Paper to be presented at the DRUID 2011

on

INNOVATION, STRATEGY, and STRUCTURE -
Organizations, Institutions, Systems and Regions
at
Copenhagen Business School, Denmark, June 15-17, 2011

AGGLOMERATIONS AND FIRM PERFORMANCE: ONE FIRMâ€™S MEDICINE IS ANOTHER FIRMâ€™S POISON

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Abstract

In this paper we aim to reduce the ambiguity surrounding the agglomeration-performance relationship. We do so by taking firm- and agglomeration-level heterogeneity into account simultaneously and focusing on the interactions between

these two levels of analysis. Our central argument is that different firms may be influenced differently by different dimensions of agglomeration. To assess our claims we estimate multi-level models with non-linear interaction effects between the agglomeration (urbanization, specialization, and knowledge intensity) and firm-level variables (size, internal knowledge base, and face-to-face contacts) using data from a sample of Dutch firms. Our results show that the effects of different dimensions of agglomeration on firm performance are strongly and nonlinearly moderated by firm characteristics. Moreover, the moderation effect is not uniform across the different agglomeration dimensions.

Jelcodes:R11,-

ONE REGION DOES NOT FIT ALL - THE MODERATING EFFECT OF FIRM CHARACTERISTICS ON THE RELATION BETWEEN AGGLOMERATION AND FIRM PERFORMANCE

ABSTRACT

In this paper we aim to reduce the ambiguity surrounding the agglomeration-performance relationship. We do so by taking firm- and agglomeration-level heterogeneity into account simultaneously and focusing on the interactions between these two levels of analysis. Our central argument is that different firms may be influenced differently by different dimensions of agglomeration. To assess our claims we estimate multi-level models with non-linear interaction effects between the agglomeration (urbanization, specialization, and knowledge intensity) and firm-level variables (size, internal knowledge base, and face-to-face contacts) using data from a sample of Dutch firms. Our results show that the effects of different dimensions of agglomeration on firm performance are strongly and nonlinearly moderated by firm characteristics. Moreover, the moderation effect is not uniform across the different agglomeration dimensions.

Keywords: Agglomeration, clusters, knowledge externalities, firm performance, productivity

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INTRODUCTION

During the last two decades, along with the proliferation of research on geographical agglomerations, strategy researchers have paid increasing attention to the performance implications for firms of locating in agglomerations. Early theoretical research, in an effort to explain the emergence of agglomerations, has concentrated predominantly on positive performance effects as incentives for firms to co-locate (Arikan, 2009a; Jacobs, 1969; Marshall, 1920; Piore & Sabel, 1984; Tallman et al., 2004). Over the years, much empirical evidence has accumulated for such positive performance effects (Baptista & Swann, 1998; Bell, 2005; DeCarolis & Deeds, 1999; Molina-Morales & Martinez-Fernandez, 2003). More recently, researchers have started highlighting possible negative performance effects (Arikan & Schilling, forthcoming; Pouder & StJohn, 1996), and a sizable amount of empirical support for such effects has emerged as well (Appold, 1995; Glasmeier, 1991; Shaver & Flyer, 2000; Staber, 1998; Stuart & Sorenson, 2003). In the face of these findings, the net performance effect for firms of locating in geographical agglomerations remains ambiguous, pointing to a need for a qualification of the performance-agglomeration relationship.

Our goal in this paper is to reduce this ambiguity by qualifying the performance-agglomeration relationships. We base our contribution on two significant developments that characterize the literature on the performance-agglomeration relationship. First, recent research showed that agglomerations are not homogenous but vary along several dimensions (Arikan, 2009b; Arikan & Schilling, forthcoming; Gordon & McCann, 2000; Markusen, 1996), yet research on the effect of *agglomeration-level heterogeneity* on the performance-

agglomeration relationship has been far from conclusive (Beaudry & Schiffauerova, 2009; Kukalis, 2010; McCann & Folta, 2008). Second, even though there is enough evidence to show that firms are not homogenous in terms of how much they are influenced by agglomeration effects (Alcacer, 2006; Chung & Kalnins, 2001; Giuliani & Bell, 2005; McEvily & Zaheer, 1999; Molina-Morales & Martínez-Fernández, 2009; Shaver & Flyer, 2000), *firm-level heterogeneity* has been understudied in the context of the performance-agglomeration relationship (McCann & Folta, 2008). Overall, the possibility that different firms may be influenced differently by different dimensions of agglomeration remains unexplored.

To fill this gap, we first argue that agglomerations are heterogeneous along three orthogonal dimensions (i.e., (1) level of urbanization, (2) level of specialization, and (3) level of knowledge intensity) that give rise to orthogonal performance implications for firms. Then we hypothesize that a firm's (1) size, (2) strength of internal knowledge base, and (3) level of local connectedness influence how much, and in what direction (positive vs. negative) the firm's performance will be influenced by locating in an agglomeration. The unique aspect of our study is that it not only deals with two levels of analysis (i.e., the agglomeration and firm levels), it also focuses on the interactions between these two levels of analysis (Short et al., 2007). Accordingly, it responds to recent calls for a multi-level interactionist perspective on the study of firms located in agglomerations (Beugelsdijk, 2007; McCann & Folta, 2008).We test our hypotheses by estimating multi-level models with non-linear interaction effects between the agglomeration and firm-level variables using survey data from a sample of Dutch firms. Our results show that the effects of different dimensions of agglomeration on firm performance are strongly and nonlinearly moderated by firm characteristics. Interestingly, the moderation effect is not uniform across the different agglomeration dimensions. For example, medium-sized firms benefit from higher urbanization and higher

specialization whereas small and large firms are negatively affected by these dimensions. For the level of knowledge intensity, however, we find the exact opposite with small and large firms benefiting from higher levels and medium sized firms suffering from it.

Our results have important research, policy, and managerial implications. First, our results clearly signal the importance of taking firm level heterogeneity as well as agglomeration level heterogeneity into account in agglomeration research. In terms of policy, agglomeration policy is predominantly based on the idea that what is good for the goose is good for the gander; in other words that stimulating a particular type of agglomeration will (equally) benefit all firms in a that region (Braunerhjelm & Feldman, 2006). Our results reveal, however, that stimulating agglomeration and clustering might provide severe disadvantages for particular types of firms. Managerial implications from our findings point to the importance of inter-regional relocations as a strategic instrument to solve 'misfits' between the firm and its geographical environment that are likely to emerge as firms grow and develop (Knoben et al., 2008).

The remainder of this paper is structured as follows. In the next section, we introduce the three dimensions of agglomeration and explain how they relate to firm performance. Then, we present hypotheses as to how firm characteristics moderate the performance-agglomeration relationship. The third section introduces our measures, data and methodology. Our results are presented in the fourth section, and the fifth section concludes.

THEORETICAL FRAMEWORK

One of the key ideas in agglomeration research is that spatial concentration of economic activity leads to the emergence of externalities in the form of emergent, collective resource pools. Access to these resource pools are limited to co-located firms, which in turn provides them with a competitive advantage over isolated firms (Appold, 1995; Knoben et al., 2008).

Below, we discuss the three most commonly studied dimensions of agglomeration (i.e., the level of urbanization, the level of specialization, and the level knowledge intensity), which give rise to different types of externalities (Anselin et al., 1997; Audretsch, 2003).

