AGGLOMERATIONS AND FIRM PERFORMANCE: ONE FIRM’S MEDICINE IS ANOTHER FIRM’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.

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

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 has concentrated predominantly on positive performance effects as incentives for firms to co-locate in an effort to explain the emergence of agglomerations (Arikan, 2009a; Jacobs, 1969; Marshall, 1920; Piore and Sabel, 1984; Tallman et al., 2004). Over the years, much empirical
evidence has accumulated for such positive performance effects (Baptista and Swann, 1998; Bell, 2005; DeCarolis and Deeds, 1999; Molina-Morales and Martinez-Fernandez, 2003). More recently, researchers have started highlighting possible negative performance effects (Arikan and Schilling, 2011; Poder and StJohn, 1996), and a sizable amount of empirical support for such effects has emerged as well (Appold, 1995; Glasmeier, 1991; Shaver and Flyer, 2000; Staber, 1998; Stuart and 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 and Schilling, 2011; Gordon and McCann, 2000; Markusen, 1996), yet research on the effect of agglomeration-level heterogeneity on the performance-agglomeration relationship has been far from conclusive (Beaudry and Schiffauerova, 2009; Kukalis, 2010; McCann and Folta, 2008). Second, even though there is some evidence to show that firms are not homogenous in terms of how much they are influenced by agglomeration effects (Alcacer, 2006; Chung and Kalnins, 2001; Giuliani and Bell, 2005; McEvily and Zaheer, 1999; Molina-Morales and Martínez-Fernández, 2009; Shaver and Flyer, 2000), firm-level heterogeneity has been understudied in the context of the performance-agglomeration relationship (McCann and Folta, 2008). Overall, the possibility that different firms may be influenced differently by different dimensions of agglomeration remains unexplored.

To fill this gap, we augment extant arguments regarding the agglomeration performance-relationship with insights from the knowledge based view of the firm, thereby
adding to both theoretical perspectives. Specifically, 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 combinative capabilities as manifested in its (1) organizing principles, (2) strength of the 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 takes into account both 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 by merging insights from strategic management and economic geography literatures (Beugelsdijk, 2007; McCann and 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 non-linearly moderated by a firm’s combinative capabilities. Interestingly, the moderation effect is not uniform across either the different agglomeration dimensions or the different sources of combinative capabilities.

Our results have important research, policy, and managerial implications. First, our results clearly signal the importance of taking firm-level heterogeneity (i.e., heterogeneity in firms’ combinative capabilities) as well as agglomeration level heterogeneity into account in agglomeration research. Moreover, our results show that not all types of combinative capabilities are equally valuable in a given agglomeration. Our findings indicate that the type of combinative capabilities required depends on the nature of the agglomeration in which the
firm is located. In terms of policy, agglomeration policy is predominantly based on the idea that stimulating a particular type of agglomeration will (equally) benefit all firms in a that region (Braunerhjelm and Feldman, 2006). To put it differently, it is assumed that the same “medicine” will work for all firms and regions. Our results reveal, however, that stimulating certain types of agglomeration might provide severe disadvantages for particular types of firms, thus be “poisonous”. 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 the 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 data, measures, 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). Below, we discuss the three most commonly studied dimensions of agglomeration (i.e., the level of urbanization, the level of specialization, and the level of knowledge intensity), which give rise to different types of externalities (Anselin et al., 1997; Audretsch, 2003). In particular, we discuss how each agglomeration dimension may give rise to both positive and negative performance effects for co-located firms.
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 are likely to enjoy positive effects equally. In contrast, a high level of urbanization creates definite negative performance effects for all firms too. For example, when many firms agglomerate in space, competition for land, workers and utility services increases which in turn is likely to lead to shortages and drive their costs up (Flyer and Shaver, 2003; Folta et al., 2006). In addition, urbanization often implies congestion costs as well as higher costs of living and doing business (Pouder and 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 and Schilling, 2011; Broersma and 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). It gives rise to an externality by creating 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 (Porter, 2000).

As we explain in detail later, not all firms are likely to enjoy the potential positive performance effects of specialization equally. In contrast, just as in the case of urbanization, a high level of specialization creates definite negative performance effects for all firms due to increased local competition (Melo et al., 2009; Sorensen and Sorenson, 2003). When there is an agglomeration of firms producing similar products or services, the market is likely to eventually become saturated causing new establishments to find it difficult to get a foothold (Sohn, 2004). In such saturated agglomerations, margins are smaller and profits diminish, resulting in lower performance particularly on behalf of the 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 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

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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.
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 and 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; Poudre and 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 (Poudre and 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 and Flyer, 2000).

As we summarized above, each of the three agglomeration dimensions we consider may give rise to both positive and negative performance effects for co-located firms. A fair amount of research has been conducted on the relationship between these three agglomeration dimensions 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 and Schiffauerova, 2009; McCann and 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 and 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 and Zander, 1992). Notwithstanding the fact that we expect these factors to have direct effects on firm performance as well, we only focus here 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 and Zander, 1992; McCann and 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 (Miller and Chen, 1994). 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 and Folta, 2011). The literature also emphasizes the inability of very small firms to internalize externally available resources (Deeds and 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).

