Skills, Education and Productivity in the KIBS Sector

- Firm Level Evidence on the Presence of Externalities

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Abstract

Increased productivity is one of the main drivers of economic growth. Questions concerning the underlying reasons for productivity differences are therefore important. This paper aims to examine these issues for the Knowledge Intensive Business Service (KIBS) sector, with a particular focus on the importance of spatial externality phenomena. The KIBS sector is special part of the service sector in that it is intensive in its use of knowledge and technology. The purpose of the paper is to analyze the role of spatial externalities in explaining productivity levels of Swedish KIBS firms for the year 2008. Externalities are defined as region-specific external effects influencing firm efficiency. These can be broadly divided in the following categories: i) urbanization economies which relate to diversity (Jacobs externalities), ii) localization economies which concern specialization and concentration (MAR externalities), iii) competition (Porter externalities), and iv) labor market externalities. However, the greatest contribution of the paper is that we also include employee specific characteristics to capture whether the effects of externalities differ with different characteristics of the workforce. In general for the KIBS sector we find evidence of localization economies or MAR externalities, urbanization economies in general but not diversity in particular, Porter externalities and also positive impacts from labor market externalities. When channeling the externality effects through education and skills of the employees we come to the conclusion that for the KIBS sector everything seems to boil down

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to the importance of education and experience, which is not surprising considering the special features of this sector. In particular, for KIBS firms to benefit from a diverse economic environment they need to have educated employees. This shows the importance of distinguishing between different types of employees, both for researchers, firm managers and policy makers.

Keywords: productivity, externalities, skills, education, Knowledge Intensive Business Services, Sweden.

Introduction

The Knowledge Intensive Business Service (KIBS) sector is as the name indicates part of the overall service sector. However, the KIBS sector has some features that distinguish it from the rest of the service sector and it is those features that makes this sector interesting to study. There is no definition of the KIBS sector generally agreed upon but Miles et al. (1995) identify three main characteristics of firms belonging to it. Firstly, they are greatly reliant on professional knowledge which imply that the typical employee in a KIBS firm is a highly educated scientist, engineer or other expert. Secondly, they provide products that are sources of information and knowledge for the users. This indicates that a typical KIBS firm often supply products and services that are based on new technologies and a feature of KIBS firms is that they are in general innovative (Nählinder 2005). Thirdly, the typical client of a KIBS firm is another business either in the private or the public sector. The reason for this is that KIBS products are in general labor-intensive which implies that they are costly and hence not very attractive to final consumers.

Turning to productivity, average labor productivity has been shown both theoretically (see for example Solow (1956)) and empirically to be one of the main determinants for economic growth. To understand growth, it is therefore essential to explain and understand the origins of productivity. Considering the transition in many countries from industrial to service economies studies of productivity in the service sector are of growing importance, however they are still rare compared to the manufacturing sector. This paper is an exception and aims to examine these issues with a particular focus on the importance of spatial externalities. Externalities are defined as region-specific, or spatially bounded, external effects with the potential to influence firm efficiency. They mostly concern knowledge spillovers originating from certain economic environments. These spillover effects affect the firms through the

employees and different types of employees have different potential to absorb and use the external knowledge. The KIBS sector is interesting to study in this context due to the special knowledge and technology intensive nature of it and its employees.

The determinants for productivity can be found inside the individual firms but also in the surrounding economic environment. These are the firm specific characteristics and the region specific characteristics or *externalities*, respectively. The purpose of the paper is to analyze the role of spatial externalities in explaining productivity levels of Swedish KIBS firms for the year 2008. In the literature in this subject three different externalities are identified as the main sources for spillover effects. Jacobs (1969; 1984) argues that among geographically close companies diversity drives innovation and growth, which is part of urbanization economies. A second view is that specialization and concentration in only one industry promote growth, named Marshall-Arrow-Romer (MAR) externalities by Glaeser et al. (1992), often called localization economies. Thirdly, Porter (1998) claims that the most important reason for firms to innovate and become more productive is competition. Another important externality which is more or less embedded in both urbanization- and localization economies concerns labor market pooling and matching, that is the size of the labor market and how well the regional workforce matches the regional companies. According to Eriksson and Lindgren (2009) a well-matched labor market is a great deal more important for productivity than being situated in a diverse or a specialized environment. Also the employment rate may work as an important motivator for employees to become more productive. A high employment rate might influence productivity positively since it creates optimism in the economy. A contribution of this paper is that we test for a broader set of externalities than is usually done.

Since firm specific characteristics, including characteristics of the workforce, are important for explaining productivity also they are included in the study. Variables such as physical and human capital are used as controls to reduce the risk of biased results. However, the uniqueness of this study is that the variables that describe the characteristics of the workforce in a firm are also used to capture potential spillover effects that influence firm productivity through the employees. Since productivity is here measured as output per employee it is evident that the employees play a very prominent role in explaining productivity. The employees have the potential to affect the way different firms absorb and use possible spillover effects and they are therefore a crucial component to channel externalities to the firm as a whole. This reasoning is in line with Cohen and Levinthal (1990) who mean that a firm's ability to utilize external knowledge is dependent on its absorptive capacity, that is its prior

relevant knowledge. This in turn depends on the absorptive capacity of the employees. Hence, characteristics of the workforce, such as skills, education and experience, are important to include in a study such as the present one. An important contribution of this paper is therefore that we do not only measure the direct effects on firm productivity of externalities, but also the indirect effects by use of variables that combine externalities with workforce characteristics. To our knowledge, this has not been done before for any part of the service sector.

The results of this study are of importance to policy makers at the regional level since they have the possibility to make policy decisions that contribute to a more productive regional environment, thereby attracting more companies and creating more jobs for the local workforce. They are also of importance to firm leaders since, even though they normally do not have the means to change the surrounding milieu, they are able to decide where to localize and how to structure their firms in order to take advantage of productivity enhancing externalities.