Dimensions of Agglomeration

Level of urbanization. Urbanization refers to the *"sheer number of and variety of division of labor within a region"* (i.e. industrial density and diversity) (Jacobs, 1969: 59). The presence of a diverse set of industries within a region implies the possibility of the presence in the region of inter-industry complementary knowledge, which in turn provides fertile ground for innovation and growth (Frenken et al., 2007). Since industrial diversity is largest in cities (Jacobs, 1969) urban areas give rise to externalities primarily by creating opportunities for firms in different industries to exchange ideas and knowledge in an effort to explore and exploit complementarities, and secondarily by giving rise to well-developed infrastructures (electronic as well as transportation), local specialized services, and a geographically-concentrated market. All of these characteristics of urbanized regions imply the possibility of positive performance effects of agglomeration.

As implied above and as we explain in detail later, urbanization only creates a *potential* for positive performance effects and not all firms enjoy positive effects equally. In contrast, a high level of urbanization creates definite negative performance effects for all firms. For example, when many firms agglomerate in space, competition for land, workers and utility services increases which is likely to drive up their costs and lead to shortages (Flyer & Shaver, 2003; Folta et al., 2006). In addition, urbanization often implies congestion costs as well as higher costs of living and doing business (Pouder & StJohn, 1996; Prevezer, 1997). All these factors influence firm performance negatively, and in some cases so much so that

they offset the benefits of urbanization (Arikan & Schilling, forthcoming; Broersma & van Dijk, 2008).

Level of specialization. Specialization relates to the extent to which a particular industry constitutes the bulk of the total economic activity in a region (Glaeser et al., 1992).[1] It gives rise to an externality by the possibility for firms from the same industry to learn from each other. More specifically, specialization may lead to the (sometimes unintended) transmission of knowledge and ideas between firms, facilitate the spreading of products and processes within a given industry, stimulate (serendipitous) business interactions, and ease the mobility of skilled labor (Saxenian, 1994). Due to these factors, firms in specialized regions may become more innovative and productive, and grow faster compared to their counterparts in non-specialized regions.

As we explain in detail later, not all firms enjoy the potential positive performance effects of specialization equally. In contrast, a high level of specialization creates definite negative performance effects for all firms due to increased local competition (Melo et al., 2009; Sorensen & Sorenson, 2003). When there is an agglomeration of firms producing similar products or services, at some point the market will become saturated and new establishments will find it difficult to get a foothold (Sohn, 2004). In such saturated agglomerations, margins are smaller and profits diminish, resulting in lower performance particularly by firms that fail to enjoy the above-mentioned positive performance effects of specialization (Staber, 1998).

Level of knowledge intensity. Both the level of urbanization and the level of specialization create performance effects due to reasons associated with knowledge

[1] Note that specialization and urbanization are orthogonal dimensions. To illustrate, a region may be characterized by both a high level of urbanization and a high level of specialization due to the presence of many industries in the region and one of these industries constituting the bulk of the total economic activity in the region.

externalities as we have explained above. The third dimension that we consider - level of knowledge intensity - is orthogonal to both of the preceding two dimensions in that it relates not to the industrial affiliations of co-located firms but to their ability to produce new knowledge. Knowledge spillovers are likely to take place in all agglomerations, however they are likely to generate larger performance effects in agglomerations where co-located firms are more capable of producing new knowledge (Beaudry & Breschi, 2003). Agglomerations where firms are not capable of producing new knowledge are likely to get locked into obsolete technologies over time, which generates negative performance effects (Glasmeier, 1991; Pouder & StJohn, 1996).

A high level of knowledge intensity in an agglomeration may also give rise to negative performance implications for some firms. For example, the presence of highly capable knowledge producing-firms is likely to accentuate local competitive pressures leading to lower performance for weaker firms (Pouder & StJohn, 1996). Furthermore, knowledge externalities are bi-directional, so firms are confronted with spill-ins as well as spill-outs (Lavie, 2006). For the most capable knowledge-producing firms, the balance of spill-outs vs. spill-ins may be negative giving rise to negative performance implications (Shaver & Flyer, 2000).

A fair amount of research has been conducted on the relationship between these three dimensions of agglomeration and firm performance. Yet two recent literature reviews reveal a lack of consensus not only on which agglomeration dimensions influence firm performance, but also on the net performance effect of those dimensions (Beaudry & Schiffauerova, 2009; McCann & Folta, 2008). We hold that part of this ambiguity may be resolved by considering how firm-level heterogeneity in combinative capabilities may moderate the performance-agglomeration relationship.

Firm Level Heterogeneity

Our discussion of the three dimensions of agglomeration highlight the *potential* positive performance effects knowledge externalities generate for agglomerated firms. Agglomerated firms can realize these potential benefits only to the extent that they are capable of using knowledge from other, co-located firms in combination with their own knowledge assets to create value (McCann & Folta, 2011). Kogut & Zander (1992) argue that firms vary significantly on these "combinative capabilities". The variations are proposed to be a function of a firm's: (1) organizing principles (as determined by its size), (2) strength of internal knowledge base, and (3) local connectedness (Kogut & Zander, 1992). We expect these factors to have direct effects on firm performance here however we focus on their moderating effects on the performance-agglomeration relationship.

Organizing principles. The first component of a firm's combinative capabilities is "organizing principles" defined as the firm's ability to coordinate different parts of the organization and transfer knowledge among them (Kogut & Zander, 1992; McCann & Folta, 2011). Size plays a large role in a firm's organizing principles. For very small firms, organizing principles reside fully with the entrepreneur or the manager of the firm whereas for larger firms "organization" is increasingly achieved through impersonal means such as standard operating procedures, routines, and/or dedicated organizational structures.

The literature points to the inertia and rigidity associated with larger firm size (Henderson & Clark, 1990). Due to the complexity of large firms, actions between large numbers of people need to be coordinated resulting in highly institutionalized and rigid rules and procedures. These structures may reduce large firms' openness to their environment as well as their flexibility and consequently prevent them from finding and effectively integrating

externally available resources to their existing resources (McCann & Folta, 2011). The literature also emphasizes the inability of very small firms to internalize externally available resources (Deeds & Rothaermel, 2003). Full reliance on one or a few individuals to assess, access, and internalize externally available resources without procedures, routines or dedicated units to aid such processes is likely to result in missed opportunities as well as a lack of a capability to utilize external resources (Kale et al., 2002).

Thus when a firm is too big or too small, it is unlikely to fully benefit from positive performance effects of agglomeration, but it still suffers from the negative performance effects mentioned above. We expect the net agglomeration effect to be negative for such firms.

H1: *Firm size is an inverted U-shaped moderator of the agglomeration-performance relationship such that the relationship is likely to be positive for medium-sized firms and negative for very small and very large firms.*

Strength of the internal knowledge base. The second component of a firm's combinative capabilities is its existing knowledge base (Kogut & Zander, 1992). As Cohen and Levinthal (1990) argue, the stronger a firm's existing knowledge base, the better it can assess, access, and internalize externally available knowledge. This means that the stronger a firm's internal knowledge base, the stronger the magnitude of positive performance effects of agglomeration, making it more likely for the net performance effect of agglomeration to be positive for the firm. On the other hand, a strong internal knowledge base also means a higher amount of unintentional spillovers of valuable knowledge out of the firm. (Shaver & Flyer, 2000). These outgoing externalities are likely to erode the firm's relative advantage over other firms in the region (Alcacer & Chung, 2007; Pouder & StJohn, 1996). Thus, an internal knowledge base

of moderate strength is likely to be most beneficial in terms of benefitting from agglomeration effects.

