabilities, making them more dependent on local resources than larger firms with a richer set of accumulated resources and capabilities internally.

The results for these sub-groups are presented in Table 3. Looking first at the results for high-tech and knowledge-intensive industries, they confirm previous findings. Our results indeed suggest that urbanization economies and diversity matters more for this group of industries as compared to low-

tech and low knowledge-intensive industries. For the former group, urbanization economies are positive and significant at both levels of spatial resolution. Extra-industry diversity is also highly significant. Localization economies, on the other hand, are only weakly significant at the neighborhood level but strong at the level of the wider region. For low-tech and low knowledge-intensive industries, we find that localization economies only pertain to the neighborhood level, whereas urbanization economies appear to primarily operate at the region level. We also find that the measure of localization economies is negative at the level of the wider region.

**Table 3.** Estimated influence of neighborhood and region external scale economies on labor productivity of single-plant firms 1997-2010, panel FE estimates.

	High-tech and knowledge intensive	Low-tech and low knowledge intensive	Small firms	Large firms
<b><i>Firm-level characteristics</i></b>				
Capital (log)	0.0449*** (0.000837)	0.0447*** (0.000570)	0.0458*** (0.000481)	0.0181*** (0.00326)
Human capital (fraction of skilled workers)	0.0716*** (0.00638)	0.00548 (0.00576)	0.0420*** (0.00423)	0.200*** (0.0706)
<b><i>Neighborhood</i></b>				
Localization economies, within 2-digit industry (log)	0.00218* (0.00117)	0.00183** (0.000740)	0.00251*** (0.000633)	0.00150 (0.00257)
Urbanization economies, outside 2-digit industry (log)	0.00707*** (0.00124)	0.00136* (0.000751)	0.00365*** (0.000657)	-0.00139 (0.00364)
<b><i>Region</i></b>				
Localization economies, within 2-digit industry (log)	0.00778** (0.00381)	-0.00600** (0.00289)	0.00170 (0.00221)	-0.00233 (0.00638)
Urbanization economies, outside 2-digit industry (log)	0.0143** (0.00609)	0.0133*** (0.00413)	0.0151*** (0.00338)	0.0286 (0.0293)
Extra-industry diversity (log)	0.0980*** (0.0289)	-0.00978 (0.0159)	0.0287** (0.0145)	-0.199*** (0.0754)
Firm fixed effects?	Yes	Yes	Yes	Yes
Year effects?	Yes	Yes	Yes	Yes
Industry effects?	Yes	Yes	Yes	Yes
Year-industry effects?	Yes	Yes	Yes	Yes
No. firm-year observations	577,645	948,651	1,497,942	28,354
No. firms	162,136	259,257	410,711	7,048

**Note:** The table reports the estimated influence of neighborhood- and region-level external scale economies on the labor productivity in 415,289 single-plant firms in Sweden operating in 2-digit NACE industries 15-74. The underlying data is panel data comprising 1,526,296 firm-year observations. Standard errors are presented within brackets. Variables are defined in section 2.3. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Turing next to the difference between small and large firms, we see that small firms indeed appear to be more dependent on external scale economies than large firms. Small firms benefit from both localization and urbanization economies at the level of the neighborhood. As in the baseline specification, localization economies are still insignificant at the level of the wider region. Extra-industry diversity is also significant and positive. On the other hand, none of the variables reflecting external scale economies at the neighborhood level is significant. At the region level it is only extra-

industry diversity that is significant, but with a negative sign. We conclude that external scale economies appear to matter little for large and medium-sized single-plant firms in Sweden.

## 5. CONCLUSIONS

The primary conclusion from the analyses in this paper is that urbanization economies and localization economies are not mutually exclusive, but that they co-exist and differ in their spatial distribution. The indicators for both localization and urbanization economies at neighborhood level are positive and statistically significant to the 1-percent level. At the regional level, the indicator for urbanization economies is positive, somewhat larger and still significant to the 1-percent level, whereas the indicator for localization economies is statistically insignificant.

Both forms of scale economies appear to operate on a sub-regional level, but the effects of localization economies attenuate sharply beyond the neighborhood level. The effects of urbanization economies on the other hand appear to grow stronger on a larger spatial scale. These results are consistent with our hypothesis that city-wide diversity is in fact a function of several local, neighborhood-level specializations. Put differently, it provides some support for that urbanization economies and localization economies not only co-exist but also co-depend.

When the results are broken down on different groups of firms, it is evident that small firms are the primary beneficiaries of both localization economies on a neighborhood level and urbanization economies both on a neighborhood and regional level. In terms of extra-industry diversity, large firms even appear to lose out on too much diversity. These observations are consistent with the assumption that small firms are more dependent on their surroundings, while large firms rely more heavily on internal resources and capabilities. Large firms are also generally more dependent on exports and international trade.

According to the robustness checks, firms in high-tech and knowledge-intensive services appear to benefit more from localization economies at a regional level than at a neighborhood level. This result is hard to interpret without further investigation but it could be explained partly by a higher degree of internal specialization in these firms, rendering our measure of localization economies too diverse.

Overall, the results and the conclusions here pertain in particular to small firms in knowledge intensive sectors. From this point of view, there are several important policy implications to this study. First, a multitude of specialized business districts seem to be preferable to a city-wide or regional specialization strategy. This also indicates that a top-down policy approach is at a disadvantage compared to a bottom-up approach. Second, small rather than large firms appear to play the main part

in external economies of scale, meaning that they are a key stakeholder in regional and urban policy-making. Third, the city is not the atom of urban growth analysis, but rather a molecule. A city is a network of neighborhood level networks. How each of these parts of the city benefit from localization economies and how they interact with each other and benefit from urbanization economies determines the collective outcome that is the measured urban growth of the city.

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