Externalities

As stated above, externalities are defined as region-specific economic effects with the potential to influence firm efficiency. In the present paper we focus on four different sources for spillovers, namely externalities from urbanization economies, localization economies, competition and the labor market.

Both Jacobs' (1969) and MAR's (Glaeser, Kallal et al. 1992) view of externalities concern effects of knowledge spillovers. However, they are somewhat in the opposite corner to each other since Jacobs, in her historical account of cities, supports diversity while the MAR theory supports specialization. Jacobs theory is that cities are the main driving force for the economy because it is in cities that innovation and technological progress, and thereby increased productivity, take place. The reason for this is that cities are diverse, they are comprised of a wide variety of industries and people and according to Jacobs the most productive knowledge spillovers are those that transcend industry boundaries. There is simply a greater flow of different ideas in diversified environments and firms in different sectors can adopt and benefit from innovations made in other sectors.

There is a rationale also behind MAR externalities and it was Marshall (1890) who made the earliest contribution to this combined theory. According to him concentration of one industry

in a city promotes knowledge spillovers within that industry which increases growth in both the industry and the city as a whole. Marshall also asserted that cities benefit from specialization since it reduces transport costs. If all firms within an industry localize themselves close to the input sources the costs of moving inputs are minimized. In Arrow's (1962) formalized model knowledge is created as a by-product from ordinary production and learning is therefore equal to gaining work experience. Arrow uses gross investment in capital as a measure of experience since more capital implies higher productivity. The only type of knowledge accounted for in the model is therefore firm-specific knowledge. The last contribution to the MAR theory is from Romer (1986; 1990). According to him new technology is re-invested in the companies and the knowledge is therefore internalized. Hence, both Arrow and Romer have a positive attitude towards specialization and concentration since there are no knowledge flows between industries. There is nothing to gain from diversity.

Jacobs (1969) also means that competition is important for an economy to prosper since competition forces firms to innovate and become more productive in order to survive. This view of competition is in line with Porter (1998), but again opposite to the MAR theory. Both Arrow (1962) and Romer (1990) consider technology and knowledge as non-rival goods, Arrow see them as completely non-excludable and Romer as partially excludable. Competition is negative for the economy since the incentives for companies to innovate are reduced when there are possibilities to free-ride and risks to not gain the full return on innovations. Porter agrees with the MAR theory that knowledge spillovers mostly occur within industries but disagrees that competition is bad for innovation. Porter's theory is that competition is positive since even though it reduces the returns on innovations it puts pressure on the companies to become more productive. Since knowledge and technology are, or are at least close to be, public goods competition fosters imitation and improvement of innovations which speed up the innovation process and increase productivity.

The last externality considered concerns labor market pooling and matching, that is the size of the labor market and how well the regional workforce matches the regional companies. Already Marshall (1890) acknowledged the importance of the labor market. One of the reasons why firms localize themselves close to similar firms is to have access to suitable employees. Eriksson and Lindgren (2009) find that externalities from the labor market are far more important for firm productivity than externalities from concentration and diversity. They argue that what is important is not labor mobility in itself but mobility in combination with

labor market matching. According to Combes and Duranton (2006) firms that localize themselves in clusters have access to larger labor markets and can hire employees who already have the relevant knowledge and hence save on training costs. However, at the same time they face costs of losing their own knowledge to other firms and also the costs of having to pay higher wages in order to keep their workers.

The Service Sector and Productivity

The focus in this paper is as already mentioned on KIBS industries, which are part of the service sector. When it comes to productivity it is however more straightforward to talk about manufacturing since the productivity measure is a great deal less problematic to use for manufacturing than for services. This is probably one reason why relatively little research is done on productivity in service firms. An underlying hypothesis in the present paper is that firms and regions should strive for higher productivity. The motivation behind this is that it positively influences growth, which in turn has the potential to increase the overall welfare. However, this might not be the case for the service sector. This sector consists very much of labor intensive industries which makes it more difficult to enhance productivity by technical means, higher productivity is instead often attained through fewer employees. Increased productivity and growth can therefore be reached at the expense of a loss in quality in the services performed, which is generally not positive from a welfare point-of view.

The importance of quality in services is addressed by, among others, Giarini (1991) who argues that output from service firms cannot be measured in the same way as output from manufacturing firms. There is a need to distinguish between quantity and quality for both inputs and output when dealing with productivity in the service sector. Vuorinen et al. (1998) conclude that to properly measure productivity in service firms quantity and quality need to be weighted together. They propose a measure of service productivity as quantity and quality of output relative to quantity and quality of input. Quantity in both inputs and output is straightforward to measure but the quality aspect is more problematic since quality is something subjective. Whether a service is perceived as high or low quality often depends not only on the service provider but also on the individual preferences of the consumer. Quality is in general measured as customer satisfaction which is obtained by regular customer feedback. Vourinen et al. use this and some additional measures of quality, such as high quality work performance, to make a case study of productivity in a Finnish insurance company.

Since quality is something subjectively perceived it is necessary to get the information from individual costumers, that is customer feedback from interviews, surveys and so forth. This is doable when conducting case studies of one or a few firms but more or less impossible to achieve when having a large data set, such as the one used in the present study. Therefore, we disregard the quality aspect and focus only on the quantity aspect of productivity, something that should be kept in mind when interpreting the results. When doing a large quantitative study we lose the quality part of services but gain the advantage to generalize the results to a much larger extent, something we cannot do with case studies.

Data, Variables and Descriptive Statistics

This study is possible to conduct due to an extensive dataset on the micro level, collected by Statistics Sweden. The dataset contains detailed information about all firms, establishments and employees in Sweden. The firms, establishments and employees are connected by identity numbers which makes it possible to tie each individual employee to both an establishment and a firm. The great majority of firms in Sweden comprise of only one establishment, only two percent constitute of two or more establishments, often spread out in different municipalities. However, data such as value added are available only at the firm level which creates a problem with the multi-establishment firms. The purpose of this paper is to capture productivity effects from regional externalities why it is important to be able to connect productivity levels and regions, which is not possible for those establishments belonging to multi-establishment firms. Hence, to be able to give a picture as clear and correct as possible we include only firms with one establishment in the estimations. With this approach we can capture the importance of the region in a more correct way.