H2: Strength of internal knowledge base is an inverted U-shaped moderator of the agglomeration-performance relationship such that the relationship is likely to be positive for firms with moderately strong internal knowledge bases and negative for those with very strong and very weak internal knowledge bases.

Level of local connectedness. The third component of a firm's combinative capabilities relates to the number of its localized connections (Kogut & Zander, 1992). Even though agglomeration benefits are proposed to accrue largely due to geographical proximity between firms without the necessity of any interaction between them (Gordon & McCann, 2000), firms also actively and purposefully collaborate with other firms to obtain, exchange, or mutually develop resources (Aharonson et al., 2008; Ronde & Hussler, 2005; Zucker et al., 1998). The benefit of collaborating with other firms in the same region comes from the fact that geographical proximity facilitates planned as well as serendipitous face-to-face interactions which foster the exchange of tacit knowledge (Knoben & Oerlemans, 2006; Storper & Venables, 2004). As such, maintaining a high number of local connections might allow firms to better extract resources from their geographical environment, which in turn makes it more likely for such firms to enjoy a net positive effect of agglomeration.

As important as local connections may be, firms also need connections with distant firms (Rosenkopf & Almeida, 2003; Zaheer & George, 2004). As Arikan (2009) argues, firms need to devote time, attention and other limited resources to each collaborative relationship so that relational routines and relative absorptive capacity (Lane & Lubatkin, 1998) may develop and the gains from the relationship may be maximized. The higher the number of local

connections a firm maintains, the less time, attention and other limited resources it has to devote to establishing and maintaining relationships with firms outside the agglomeration. The absence of outside relationships may cause to firm to become technologically locked in and unresponsive to changes originating from outside the agglomeration (Knoben, 2009; Narula, 2002). Based on these arguments, we expect firms that maintain a moderate number of local connections to benefit most from agglomeration effects.

H3: *Number of local connections is an inverted U-shaped moderator of the agglomeration-performance relationship such that the relationship is likely to be positive for firms that maintain a moderate number of local connections and negative for those with very high and very low numbers of local connections.*

DATA AND METHODOLOGY

Data

For the firm-level information, our paper draws data from an establishment level survey that was conducted in 2005 in the Netherlands. The survey targeted firms in the manufacturing and business services industries. We excluded retail industries and customer-related services as these predominantly follow the distribution of the population and are therefore unlikely to exhibit distinct and geographically differentiated patterns of agglomeration. Moreover, we focused our survey on the eight biggest cities in the Netherlands and their (rural) surroundings. This implies that we targeted firms in a total of 136 out of 467 Dutch municipalities.

Within the manufacturing and business services industries in the selected regions, we took a random stratified sample, taking firm size, industry and region (i.e. municipalities) into account. This sample was taken from the LISA database (an employment register of all Dutch

organizations at the establishment level) but we included only firms with more than one employee. The reason for this latter choice is that the Netherlands is characterized by an extremely large number of self-employed people without personnel (well over a million in a labor force of less than eight million) who register their 'business' at their home address. However, these self-employed people do not truly own a business establishment but rather keep working for (several) larger organizations. The reasons to register as a self-employed are largely related to tax and social security benefits. As such, including this group of firms in our research would bias our results.

Ultimately, the size of the sample was 28637 firms. The survey was targeted at the directors or owners at the establishment level. After a round of reminders, the response rate was approximately 7% (N=2009) and the final sample is representative for the stratification by region, size and industry. Table 1 summarizes the population and survey responses.

Insert table 1 here

Measurements: firm level

Firm performance. Earlier research on the relation between agglomeration effects and firm performance has utilized a wide array of different performance indicators. Some of the measures used are highly context dependent such as 'revenues per room' in the lodging industry (e.g. Canina et al., 2005; Chung & Kalnins, 2001), 'IPO valuation' in the biotech industry (e.g. DeCarolis & Deeds, 1999) or 'patenting' in high-tech industries (e.g. Folta et al., 2006). Since our sample consists of a heterogeneous group of firms, these context-specific measures are unsuitable for our study. For example, due to large differences in the propensity to patent between small and large firms and between industries (Arundel & Kabla, 1998), patents would be a very biased performance indicator for our research context.

Performance measures that are frequently used in cross-industry studies are employment growth and productivity (Beaudry & Schiffauerova, 2009). Employment growth, however, has been heavily criticized as a performance measure (Almeida, 2007; Cingano & Schivardi, 2004; Dekle, 2002). For example, well performing firms investing in labor-saving innovations, particularly in the manufacturing industries, would be reflected as poor performers with such an indicator (Delmar et al., 2003).

Considering the above issues, we decided to adopt the level of productivity of the firm, measured as the added value of a firm per employee, as our performance measure. This widely used measure (e.g. Beaudry & Swann, 2009; Cantwell, 2009; Ciccone, 2002; Ciccone & Hall, 1996; Delmar et al., 2003; Le Bas & Miribel, 2005) is most suitable for our setup that by definition incorporates a large amount of firm heterogeneity. The firm's added value is determined as the yearly gross turnover in 2004 minus purchases for that year (all intermediate goods and service needed in the production process of the firm). The added value includes the firm's taxes, subsidy, wages, and profits. Productivity is distilled by dividing the added value at the firm level by the number of employees of the firm (again measured for 2004).

Firm size. Firm size was measured by the gross sales of the firm in the year 2004. As with our dependent variable, the choice of our size measure was heavily influenced by the research design which aimed to capture highly heterogeneous firms. Given this heterogeneity, measures of size based on employment are likely to be biased given the large differences in labor intensity between industries in general (Delmar et al., 2003) and the large amount of labor saving innovations that have implemented in manufacturing industries in particular (Cohen & Klepper, 1996). As a result gross sales is commonly considered to be the most applicable measure for firm size in cross-industry research (Cohen & Klepper, 1996).

Internal knowledge base. It is often suggested that for manufacturing firms the intensity of R&D expenditures constitutes the strength of a firm's internal knowledge base (Cassiman & Veugelers, 2006). For business services firms (which conduct less R&D, but rely heavily on professional knowledge), this is often proxied by the number of knowledge-intensive jobs (Illeris, 1996). We measure a firm's total number of knowledge-intensive occupations as a percentage of the total number of jobs within the firm. Knowledge-intensive occupations are defined as, for manufacturing firms, the number of occupations in research and development and, for business services, the number of occupations in consulting (marketing- and design-related).

Localized external linkage. The benefit of maintaining localized external links comes from the fact that geographical proximity facilitates planned as well as serendipitous face-to-face interactions which foster the exchange of tacit knowledge (Storper & Venables, 2004). As such, an external linkage is defined to be localized if the distance between the partners allows for frequent face-to-face contacts without prohibitive costs (Knoben & Oerlemans, 2006). In line with these arguments, our questionnaire contained a question in which respondents were asked to indicate what percentage of their total interorganizational contacts (regardless of their nature) took place through 'face-to-face contacts,' 'telephone contacts',' e-mail', 'tele/video-conferencing', 'snail mail', or 'other communication channels'. To operationalize the firm's localized external linkage we use the percentage of all inter-organizational contacts maintained by the firm that take place through face-to-face contacts.