The above arguments suggest that 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 definite negative performance effects mentioned above. For such firms, we expect the net agglomeration effect to be negative.

**Hypothesis 1**: 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 combative capabilities is its existing knowledge base (Kogut and 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 and Flyer, 2000). These outgoing externalities are likely to erode the firm’s relative advantage over other firms in the region (Alcacer and Chung, 2007; Pouder and StJohn, 1996). Thus, an internal knowledge base of moderate strength is likely to be most beneficial in terms of benefitting from agglomeration effects.
**Hypothesis 2:** 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 and 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 and McCann, 2000), firms also actively and purposefully collaborate with other firms to obtain, exchange, or mutually develop resources (Aharonson et al., 2008; Ronde and 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 (Bell and Zaheer, 2007; Knoben and Oerlemans, 2006). 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 and Almeida, 2003; Zaheer and George, 2004). As Arikan (2009) argues, firms need to devote time, attention and other resources that happen to be in limited supply to each collaborative relationship so that relational routines and relative absorptive capacity (Lane and 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 in turn 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.

**Hypothesis 3**: 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**

At the firm-level, we used data from an establishment level survey that was conducted in 2005 in the Netherlands. We opted for a survey instead of relying on secondary data since our research goal requires detailed data at the establishment level (rather than the consolidated firm-level) from a wide range of industries and size classes. Existing databases fail to meet at least one of these requirements. The survey targeted firms in the manufacturing and business-services industries. We excluded retail 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.

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

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2 In our sample, we included only firms with more than one employee. The reason for this 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 work for (at times several) larger organizations. The reasons to register as self-employed are largely related to tax and social security benefits. As such, including this group of firms in our sample would bias our results.
the stratification by region, size and industry. Table 1 outlines the population and response rates.

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**Measures: Firm level**

**Firm performance.** Earlier research on the relationship between agglomeration effects and firm performance has utilized a wide variety of performance indicators. Some of these measures are highly context dependent. Some examples are: "revenues per room" in the lodging industry (e.g. Canina *et al.*, 2005; Chung and Kalnins, 2001), "IPO valuation" in the biotech industry (e.g. DeCarolis and 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 not suitable for our study. To illustrate, due to large differences in the propensity to patent between small and large firms and between industries (Arundel and Kabla, 1998), patents would be a very biased performance indicator for our context.

Performance measures that are frequently used in cross-industry studies are employment growth and productivity (Beaudry and Schiffauerova, 2009). Employment growth, however, has been heavily criticized as a performance measure (Almeida, 2007; Cingano and 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, defined as the added value of a firm per employee, as our performance measure. This widely used measure (e.g. Beaudry and Swann, 2009; Cantwell, 2009; Ciccone, 2002; Ciccone and Hall, 1996; Delmar *et al.*, 2003; Le Bas and 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.** 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 been implemented in manufacturing industries in particular (Cohen and Klepper, 1996). Consequently, we used gross sales of the firm in the year 2004 as our size measure. This measure is commonly considered to be the most applicable size measure in cross-industry research (Cohen and Klepper, 1996).

**Strength of the 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 and Veugelers, 2006). For business services firms (which conduct less R&D, but rely heavily on professional knowledge), strength of internal knowledge base is often proxied by the number of knowledge-intensive jobs (Illeris, 1996). We measured 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 and 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 and Oerlemans, 2006). In line with these arguments, one question in our survey asked respondents 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 used the percentage of all inter-organizational contacts maintained by the firm that take place through face-to-face contacts.

Measures: Region level

All region-level variables were measured at the level of the municipality, which is similar to the metropolitan statistical area in the USA. This relatively low level of spatial aggregation is based on the understanding that knowledge spillovers and other spatial externalities have a rather steep distance decay function (Baldwin et al., 2010). As such, it corresponds to one of the most frequently used spatial level of analysis in earlier research (Beaudry and Schiffauerova, 2009) and has been shown to be the most relevant level of analysis for agglomeration research in the specific context of the Netherlands (Van Oort, 2004).3 Not all municipalities were included in the sampling frame, but we focused our survey on the eight biggest cities in the Netherlands and their (suburban and rural) surroundings. This implies that we targeted firms in a total of 136 out of 467 Dutch municipalities.

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3 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. We found that our results are not sensitive to our choice of special level of analysis (see section titled robustness checks)
As Henderson (2003) suggested, it takes time for knowledge to spill over and become embedded in firms. Following Henderson (2003), we used 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 rather stationary nature of regional characteristics. For example, the correlation between our urbanization measure based on 1995 data and 2010 data is 0.997. As a result, our findings are insensitive to the length of the time-lag that is used.

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

**Knowledge intensity.** The region’s level of knowledge intensity was 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 largely similar to other knowledge intensity measures such as patenting and R&D expenditures (Hagedoorn and Cloodt, 2003). The CIS measure has the advantage over these other indicators that it is less biased towards particular types of knowledge and/or economic activities (Raspe and Van Oort, 2006).
Specialization. Economies of specialization were, as is common practice (Beaudry and 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, where ‘i’ denotes the region, ‘j’ denotes the industry and ‘E’ denotes employment.