We eliminate firms with negative or zero value added and include only those with at least one employee. Lastly, we also restrict the industrial classifications to four digits and include only the KIBS industries, which are found in industry 72 to 74 according to the 2002 Standard Industrial Classification by Statistics Sweden. This leaves us with 35,856 firms in 17 different four-digit industries. The distribution of firms among these together with a description of the included industries is found in Appendix 1.

The regions referred to in this paper are, unless stated otherwise, the 290 Swedish municipalities.

Variables

The dependent variable in this study is average labor productivity which is measured as value added per employee[2] per firm.

Urbanization economies

To measure urbanization economies, or more specifically diversity, we use an inverse Herfindahl index. Since diversity is the opposite to specialization, the Herfindahl index (Acar and Sankaran 1999) is commonly used as a measure of industry[3] diversity (see for example Henderson et al. (1995) and Duranton and Puga (2000));

$$H_r = \sum_{i=1}^{n} \left(\frac{e_{i,r}}{e_r}\right)^2,$$

where H_r denotes the Herfindahl index of concentration for municipality r, $e_{i,r}$ the number of employees in industry i and municipality r, e_r the total number of employees in municipality r and n the number of industries in municipality r. The inverse of this index gives a more direct measure of diversity;

$$D_r = {}^{1}/_{H_r}.$$

The range of D_r is between 1 (no diversity, only one industry present) and n (maximum diversity). Hence, an increase in D_r implies an increase in diversity.

However, also density is used as a variable for urbanization economies since it measures externalities from concentration of economic activity per se, no matter its composition. Ciccone & Hall (1996) and Ciccone (2000) find a significant relationship between average labor productivity and employment density for USA and five European countries[4], respectively. Their results show that density of economic activity is of great importance when explaining productivity levels and according to the estimations the elasticity of average labor productivity with respect to employment density is 5 percent in USA and 4.5 percent in the European countries (Ciccone 2000). Density is usually measured as employees per square kilometer. However, for a country as Sweden with a relatively large area and a relatively small population that is concentrated in urban regions such a density measure is not very

[2] Both value added and number of employees are self-reported by the firms. The number of employees is a yearly average.
[3] The industries are measured at the two-digit level for all externality measures.
[4] France, Germany, Italy, Spain and the UK.

suitable. Instead we measure density of economic activity as the size of the accessible market, adjusted for traveling times inside the market. Johansson et al. (2002) divide the accessible market in a local, an intra-regional and an extra-regional part, based on time distances. The local market consists of the municipality in question and the intra-regional market of the functional economic region which typically consists of 4-5 municipalities including the relevant one. The total market accessibility, A_r^{tot}, is then given by;

$$A_r^{tot} = A_r^l + A_r^{ir} + A_r^{er},$$

where A_m^l denotes the local, A_m^{ir} the intra-regional and A_m^{er} the extra-regional market accessibility for municipality *r*. (Johansson, Klaesson et al. 2002; Andersson and Klaesson 2009) The size of a market can be measured in various ways, such as population, gross regional product or wage sum. Here we use wage sums (*WS*) to calculate the different accessibility measures and for estimations we use the three measures separately. According to Andersson and Klaesson (2009) the combined measure is one of market potential when the municipality is not exposed to competition from other municipalities. Since this is in general not the case it is more relevant to use the division above. The different accessibility measures are calculated as follows (Andersson and Klaesson 2009);

$$A_r^l = WS_r \exp\{-\lambda_r t_{rr}\},$$

$$A_r^{ir} = \sum\nolimits_{R-m} WS_k \exp\{-\lambda_{ir} t_{rk}\},$$

$$A_r^{er} = \sum\nolimits_{W-R} WS_k \exp\{-\lambda_{er} t_{rk}\},$$

where *R* constitutes all municipalities within a functional economic region and *W* is the set of all Swedish municipalities. As *r*, *k* denotes municipalities where $r \neq k$, and t_{rk} is the travel time distance between municipality *r* and municipality *k*. Finally, the λ's are measures of time distance sensitivity. The values used for the different λ's are estimated by Johansson et al. (2003) using Swedish commuting data for 1998, where λ_r was estimated to be 0.02, λ_{ir} 0.1 and λ_{er} 0.05.

Localization economies

To measure localization economies, or more specifically industry concentration, the localization quotient, $LQ_{i,r}$, is applied;

$$LQ_{i,r} = \frac{e_{i,r}/e_r}{e_i/e},$$

where e_i measures the number of employees in industry *i*, *e* the total number of employees in Sweden and $e_{i,r}$ and e_r as above. The localization quotient is a relative measure in that it measures the regional share of workers in a specific industry relative to the national share of workers in that industry. If the localization quotient is larger than one the interpretation is that the industry has a larger share of the employees in a region than the country as a whole, implying that the municipality is more specialized than average in that specific industry.

Competition

Competition arises when there are many firms producing similar products and competition can thus be interpreted as the antonym to concentration *within* an industry. The less concentration the more competition. This is shown by the Herfindahl index on a different level;

$$H_{i,r} = \sum_{j=1}^{m} \left(\frac{e_{j,i,r}}{e_{i,r}}\right)^2,$$

where $H_{i,r}$ denotes the value for employee concentration within industry *i* in municipality *r*, $e_{j,i,r}$ and $e_{i,r}$ as above. To facilitate the interpretation of the variable we use the following measure for competition within industry *i* and municipality *r* (which is also used by Martin et al. (2011));

$$C_{i,r} = {}^{1}/_{H_{i,r}}.$$

This index ranges from 1 (no competition, only one firm) to *m* (maximum competition), where *m* is the total number of firms within industry *i* and municipality *r*.