Measurements: regional level

All regional variables have been measured at the level of the municipality. Not only does this correspond to the most frequently used spatial level of analysis in earlier research (Beaudry & Schiffauerova, 2009) it has also been shown to be the most relevant level of analysis for agglomeration research in the Netherlands (Van Oort, 2004).[2]

As put forth by Henderson (2003) it is to be expected that it takes time for knowledge to spill over and become embedded in firms. Following Henderson (2003), we use a three year 'lag' by linking firm productivity in 2004 to variables in the firm's geographical environment in 2002. It should be noted, however, that using different time-lags does not have any impact on the outcomes due to the stationary nature of regional characteristics. For example, the correlation between our urbanization measure based on 1995 data and 2010 data is 0.997.

Urbanization. Job density is used as an indicator of urbanization externalities stemming from a large concentration of economic activity per se (Jacobs, 1969). We use density rather than absolute number of jobs to correct for differences in geographical size between municipalities (Beaudry & Schiffauerova, 2009). Urbanization economies are thus measured by a density indicator reflecting the number of total jobs per square kilometer within the responding firm's municipality.

Specialization. Economies of specialization are, as is common practice (Beaudry & Schiffauerova, 2009; Ejermo, 2005; Glaeser *et al.*, 1992), measured by the location quotient for the region and industry in which the responding firm is active (based on its 2-digit SIC-code). The calculation of the location quotient is expressed in equation 1, in which 'i' denotes the region, 'j' denotes the industry and 'E' denotes employment.

[2] To make sure our results are not dependent on this particular spatial level of analysis we performed robustness tests to check how sensitive the results are to changes in the spatial level of analysis. Our results are not sensitive to our choice of special level of analysis (see section titled robustness checks)

$$Specialization_{ij} = \frac{E_{ij}}{\sum_j E_{ij}} \Bigg/ \frac{\sum_i E_{ij}}{\sum_i \sum_j E_{ij}} \qquad (1)$$

Please note that the specialization measure is region and industry specific whereas the other two agglomeration measures are region specific only. Again, the specialization data pertain to the year 2002.

Knowledge intensity. The regional level of knowledge intensity is measured as the percentage of all firms in a region that have generated technological innovations in a 2 year period (2000-2002). Technological innovations are defined as the introduction of new or improved products, services, or processes for which the novelty or improvement lies in the application of new or recently developed technologies.

This measure is based on the firm level Eurostat Community Innovation Survey (CIS) and has been shown to be extremely similar to other knowledge intensity measurement, such as patenting and R&D expenditures (Hagedoorn & Cloodt, 2003). The CIS measurement has the advantage over these other indicators that it is less biased towards particular types of knowledge and/or economic activities (Raspe & Van Oort, 2006).

Controls. In all of our models we include industry fixed effects to control for differences between industries that are not captures by our main effects. We included industry dummies at the 2-digit SIC level.

Descriptives and collinearity diagnostics

Descriptive statistics are presented in table 2. Because all variables were skewed to the left, they have been log-transformed. The bivariate correlations reveal our independent variables are not heavily related to each other. There is a weak negative correlation between

firm size and the intensity of use of face-to-face contacts, which is not surprising given that larger firms often have larger areas of operation. Furthermore, there are some weak correlations between firm size on the one hand and regional specialization and knowledge intensiveness on the other, indicating that larger firms are slightly more often found in such regions. Importantly, the correlations also reveal that the regional level variables we use are largely independent from each other. Even though the knowledge intensiveness of a region correlates positively with its level of urbanization and specialization, these correlations are rather low (0.201 and 0.083 respectively). These statistics show that our agglomeration dimensions are indeed orthogonal as theorized.

These low correlations are also reflected in the Variance Inflation Factors reported in table 2, which are all very close to 1 whereas the common problematic threshold values mentioned in the literature are 5 or even 10 (Greene, 2000). This is a strong indication that the data do not suffer from any collinearity problems. To reduce any collinearity problems with interaction effects, all variables that are included in interaction effects have been mean-centered before calculating the interaction variable.

Insert table 2 here

Methodology

The most important characteristic of our analysis is that it includes explanatory variables at two different levels of analysis, the firm and the region. In particular, we expect that differences in firm-specific characteristics cause firms to be differentially influenced by their context. Thus by design, all firms within a particular municipality get the same scores for their regional level variables. As a result, fitting a standard ordinary least squared regression would result in biased estimates (Hox, 2002). Matters are complicated further by the fact that

we introduce interaction effects between the different levels. To correct the potential biases resulting from this data structure we estimated multilevel models in the statistical program MLwiN (Rabash et al., 2005). Multilevel models were explicitly developed to resolve this dilemma by working at more than one level simultaneously, so that an overall model can handle the micro-scale of firms and higher order scales, like regions. The basic concept underlying multilevel modeling is the simultaneous specification of models at each level. More specifically, there is an individual-level micro model that represents the within-place equation and an ecological macro-model in which the parameters of the within-place model are the responses in the between-places model. Thus, multilevel models decompose the total variance into 'within-place' and 'between-place' components. The latter, the covariation between firm performances sharing the same regional externalities, can be expressed by the intra-class correlation (Hox, 2002).

We estimated four different models. The first model includes only firm level effects. Because we hypothesized non-linear interaction effects we have also included the squared term of these firm level variables. Model 2 includes only the regional level variables, whereas model 3 includes both the firm and the regional level variables. Finally, model 4 introduces the cross-level interaction effects.

RESULTS

Insert table 3 here

The results are presented in table 3. All four models are highly significant. Interestingly, model 2 reveals that two out of three regional level variables have no effect on firm productivity when looking at their direct effect in isolation. Only the regional level of knowledge intensity has a positive and significant effect. On the basis of these results, one

would conclude that urbanization and specialization effects do not matter for firm performance. When including firm and regional level variables (model 3) the model fit is slightly better as compared to the first two models. Again, only the regional level of knowledge intensity seems to have an effect on firm productivity. The picture drastically changes, however, when the cross-level interaction effects are included (model 4). The model fit drastically improves, both at the firm and at the regional level, and many interesting effects are revealed. However, due to their non-linear nature, these interaction effects are extremely difficult to interpret based on table 3. Therefore, the combinations of firm and regional level variables for which significant interaction effects have been found will be graphically presented.

Figure 1 presents the interaction effect between urbanization and firm size. The left-hand part of the figure presents the productivity effects of the whole range of combinations between the two variables, whereas the right-hand side of the picture presents the relation between urbanization and performance for three selected levels of firm size. The figure clearly reveals that the relation between urbanization and performance is qualitatively different for different levels of firm size. In-line with hypothesis 1, the relation is positive for medium sized firms but negative for small and large firms. Interestingly, the relation is significantly more negative for small firms as compared to large firms.

Figure 2 presents the interaction effect between specialization and firm size. Again, and in-line with hypothesis 1, the relation between the agglomeration effect and firm productivity is positive for medium sized firms, but negative for small and large firms. In this instance, however, the strength of the negative relation does not significantly differ between large and small firms.

Figure 3, as the last figure including firm size, presents the interaction effect between regional knowledge intensity and firm size. Contrary to the previous two effects and hypothesis 1 the relation between regional knowledge intensity and firm productivity is negative for medium sized firms, but positive for small and large firms.