Another measure for competition is applied by Glaeser et al. (1992);

$$Co_{i,r} = \frac{w_{i,r}/e_{i,r}}{w_i/e_i},$$

where $w_{i,r}$ denotes the number of firms in industry *i* and municipality *r*, w_i the total firms in industry *i* and $e_{i,r}$ and e_r as above. As the localization quotient, this is a relative measure in that it measures firms per employee in industry *i* and municipality *r* in relation to total firms

per employee in industry *i*. If the value is larger than one the industry is more competitive in that municipality than the country average.

These two different measures of competition are not very correlated which leads us to an important conclusion. When estimating the effects from externalities it is important to distinguish between absolute and relative measures and it is important to be clear with what is actually measured. Regarding competition it is important to differentiate between competition on the input market and competition on the output market. The inverse Herfindahl index above can be interpreted as a measure of competition on the output market since it measures to what extent other firms producing similar products are present in the same municipality. On the other hand, the relative measure of competition can be interpreted as a measure of competition on the input market, more specifically competition for labor. The more firms an industry has in a municipality relative to the number of employees in that industry, relative to the industry as a whole, the greater is the competition for labor.

Education and skills

As mentioned above, the employees play a very prominent role in determining productivity levels. To assess the education and skills of the workforce we use five different variables, one for education and four for skills. The education variable measures the number of employees at each firm with three or more years of university education. For the skills variables, we follow the division by Johansson and Klaesson (2011) of the occupations into four different categories; cognitive skills, management and administration skills, social skills, and motor and other skills. Typical occupations for each type of skill are given by table 1.

Table 1. Examples of professions within skill categories and number of KIBS employees within each category.

Cognitive skills	**Management and administration skills**	**Social skills**	**Motor and other skills**
Engineers Natural and computer scientists Teaching professionals	Directors Office clerks Other managers	Health and social workers Business service agents Sales personnel	Motor-vehicle drivers Machine operators Electronic equipment mechanics and fitters
69,995	55,042	23,534	15,159

Source: Johansson and Klaesson (2011).

As explanatory variables we use the firms number of employees in each category. The inspiration for this division of skills comes from Bacolod et al. (2009) who saw a need of distinguishing worker skills in more aspects than differences in education levels. This gives a more thorough assessment of the competence of the workforces at the different firms.

Labor market externalities

As mentioned in the introduction, labor market externalities are not distinctive externalities since they relate to both urbanization- and localization economies. Urbanization economies in the sense that the labor market depends on the size and activity in the regional economy and localization economies since a well-matching labor market indicates some sort of regional specialization. However, we still choose to treat them separately since the interest lies in the characteristics of the employees in the region, something we do not consider for the above externality measures.

A well-functioning labor market is crucial for both firms and potential employees. It is self-evident that productivity will be higher if the right person is in the right place. However, except for finding suitable employees in the first place firms also need to be able to replace the ones they already have if the circumstances change. The same goes for the employees, they need to have the possibility to switch jobs. For this to be a reality, the characteristics of the potential employees, that is the regional workforce, need to match the needs of the regional firms and vice versa. A well-functioning labor market with rapid matching processes has the potential to positively influence the productivity levels of the firms. We assess how well this labor market matching works at the firm level by measuring the concordance between the employees at a firm and all employees in the respective region regarding levels of education combined with types of skills. The skill categories are the same as above (see table 1) and for the levels of education six different levels are used. This means that for each firm and each region, we calculate the share of employees for all 24 possible combinations of education levels and skills. To produce a single measure of the labor market matching these are weighted together according to the following formula;

$$LM_j = \frac{1}{(\sum_{a=1}^{24}(se_a^{est} - se_a^r)^2)},$$

where LM_j gives the labor market matching value for firm j, se_a^r the combinations of education and skills at the municipal level and se_a^{est} the corresponding combinations of education and skills at the firm level. The interpretation of this measure is that the larger it is for a firm the better does that firm's employment needs match the regional labor market. Hence, the higher is the probability that the right person is at the right place and the higher is the probability that the employees can be replaced.

Another externality effect may arise from the employment level in the respective region. A low employment rate is often associated with a downturn of the economy which in turn can imply decreasing real wages. According to Akerlof and Yellen (1990) employees respond to decreasing wages by lowering their effort, especially if the wage falls below the level that the employee considers as fair. Darity and Goldsmith (1996) argues that being unemployed can have a negative effect on the psychological well-being which might affect the productivity if the unemployed becomes employed. On the other hand, when the employment rate is high the economy is usually prospering and wages instead increasing, creating an optimistic spirit in the society and among the employees which then positively influence productivity.

Combined variables

To capture indirect spillover effects on productivity levels we combine measures of externalities with characteristics (education and skills) of the employees. By this approach we aim to capture if the externality effects differ with differences in the workforce. More specifically, we multiply the inverse Herfindahl index of diversity with the number of employees with three or more years of higher education, and also with the number of employees that are classified in each of the four different groups of skills. This is also done for the localization quotient, both measures of competition and the labor market matching value. In order to ease the logarithmic transformation one employee is added to each firm before doing these computations. This also implies that firms with no employees in a certain skill group will be assigned the original externality values.

A list of explanatory variables is given by Table 2 and 3 on the following page.

Table 2. Variables describing firm characteristics.

Variable	Definition
Industry	
SNI7210-7487	Dummy=1 if the firm belongs to industry 7221-7487, respectively (one dummy for each industry, 7210=base)
Size[5]	
Micro firm	Base, number of employees at the establishment is between 1 and 9
Small firm	Dummy=1 if number of employees at the establishment is between 10 and 49
Medium firm	Dummy=1 if number of employees at the establishment is between 50 and 249
Large firm	Dummy=1 if number of employees at the establishment is ≥ 250
Capital	(This variable is not yet available)
Labor	Number of employees
Maturity	Years since establishment
Age	Average age of employees
Female	Percentage of females
Employee tenure	Percentage of employees common to 2007
Education	Number of employees with three or more years of university education
Skills:	
Cognitive	Number of employees classified as cognitive skill workers
Management	Number of employees classified as management and administration skill workers
Social	Number of employees classified as social skill workers
Motor	Number of employees classified as motor skill workers

Table 3. Variables describing regional characteristics.