In a nutshell, hypothesis 1 is confirmed for urbanization and specialization effects, but rejected for the regional level of knowledge intensity. Apparently there are important differences in the agglomeration effects resulting from urbanization and specialization on the one hand, and knowledge intensiveness on the other. Whereas medium sized firms are best at benefitting from the former, their performance is severely harmed by higher levels of the latter. For small and large firms, the opposite finding holds.

Insert figure 1 here

Insert figure 2 here

Insert figure 3 here

Figure 4 presents the interaction effect between regional knowledge intensity and the strength of a firm's internal knowledge base. As with the previous interaction effect of knowledge intensity, the findings contradict the hypothesis (hypothesis 2 in this case). The relation between the regional level of knowledge intensity and firm productivity is negative for firms with a moderately strong internal knowledge base, but positively for firms with a weak or strong internal knowledge base. Apparently, firms with a weak internal knowledge base are not hampered by a lack of absorptive capacity nor do firms with a strong internal knowledge base suffer from a net spill-out effect. It should be noted, however, that the

magnitude of these effects is relatively small as compared to the interaction effects including firm size. On the basis of these findings hypothesis 2 can be rejected, but we can also conclude that the strength of a firm's internal knowledge base is a relatively unimportant moderator for the relation between agglomeration effects and firm productivity.

Insert figure 4 here

Figure 5 depicts the interaction effect between the intensity of face-to-face interaction and the regional level of urbanization. Again the findings contradict the hypothesis, with firms without or with very high levels of face-to-face interactions benefitting from high levels of urbanization. Firms with medium levels of face-to-face interaction are actually hampered by higher levels of urbanization. The magnitude of the effects, however, is again relatively small. Especially when compared with those depicted in figure 6.

Figure 6 presents the interaction effect between the intensity of face-to-face interactions and the regional level of knowledge intensity. Here, the findings perfectly correspond to the hypothesized effects. Firms with moderate levels of face-to-face interactions exhibit a positive relation between the regional level of knowledge intensity and firm productivity, whereas the opposite holds for firms with no or very high levels of face-to-face interactions.

On the whole, hypothesis 3 is confirmed for the regional level of knowledge intensity but rejected for the other two regional characteristics. Interestingly the findings for the intensity of face-to-face interactions reveal large differences between the different types of agglomeration effects. Whereas firms with medium intensities of face-to-face communication benefit from being located in more knowledge intensive regions, the same firms are hampered by being located in highly urbanized areas. These findings echo the findings regarding firm size, albeit in mirror image.

Insert figure 5 here

Insert figure 6 here

The results are summarized in figure 7. Firm size seems to be the most important moderator for the relation between agglomeration effects and firm performance. The intensity of face-to-face contacts also plays an important role, but the moderating effect of a firm's internal knowledge base is marginal. In most cases where we find significant and sizeable effects, these effects correspond to the hypothesized ones. However, simply accepting or rejecting hypotheses would not do justice to one of the most salient findings, namely that there seem to be important differences between the types of firms that benefit from particular types of agglomeration dimensions. We will get back to those differences and their implications in the discussion section of this paper.

Insert figure 7 here

Robustness checks

We performed several robustness checks to assess the sensitivity of our results to changes in the variables included in the analysis. First, we estimated the equivalent of model 4 for each of the regional level variables separately, yielding results identical to those reported in table 4. As such, it is not the case that the simultaneous inclusion of the regional variables leads to distortion of their effects.

Second, to assess whether the interaction effects between the firm and the regional level are truly non-linear we estimated the equivalent of model 4 but without the interaction effects

with the squared firm level variables. The results show that in this case, the addition of the cross-level interaction effects adds relatively little explanatory power to the model as compared to model 3 and the model fit is significantly lower than for the model with the non-linear interaction effects. This provides strong support for the conclusion that firm characteristics do not linearly moderate the relation between agglomeration and performance.

Third, to rule out the possibility that our findings are driven by cross-industry differences in productivity we estimated our models for the manufacturing and the service industries separately. Even though differences in the absolute levels of productivity between these industries (captured in the industry fixed effects in our main analyses) impact on the magnitude of the coefficients, the findings with regard to the moderation of the agglomeration-performance relationship by firm characteristics are virtually identical for both industry specific models.

Finally, we examined whether our findings are sensitive to the spatial scale at which we measure our regional characteristics. Even though the municipal level is shown to be the most applicable level of measurement of agglomeration effects (Van Oort, 2004) one could raise the concern that these are administrative regions and that agglomeration effects are not necessarily limited by their boundaries (McCann & Folta, 2008). Using a higher level administrative region would suffer from exactly the same critique. Therefore we utilized spatial econometrics to come as close as possible to modeling space in a continuous way (Doh & Hahn, 2008). For each regional level variable we calculated the spatial lag for each of the municipalities based on a quadratic distance decay function and added this spatial lag to the score of the municipality itself. The result is a score for each municipality that is based on its own characteristics, the characteristics of its neighbors, the characteristics of its neighbor's neighbors and so on, with the weight of the characteristics diminishing quadratically with the distance between the regions. When estimating our models with these spatially weighted

regional variables we find identical results to those reported in table 3, indicating that our findings are robust to changes in the level of analysis of our regional characteristics.

DISCUSSION AND CONCLUSION

We set out to provide more nuanced insights regarding the relationship between agglomeration effects and firm performance. In order to so we took into account firm and regional level heterogeneity simultaneously and explicitly tested whether all firms benefit equally from different agglomeration dimensions. The results strongly indicate that this approach is highly fruitful. Our central finding is that firm characteristics do moderate the performance-agglomeration relationship in complex and non-linear ways.

Firm-level Heterogeneity within Geographical Agglomerations

We find large differences in the effects of agglomeration dimensions on firm performance across firms. In particular, firm size and the intensity of face-to-face communication exert a large moderating effect on the relation between agglomeration and performance. The strength of the internal knowledge base also moderates this relation, but to a much lesser extent. If we do not take these moderation effects into account, only the regional level of knowledge intensity seems to impact on firm performance. Including those moderation effects reveals a hidden cache of relations. As such, our results show that the idea that the performance of all firms is equally influenced by agglomeration effects is a clear fallacy (McCann & Folta, 2008). Interestingly, for several types of firms the relation between agglomeration and performance is negative. These are the firms that fail to realize the potential benefits of the agglomeration dimension but suffer from definite negative effects such as diseconomies of agglomeration, crowding effects and increased local competition. This finding underlines the importance of not only focusing on the positive effects of agglomerations, as is often the case

(Baptista & Swann, 1998; Bell, 2005; DeCarolis & Deeds, 1999; Molina-Morales & Martinez-Fernandez, 2003), but to give a fair account of their downsides as well (Arikan, 2009a).

Our findings also reveal that being bigger, having a stronger internal knowledge base, or relying heavily on face-to-face contacts is not always better in terms of benefitting from agglomeration effects. All of the interactions we find are non-linear indicating that there is always a delicate balance between benefitting and suffering from agglomeration effects. These non-linear firm-level moderation effects need to be taken into account in future research linking agglomeration effects and firm performance.

Agglomeration Level Heterogeneity within Geographical Agglomerations

We also find qualitative differences between different kinds of agglomeration effects. Especially striking is the fact that the effects of knowledge intensity on performance mirror image the effects of urbanization and specialization effects. Firms that benefit from the latter two are disadvantaged by the former and vice versa. As such, it seems fruitful to distinguish between the traditional agglomeration effects resulting from urbanization and specialization and the more novel ideas of knowledge and R&D externalities. Extant research often conflates these into single concepts such as clusters and industrial districts (Moulaert & Sekia, 2003). Given that different firms benefit from different types of agglomeration effects, disentangling them is both fruitful and necessary.