Variable	Definition
Urbanization economies	
Diversity	Industry diversity measured as the inverse Herfindahl index
Local	Accessibility to local market
Intra-regional	Accessibility to regional market
Extra-regional	Accessibility to extra-regional market
Localization economies	
Specialization	Industry specialization/concentration measured as the localization quotient
Competition	
Competition	Concentration within an industry measured as inverse Herfindahl index at industry level
Relative competition	Municipal firms per employee relative to national firms per employee, at industry level
Labor market	
Labor matching	Concordance between firm and municipal workforce
Employment rate	Municipal employment rate in percent

[5] The classification of firm sizes is based on the definition by the European Commission.

Descriptive statistics

Table 4 presents the descriptive statistics of the variables presented in Table 2 and 3.

Table 4. Descriptive Statistics.

Variable	Mean	Median	Min	Max
Value added	684	561	0.50	111,000
Capital				
Labor	4.69	2.00	1.00	1,230
Maturity	8.14	6.00	1.00	23.0
Employee tenure	83.9	100	0	100
Age	46.3	45.0	16.0	84.0
Female	33.0	18.8	0	100
Education	1.83	1.00	0	424
Skills:				
Cognitive	1.95	1.00	0	549
Management	1.54	1.00	0	448
Social	0.66	0	0	191
Motor	0.42	0	0	163
Urbanization economies				
Diversity	12.2	12.4	2.50	19.0
Local	46.3E9	13.4E9	127E6	139E9
Intra-regional	31.6E9	23.2E9	0	150E9
Extra-regional	2.38E9	1.49E9	123,000	12.9E9
Localization economies				
Specialization	1.26	1.12	0.02	34.8
Competition				
Competition	155	65.5	1.00	522
Relative competition	1.37	0.83	0.14	15.6
Labor market				
Labor matching	2.92	1.74	0.86	74.3
Employment rate	77.2	76.9	62.9	86.5

The descriptive statistics show that Swedish firms and regions are heterogeneous. For the purpose of the paper the most interesting is to look at the values of the externality measures. All of these show that there is variation between the different regions. For urbanization economies, the diversity measure ranges from a relatively low number to a relatively high number showing that some municipalities have few different industries while others have great variation in industries. However, the mean and the median show that Swedish municipalities have on average a relatively high degree of industry diversity. In connection to this it is interesting to look at the specialization measure. Considering the minimum and maximum values industries within municipality boundaries seem to have a fairly low degree of specialization. However, the localization quotient is a relative measure which implies that even though the mean and the median are low in value they still show that industries are on

average more specialized in municipalities than the industry country average. On the other hand, this could reflect that the country as a whole is not very specialized.

For competition, the absolute competition measure ranges from one, which indicates that in at least one municipality and for one industry one firm is the single representative, to 522, indicating very strong competition on the output market in one municipality for at least one industry. However, the mean and the median are considerable lower, but still fairly high, which implies that Swedish KIBS firms are on average exposed to a high degree of competition. When instead looking at the values for relative competition, or competition on the input market, they give a somewhat different picture. The minimum and maximum values show that there are industries in municipalities that are a lot less competitive than the country average and industries in municipalities that are a great deal more competitive than the country average. The mean industry is slightly more competitive and the median industry slightly less competitive on the input market in municipalities than the country average.

The minimum value for the labor market matching measure is relatively close to zero which indicates that some firms match the regional workforce very poorly. Compared to the maximum value also the mean and the median are low, implying that extremely large values of labor market matching is not the general case.

Model and Empirical Estimations

As a point of departure, we use a basic production function;

$$Y_j = F(K, AL) = K_j^{\alpha}\left(A_j L_j\right)^{\beta}, \tag{1}$$

where Y_j denotes production (or value added), K_j capital, A_j the efficiency of the employees and L_j number of employees, all for firm j. However, since we measure productivity as value added per employee we simply divide both sides of equation 1 by L_j;

$$\frac{Y_j}{L_j} = \frac{K_j^{\alpha}\left(A_j L_j\right)^{\beta}}{L_j} = K_j^{\alpha} A_j^{\beta} L_j^{\beta-1} = K_j^{\alpha} A_j^{\beta} L_j^{\gamma}. \tag{2}$$

The variables described in the above section are contained in A_j since they are all factors that have the potential to affect the efficiency of the employees. We therefore extend the above model by substituting A_j for all these variables. To facilitate the empirical estimations we

transform equation 2 into logarithmic form and also include a constant. Hence, the model used for estimations is the following;

$$\ln\frac{Y_j}{L_j} = \beta_0 + \alpha \ln K_j + \gamma \ln L_j + \sum_j \beta_j \ln \Gamma_j + \sum_{jir} \beta_{jir} \ln Z_{jir} + \sum_{jr} \beta_{jr} \ln H_{jr} + \sum_{jx} \beta_{jx} \ln X_{jx} + \sum_{jD} \beta_{jD} D + \varepsilon_j, \quad (3)$$

where Γ is the set of firm characteristics described in table 2, Z the set of industry- and region specific characteristics and H the set of region specific characteristics found in table 3. X denotes the set of combined variables, D the set of dummy variables found in table 2 and ε is the usual error term. Since equation 3 is in logarithmic form the estimated coefficients can be interpreted as elasticities. Not all terms of equation 3 are used for all estimations, mainly because of correlations between explanatory variables.

Results

Table 5 on the following page presents the results from regressions including only firm characteristics and also firm characteristics together with three sets of different regional characteristics.