Implications

These findings not only contain fruitful directions for future research but also have important implications for policy makers and managers. Agglomeration and clustering policy is predominantly based on the idea stimulating agglomeration is beneficial for the firms

within those regions (Braunerhjelm & Feldman, 2006). Our results reveal, however, that doing so might provide severe disadvantages for particular types of firms. Which types of firms benefit and which suffer depends on the type of agglomeration being stimulated. Stimulating the co-location of similar activities (i.e. specialization), for example, is harmful for small and large firms, whereas these groups of firms would benefit from the stimulation of concentrations of knowledge intensive activities. As such, agglomeration and clustering policy should move away from generic policies and should instead be customized to the firm-level composition of the region that is being targeted with the policy.

Managerial implications from our findings pertain to the strategic importance of (re)location and decisions. There is no universal 'best' practice in terms of location choice. The optimal location for a small start-up with a weak internal knowledge base differs significantly from that of a large firm which relies heavily on face-to-face contacts. Earlier research provides some evidence that firms take regional characteristics into account during their location decision. For example, consistent with our findings, it has been shown that large firms shun highly specialized areas (Kalnins & Chung, 2004; Knoben, forthcoming). However, our results reveal that a firm's optimal locations depends on the constellation of a firm's size, internal knowledge base and dependence on face-to-face contacts. Even if the firm picks the 'right' location, a 'misfit' between the firm and its geographical environment is likely to emerge over time as the firm grows and develops. As such, our findings also point to the importance of inter-regional relocations as a strategic instrument to deal with such 'misfits' (Knoben et al., 2008). As firms develop managers should maintain a critical stance towards the location of the firm and prevent falling into the geographical path-dependence trap leading towards spatial inertia (Knoben, forthcoming; Romo & Schwartz, 1995).

Taking the above into account it comes as no big surprise that the findings of earlier studies, which often did not take firm and/or agglomeration heterogeneity into account, are rather ambiguous. Depending on the distribution of firm characteristics in the sample, the industry being researched and the particular region(s) under scrutiny the effects found could be positive, negative, and, as it frequently turned out, insignificant (Beaudry & Schiffauerova, 2009; McCann & Folta, 2008). It seems highly fruitful to re-do the analyses from earlier firm-level agglomeration papers and thereby take cross-level interaction effects into account. Doing so will allow us to assess the generalizability of the results of our research and is likely to yield a treasure trove of results.

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TABLE 1

Region	# Municipalities sampled	# Firms sampled	Response (%)
Amsterdam	16	5980	399 (6.7%)
Rotterdam	28	4818	357 (7.4%)
Groningen	12	2128	167 (7.8%)
Eindhoven	16	3763	289 (7.7%)
Apeldoorn	14	2217	162 (7.3%)
Arnhem	24	3259	271 (8.3%)
the Hague	13	3117	185 (5.9%)
Utrecht	13	3355	179 (5.3%)
TOTAL	136	28637	2009 (7.0%)

Geographical Breakdown of Population and Survey Response

TABLE 2
Descriptive Statistics and Pairwise Correlations[a]

Variable[b]	Mean	s.d.	Min.	Max.	VIF	2	3	4	5	6	7
1. Firm productivity	10.76	1.89	0.00	13.54	-						
2. Size	13.83	1.87	-9.21	20.91	1.020	-					
3. Internal knowledge base (IKB)	0.67	3.49	-4.61	4.61	1.013	0.005	-				
4. Face-to-face contacts (F2F)	3.01	2.28	-6.91	4.61	1.005	-0.052*	0.043	-			
5. Urbanization	5.63	1.10	3.01	8.03	1.043	0.002	0.032	0.002	-		
6. Specialization	0.04	0.62	-9.21	2.37	1.023	0.088**	0.099**	0.013	0.025	-	
7. Knowledge intensity	4.02	0.16	3.23	4.41	1.059	0.102**	0.024	-0.013	0.201**	0.083**	-

[a] n = 2009 organizations
[b] for all variables the natural log has been used
* $p < .05$
** $p < .01$

TABLE 3
Hierarchical Multilevel Regression Models of Firm Productivity[a]

Variable	Model 1		Model 2		Model 3		Model 4	
Firm level variables								
Size	0.31***	(0.02)			0.31***	(0.02)	0.31***	(0.02)
$Size^2$	-0.02***	(0.00)			-0.02***	(0.00)	-0.06***	(0.00)
IKB	0.05**	(0.02)			0.05**	(0.02)	0.04**	(0.02)
IKB^2	0.01*	(0.01)			0.01*	(0.01)	0.01*	(0.01)
F2F	0.04	(0.06)			0.04	(0.06)	0.08†	(0.06)
$F2F^2$	0.01	(0.01)			0.01	(0.01)	0.01	(0.01)
Regional level variables								
Urbanization			0.02	(0.05)	0.04	(0.05)	0.06	(0.05)
Specialization			0.04	(0.07)	-0.02	(0.07)	-0.18	(0.07)
Knowledge intensity			0.72**	(0.32)	0.35†	(0.28)	-1.21**	(0.59)
Cross-level interaction effects								
Size*Urbanization							-0.03*	(0.02)
$Size^2$*Urbanization							-0.01**	(0.01)
Size*Specialization							-0.03	(0.04)
$Size^2$*Specialization							-0.03***	(0.01)
Size*Knowledge intensity							-0.25†	(0.16)
$Size^2$*Knowledge intensity							0.39***	(0.05)
IKB*Urbanization							0.00	(0.02)
IKB^2*Urbanization							-0.01	(0.01)
IKB*Specialization							-0.07	(0.10)
IKB^2*Specialization							-0.01	(0.01)
IKB*Knowledge intensity							0.17†	(0.11)
IKB^2*Knowledge intensity							0.09**	(0.04)
F2F*Urbanization							0.12**	(0.05)
$F2F^2$*Urbanization							0.02***	(0.01)
F2F*Specialization							-0.07	(0.10)
$F2F^2$*Specialization							-0.01	(0.01)
F2F*Knowledge intensity							-0.96**	(0.39)
$F2F^2$*Knowledge intensity							-0.11**	(0.04)
Constant	10.86***	(0.23)	10.80***	(0.06)	10.87***	(0.23)	10.86***	(0.23)
Observations	2009		2009		2009		2009	
Number of regions	128		128		128		128	
Industry fixed effects	Yes		Yes		Yes		Yes	
R-squared regional level	56.6%		47.0%		60.2%		75.9%	
R-squared firm level	13.5%		1.0%		13.5%		18.1%	
Log-likelihood	7910.66		8239.04		7907.71		7772.15	
AIC	7922.66		8245.04		7925.71		7826.15	

[a] Standard errors in parentheses

† $p < .10$
* $p < .05$
** $p < .01$
*** $p < .001$

FIGURE 1
Graphical representation of multilevel interaction between firm size and urbanization effects

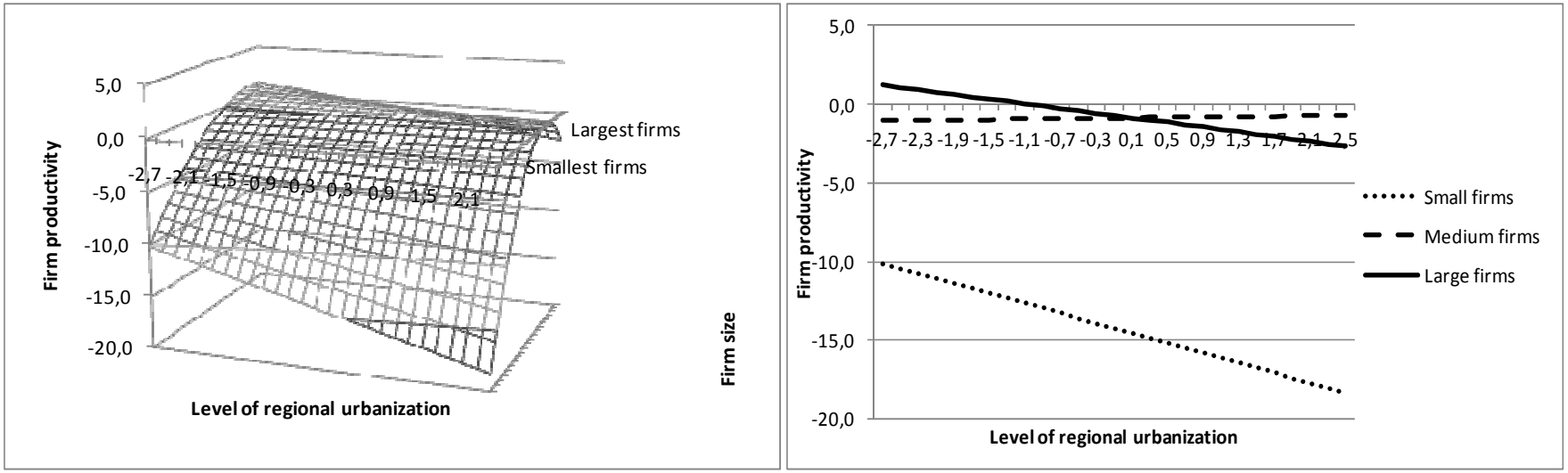

FIGURE 2
Graphical representation of multilevel interaction between firm size and specialization effects

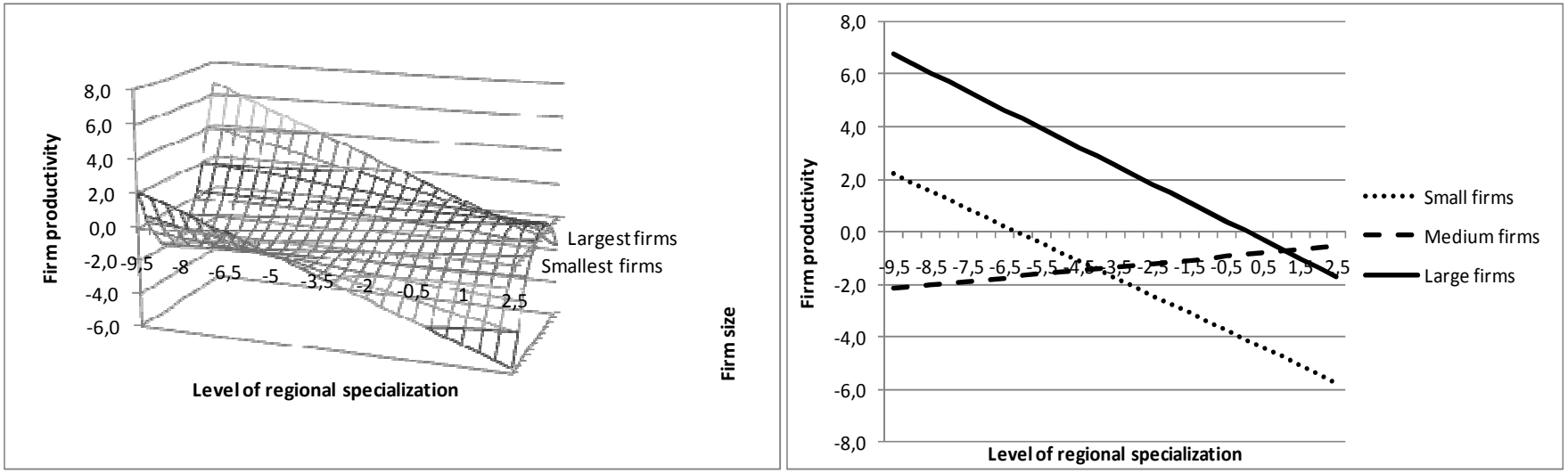

FIGURE 3
Graphical representation of multilevel interaction between firm size and knowledge intensity effects

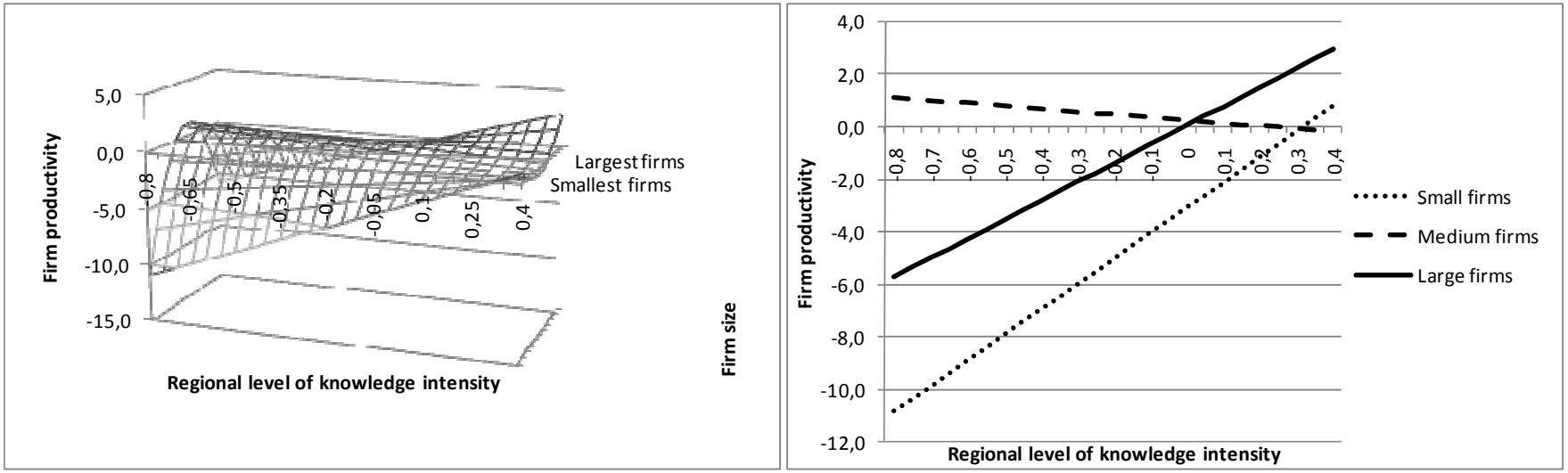

FIGURE 4
Graphical representation of multilevel interaction between internal knowledge base and knowledge intensity effects