Firm characteristics

For the firm characteristics, they are all highly significant in all four models. That labor has a negative sign does not mean that more employees produce less. What we estimate is γ which implies that β is approximately equal to 0.7 ($\gamma = \beta$ - 1). Since this figure is less than one we have found diminishing marginal productivity of labor. Hence, our results support one of the most basic assumptions in economics. The factors that positively influence productivity are age of the firm and the percentage of employees that are the same as the year before. These results are expected since both age of the firm and tenure are measures of experience, maturity measures experience on firm level and tenure experience on employee level. More experience implies greater knowledge of the production processes which intuitively enhances productivity. However, since KIBS firms are in general innovative and use new knowledge and technology one might argue that age of a firm is not a comparative advantage. On the other hand, according to table 4 the median age of KIBS firms is only six years, which is low compared to for example the manufacturing sector. This implies that an increased age of a firm might simply show that the firm has overcome start-up problems and has turned profitable and productive. Not that the firm is old and mature.

Table 5. Regressions including regional characteristics. Dependent variable: average labor productivity.

Variables	**Model I**	**Model II**	**Model III**	**Model IV**
Firm characteristics				
Labor	-0.292***	-0.304***	-0.292***	-0.292***
Maturity	0.0899***	0.0884***	0.0909***	0.0904***
Employee tenure	0.113***	0.118***	0.114***	0.114***
Age	-0.260***	-0.226***	-0.245***	-0.245***
Female	-0.0250***	-0.0267***	-0.0249***	-0.0248***
Education	0.156***	0.140***	0.142***	0.142***
Cognitive	0.220***	0.214***	0.222***	0.222***
Management	0.267***	0.258***	0.269***	0.269***
Social	0.0850***	0.0628***	0.0836***	0.0842***
Motor	0.0901***	0.0782***	0.101***	0.0994***
Regional characteristics				
Diversity		-0.0790***		
Specialization		0.0631***		
Labor matching		0.0528***		
Competition			0.0359***	
Relative competition			-0.0200**	
Employment rate			0.237***	
Local				0.0223***
Intra-regional				0.00343***
Extra-regional				-0.00266
Dummy variables				
Industry dummies	*Yes*	*Yes*	*Yes*	*Yes*
Size dummies	*Yes*	*Yes*	*Yes*	*Yes*
Constant	6.408***	6.473***	5.214***	5.808***
R^2	0.117	0.122	0.121	0.120
Observations	35,856	35,856	35,856	35,856

*** p<0.01, ** p<0.05, * p<0.1.

Factors that seem to negatively affect average labor productivity are average age of employees and share of females. Why an increased share of females affects productivity negatively is not straightforward to explain but it could be related to the overall nature of the KIBS sector. This sector contains many jobs requiring educations that are at least traditionally seen as male dominated[6], such as engineering. At least in Sweden men are overrepresented in technology-oriented courses while women are overrepresented in socially-oriented courses. This together with women working part-time more frequently could imply that women in the KIBS sector are in general less experienced. However, neither labor nor females have as large negative impact as the average age of employees. This can be explained by younger employees being more newly and appropriately educated and hence more productive. This is especially relevant for the KIBS sector since firms in this sector are, as previously mentioned, in general young and in use of new technology and knowledge.

[6] 38 percent of employees in Swedish KIBS firms are female, year 2008.

As expected, the number of employees with at least three years of higher education influences productivity positively. Education level is one measure of human capital which is commonly thought of as a key input factor in production functions. Also, an increased number of employees with either cognitive, management, social or motor skills has a positive effect, however to varying degrees. The largest impact is according to the results from employees with cognitive and management skills and the lowest from employees using social and motor skills. This can be connected to education levels and experience. Positions requiring cognitive and management skills are often filled with highly and newly educated and/or experienced employees, which have both been shown to enhance productivity. Positions requiring motor skills, such as machine operators and other manufacturing workers, are instead commonly filled with less experienced and less educated employees. However, it should be noted that employees with motor skills is a relatively rare phenomenon in the KIBS sector (see table 1).

Regional characteristics

For urbanization economies, the results are somewhat mixed. They show that a more diverse industry structure, measured as the inverse Herfindahl index, is actually decreasing productivity among KIBS firms. That diversity is negative for these firms does not necessarily mean that knowledge spill-overs between different industries decrease productivity. It might simply mean that there are very few interactions between KIBS firms and firms in other sectors and hence no possibility for knowledge-spillovers. The explanation for this could be that KIBS firms are special in that they are in general high technology and knowledge intensive. This could imply that they interact with and benefit from firms with a similar high level of technology and knowledge. To put it simply; the more firms belonging to the same industry within a municipality, the larger are the interaction and knowledge-spillovers within that industry and the larger are the benefits for the individual firms in the industry. However, urbanization economies in general seem to influence productivity positively, in that the size of the local and intra-regional market are significant with positive signs. Our results show that the economic size of the municipality the firm is situated in is more important than the economic size of surrounding municipalities. Since economic activity per se is productivity-enhancing, our results are in line with those by Ciccone and Hall (1996) and Ciccone (2000). The results also show a significant relationship between average labor productivity and specialization, or localization economies, which further strengthens the discussion above about diversity. In general for the Swedish KIBS sector it appears as if most interactions and knowledge spillovers are between firms belonging to the same two-digit industry, why

specialization, and not diversity, is productivity enhancing. That is, our results support MAR externalities but do not support Jacobs externalities.

Both measures of competition are highly significant but they have different signs which is not unexpected considering the discussion above about the differences in these measures. When looking at the absolute competition measure we find clear evidence of Porter externalities. More firms within an industry and municipality fosters productivity since competition puts pressure on the firms to enhance their efficiency in order to sell enough products to survive. The relative competition measure is instead negative which implies that increased competition for input factors such as labor is harmful for the firms. This is intuitive since competition for potential employees probably does not give rise to productivity-enhancing innovations to the same extent as competition for customers. Our results show that this type of competition even affects productivity negatively which can be interpreted as if it gives rise to a waste of resources that could have been used in a better (more productive) way.