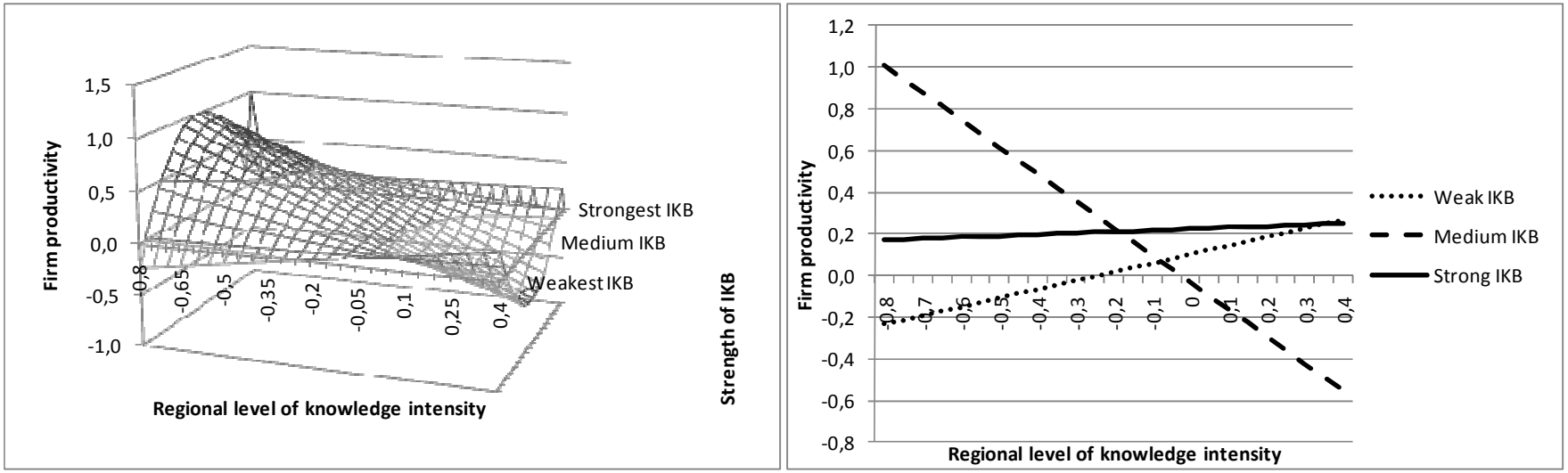

FIGURE 5
Graphical representation of multilevel interaction between F-2-F contacts and urbanization effects

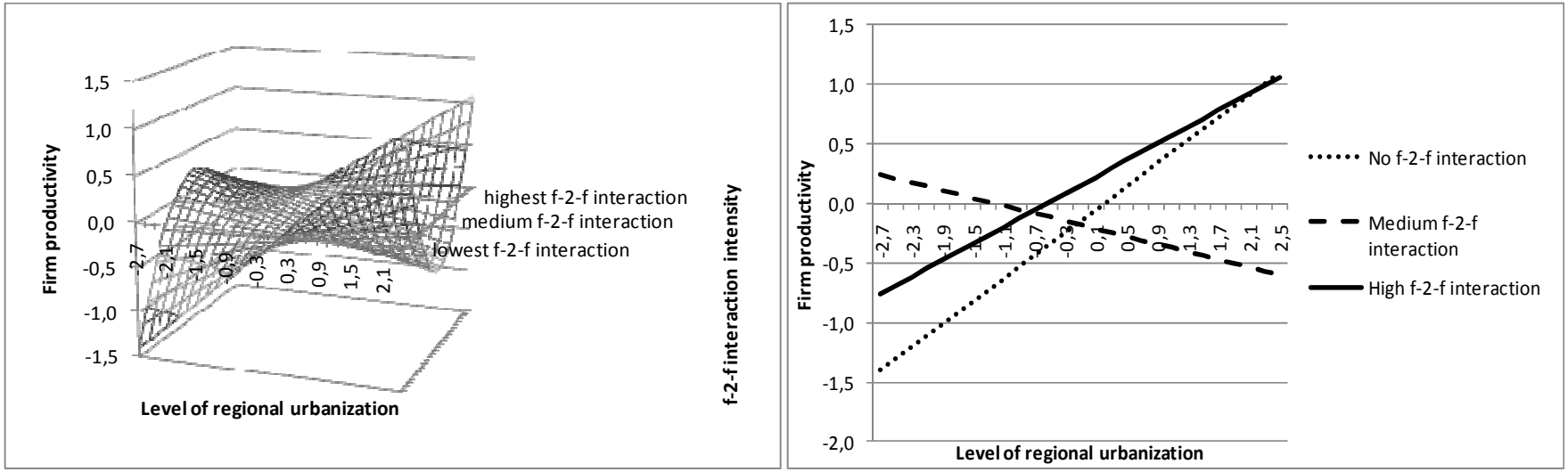

FIGURE 6
Graphical representation of multilevel interaction between F-2-F contacts and knowledge intensity effects

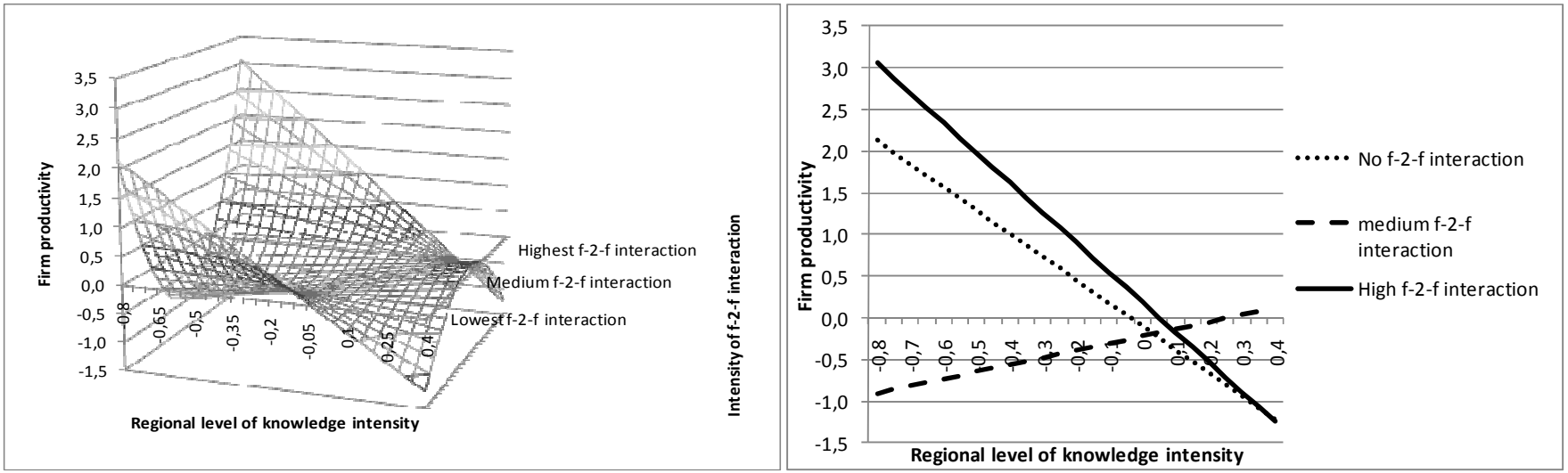

FIGURE 7
Overview of results

		Urbanization	Specialization	Knowledge intensity
H1	Size	Large effects; As hypothesized	Large effects; As hypothesized	Large effects; Counter hypothesized
H2	IKB	No significant effects	No significant effects	Small effects; Counter hypothesized
H3	F2F	Small effects; Counter hypothesized	No significant effects	Large effects; As hypothesized