The last group of externalities tested for is concerning the labor market and the characteristics of the employees. In line with Eriksson and Lindgren (2009) our results show that these externalities are very important for productivity. Increased concordance between the firm workforce and the regional workforce significantly enhances productivity. This is intuitive since the higher the labor matching value is the greater are the possibilities for individual firms to have the right person at the right place. Also the employment rate is highly significant and influences productivity positively. Our results therefore supports the theories by Akerlof and Yellen (1990) and Darity and Goldsmith (1996). An increased employment rate can also mean that firms in the region are doing well or that the labor market matching works well, which has been shown to be productivity-enhancing above.

Combined variables

A question posed in earlier sections is whether the effects from externalities differ with differences in workforce composition. To test for this we run regressions with firm characteristics and different sets of the combined variables. Education, skills and the individual externality measures are omitted because of correlations between them and the combined measures. Even though the individual externality measures are excluded from the models they are indirectly present. The difference is that instead of looking at the direct effect from externalities they are channeled through the education and skills variables. With this

approach we can find whether certain types of employees give an enhanced or a decreased externality effect on productivity. Table 6 presents the results of these estimations.

Table 6. Regressions including combined variables. Dependent variable: average labor productivity.

Variables	**Model IV**	**Model V**	**Model VI**	**Model VII**	**Model VIII**
Firm characteristics					
Labor	-0.197***	-0.185***	-0.211***	-0.124***	-0.120***
Maturity	0.0900***	0.0913***	0.0884***	0.0977***	0.0975***
Employee tenure	0.117***	0.116***	0.119***	0.106***	0.106***
Age	-0.239***	-0.235***	-0.221***	-0.288***	-0.299***
Female	-0.0226***	-0.0228***	-0.0247***	-0.0181***	-0.0184***
Regional characteristics					
Diversity		-0.0677***	-0.0730***		
Specialization	0.0674***		0.0596***		
Labor matching	0.103***	0.103***			
Competition					0.0404***
Relative competition				-0.0215***	
Employment rate				0.267***	-0.0455
Combined variables					
Diversity Education	0.117***				
Diversity Cognitive	0.0753***				
Diversity Management	0.117***				
Diversity Social	-0.0700***				
Diversity Motor	-0.0998***				
Specialization Education		0.108***			
Specialization Cognitive		0.0656***			
Specialization Management		0.106***			
Specialization Social		-0.0808***			
Specialization Motor		-0.108***			
Labor matching Education			0.115***		
Labor matching Cognitive			0.0812***		
Labor matching Management			0.119***		
Labor matching Social			-0.0774***		
Labor matching Motor			-0.100***		
Competition Education				0.106***	
Competition Cognitive				0.0406***	
Competition Management				0.0880***	
Competition Social				-0.0745***	
Competition Motor				-0.115***	
Relative com Education					0.110***
Relative com Cognitive					0.0403***
Relative com Management					0.0872***
Relative com Social					-0.0749***
Relative com Motor					-0.121***
Dummy variables					
Industry dummies	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Size dummies	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Constant	6.062***	6.578***	6.503***	5.351***	6.742***
R^2	0.108	0.109	0.111	0.102	0.100
Observations	35,856	35,856	35,856	35,856	35,856

*** p<0.01, ** p<0.05, * p<0.1.

The analysis of the variables describing firm characteristics is basically the same as above which indicates robustness of the results. Also the results for the individual externality measures resemble those in table 5, with the exception of externalities concerning the labor market. The coefficient for labor matching is almost twice the size which shows an increased importance of matching firm and regional workforces when channeling the externality measures through education and skills. However, due to the differences in this coefficient we cannot draw any conclusions on the size of the productivity-enhancing effect of labor market matching. In the very last model, the previously highly significant employment rate variable becomes insignificant, which further indicates that it is difficult to draw conclusions about the size of labor market externalities.

However, what is most interesting is the combined variables. At a first glance it might seem as if the results are very similar for variables including different externalities. What they have in common is that an increased number of employees with university education, cognitive or management skills gives a positive productivity effect together with any of the externality measures while the opposite is true for an increased number of employees with either social or motor skills. Another result that holds over all five externalities is that cognitive skills have a significantly smaller positive impact than education and management skills.

As previously mentioned, occupations categorized as using cognitive or management skills often require experienced and/or university educated employees. This may be interpreted as what is most important for firms is to have educated and experienced employees, no matter what the economic environment looks like. However, when looking at the results more in-depth the answer is not that straightforward. The economic environment does make a difference, which has also been shown in table 5 above.

When combining the externality measures with education and skills the positive impact from an increased number of employees in any of them significantly decreases in all five cases (it even becomes negative for social and motor skills). When comparing the coefficients for the combined variables with diversity, specialization and labor market matching they are not significantly different from each other, as can be seen from the confidence intervals in Appendix 2. This is striking considering the difference in impact from externalities when used as individual variables. Even though diversity in itself has a strongly negative effect on average labor productivity while specialization and labor market matching have a positive effect they give the same results when channeled through the education and skills variables.

An explanation for this result could be that for diversity to be productivity enhancing it is dependent on educated employees. The reason for this is that those employees have in general the ability to be more open-minded and hence have the means to take advantage of diverse environments and make use of knowledge and knowledge spill-overs not directly applicable to their own fields.

Specialization, on the other hand, do not need a certain type of employees to increase productivity, it is productivity enhancing in itself. This is natural since it is easier for everyone to interact with like-minded and utilize the knowledge gained from these contacts. However, that social and motor skills give a negative productivity effect from specialization might be because these types of employees do not interact with outside actors, neither in their own industry nor in others. Hence, they have no possibility to gain productivity enhancing knowledge and since they often lack higher education they have not the ability to utilize knowledge spill-overs. Neither does labor market matching require a certain type of employees to enhance average labor productivity which is intuitive. A well-matched labor market is on average important for all firms. However, when looking more closely there is again a difference between educated and non-educated employees. This is also intuitive since when hiring employees such as machine operators it is not as important that these potential employees have certain education and skills why the labor market matching is naturally of less significance. The negative sign even shows that given a certain number of motor or social skills workers, an increased labor market matching decreases productivity.

The same reasoning as for diversity, specialization and labor matching above applies for competition on the output market and competition on the input market. Even though relative competition is negative in itself while competition is positive the effects from them are very similar when channeled through the education and skills variables. Competition on the output market does not require a certain type of employees to increase productivity in general. The opposite seems to be the case for competition on the labor market. It again boils down to the importance of education and experience. Firms are benefiting from competition for labor if they already have relatively more employees that are highly educated and/or classified as either cognitive or management skills workers. The reason for this could be that these firms are more attractive to potential employees.

Conclusions

In this paper we have tested for a broader than usual range of externalities and we have also combined some of them with the education and skills of the employees at the respective firms. Our results show that in general for the manufacturing sector specialization promotes average labor productivity while diversity decreases it. Hence, we have found evidence of MAR externalities but not Jacobs externalities. However, urbanization economies in general have a positive impact on productivity. Also competition on the output market promotes productivity which shows evidence of Porter externalities, while being situated in a municipality which is relatively more competitive on the input market decreases productivity. Another important type of externalities concerns the labor market, labor market matching and the employment rate have positive impacts on average labor productivity, even though it is difficult to make conclusions about the size of the effects.

When channeling the externality effects through education and skills of the employees we come to the conclusion that for the KIBS sector everything seems to boil down to the importance of education and experience. This is not surprising considering the characteristics of this sector (see Miles et al. (1995)). The KIBS sector is extremely knowledge, technology and labor intensive which makes it naturally dependent on highly educated employees. A result that differs from the general ones above is that for firms to benefit from a diverse economic environment they need to have educated employees in general and cognitive and management skills workers in particular. An important conclusion from these results is that when investigating the impact of externalities it is critical to look at the composition of the workforce, since it is through the employees that the spillover effects reach the firm as a whole. This is also of importance for managers when they deciding upon locations for their firms. What type of environment that is beneficial for the firm depends upon the types of employees.

Our results are interesting and important also from a policy perspective. In general, we have shown the importance of matching the regional workforce with the regional firms. This can be done either by educating the inhabitants so that they match the needs of the firms or by attracting suitable firms for the current characteristics of the workforce. The right solution certainly differ between different municipalities. However, if a region wants to retain and attract KIBS firms in particular it is important that the regional workforce is appropriately educated. We have also shown that it is not straightforward to promote either diversity, specialization or competition in a region. As for managers it is important to take the

composition of the regional workforce and the regional industry structure into consideration when deciding upon policies for the economic environment. For competition issues, it is also important to distinguish between different types of competition and also take the economic environments of surrounding municipalities into consideration when making policy decisions. On the whole, more research is needed before any clear answers can be given.

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Appendix 1

SIC code	Description	Number of firms
72	*Computer and related activities*	
7210	Hardware consultancy	253
7221	Publishing of software	1260
7222	Other software consultancy and supply	4916
7230	Data processing	243
7240	Data base activities	150
7260	Other computer related activities	82
73	*Research and development*	
7310	Research and experimental development on natural sciences and engineering	538
7320	Research and experimental development on social sciences and humanities	48
74	*Other business activities*	
7411	Legal activities	1840
7412	Accounting, book-keeping and auditing activities; tax consultancy	3929
7413	Market research and public opinion polling	145
7414	Business and management consultancy activities	7915
7420	Architectural activities and related technical consultancy	7959
7430	Technical testing and analysis	183
7440	Advertising	3127
7450	Labor recruitment and provision of personnel	1091
7487	Other business activities n.e.c.	2177

Source: Statistics Sweden for SIC-codes and descriptions, definition of the KIBS sector is based on Nählinder (2005).

Appendix 2

Combined variables	Coefficient	Std. error	95 % Confidence Interval	
			Lower bound	Upper bound
Diversity Education	0.117	0.00880	0,099752	0,134248
Diversity Cognitive	0.0753	0.00810	0,059424	0,091176
Diversity Management	0.117	0.00863	0,1000852	0,1339148
Diversity Social	-0.0700	0.00908	-0,0877968	-0,0522032
Diversity Motor	-0.0998	0.00933	-0,1180868	-0,0815132
Specialization Education	0.108	0.00873	0,0908892	0,1251108
Specialization Cognitive	0.0656	0.00753	0,0508412	0,0803588
Specialization Management	0.106	0.00806	0,0902024	0,1217976
Specialization Social	-0.0808	0.00857	-0,0975972	-0,0640028
Specialization Motor	-0.108	0.00869	-0,1250324	-0,0909676
Labor matching Education	0.115	0.00876	0,0978304	0,1321696
Labor matching Cognitive	0.0812	0.00774	0,0660296	0,0963704
Labor matching Management	0.119	0.00815	0,103026	0,134974
Labor matching Social	-0.0774	0.00835	-0,093766	-0,061034
Labor matching Motor	-0.100	0.00847	-0,1166012	-0,0833988
Competition Education	0.106	0.00881	0,0887324	0,1232676
Competition Cognitive	0.0406	0.00742	0,0260568	0,0551432
Competition Management	0.0880	0.00798	0,0723592	0,1036408
Competition Social	-0.0745	0.00840	-0,090964	-0,058036
Competition Motor	-0.115	0.00852	-0,1316992	-0,0983008
Relative com Education	0.110	0.00884	0,0926736	0,1273264
Relative com Cognitive	0.0403	0.00765	0,025306	0,055294
Relative com Management	0.0872	0.00818	0,0711672	0,1032328
Relative com Social	-0.0749	0.00856	-0,0916776	-0,0581224
Relative com Motor	-0.121	0.00861	-0,1378756	-0,1041244

Source: Own regressions.