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Specialization_{ij} = \frac{E_{ij}}{\frac{\sum_j E_{ij}}{\sum_i \sum_j E_{ij}}}
\]

Note that the specialization measure is region and industry specific whereas the other two agglomeration measures (i.e., urbanization and knowledge intensity) are region specific. Again, the specialization data pertain to the year 2002.

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

Descriptive statistics 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 that our independent variables are not heavily collinear. 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 region-level variables 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 we suggested in our theory section.

These low correlations are also reflected in the Variance Inflation Factors reported in table 2, which are all very close to 1 whereas the commonly mentioned threshold values 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.

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**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 different agglomeration dimensions. Thus by design, all firms within a particular municipality get the same scores for their region-level variables. As a result, fitting a standard ordinary least squared regression would result in biased estimates (Hox, 2002). Matters are complicated further as 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 work 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 correlations (Hox, 2002).

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

RESULTS
The results are presented in table 3. All four models are highly significant. Model 1 shows two firm level characteristics with a direct effect on firm performance. Not surprisingly model 1 shows that the performance effect is positive but with diminishing returns for firm size (Barro and Sala-i-Martin, 1995) and monotonically positive for the strength of the internal knowledge base (Cohen and Levinthal, 1990). Model 2 reveals that two out of three region-level variables (i.e., urbanization and specialization) have no effect on firm productivity when looking at their direct effect in isolation. Only knowledge intensity has a positive and significant effect. Model 3 illustrates that the findings of model 1 and 2 remain unchanged when firm and region-level variables are included simultaneously. Again, the only region-level variable that seems to have an effect on firm productivity is knowledge intensity. Model 4, however, shows that the picture changes drastically when the cross-level interaction
effects are included. The model fit improves significantly and both at the firm and at the region level and many interesting effects are revealed. Due to their non-linear nature, these interaction effects are extremely difficult to interpret based on table 3. Therefore, the combinations of firm and region-level variables for which significant interaction effects were found will be presented graphically.

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Figure 1 presents the interaction effect between urbanization and firm size. Figure 1a presents the productivity effects of the whole range of combinations between the two variables, whereas figure 1b presents the relationship 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 relationship is positive for medium sized firms but negative for small and large firms. The relationship 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 relationship between the agglomeration effect and firm productivity is positive for medium sized firms, but negative for small and large firms. However in this instance, 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 relationship 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, but rejected for regional knowledge intensity. Apparently there are important differences in the agglomeration effects resulting from urbanization and specialization on the one hand, and knowledge intensity on the other. Whereas medium-sized firms are best at benefitting from the former, their performance is severely hurt by higher levels of the latter. For small and large firms, the opposite holds.

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Figure 1

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Figure 2

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Figure 3

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Figure 4 presents the interaction effect between regional knowledge intensity and the strength of a firm’s internal knowledge base. Contrary to hypothesis 2, the relationship between regional knowledge intensity and firm productivity is negative for firms with a moderately strong internal knowledge base, but positive for firms with a weak or strong internal knowledge base. Apparently, firms with a weak internal knowledge base are not hurt 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 compared to the interaction effects including firm size. On the basis of these findings hypothesis 2 can be rejected. We can also conclude that the strength of a firm’s internal knowledge base is a relatively unimportant moderator for the relationship between agglomeration effects and firm productivity.
Figure 5 depicts the interaction effect between the intensity of face-to-face interaction and 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 hurt by higher levels of urbanization. The magnitude of the effects is again relatively small, especially when compared to those depicted in figure 6.

Figure 6 presents the interaction effect between the intensity of face-to-face interactions and the regional 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 regional knowledge intensity and firm productivity, whereas the opposite holds for firms with very low or very high levels of face-to-face interactions.

On the whole, hypothesis 3 is confirmed for regional 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 levels of face-to-face communication benefit from being located in more knowledge intensive regions, the same firms are hurt by being located in highly urbanized areas. These findings echo the findings regarding firm size, albeit in mirror image.
These results are summarized in figure 7. Firm size seems to be the most important moderator for the relationship 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: 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 our discussion section.

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 region-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 region-level variables leads to distortion of their effects.

Second, to assess whether the interaction effects between the firm and region-level variables are truly non-linear, we estimated the equivalent of model 4 but without the interaction effects between the regional and 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 result provides strong
support for the conclusion that firm characteristics do not linearly moderate the relationship 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 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) influence the coefficients, the results 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 has been shown to be the most applicable level of measurement for 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 and 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 and Hahn, 2008). For each region-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 with the distance between the regions.\footnote{As we specified a quadratic distance decay function double the distance means one quarter of the weight.} 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

Explaining variance in firm performance is perhaps the most fundamental quest of strategy research (Rumelt et al., 1994). In the last couple of decades, geographical agglomerations has emerged as a prevalent context that gives rise to important performance implications for firms located within them (Porter, 2000). Yet extant research on agglomerations has so far been inconclusive with respect to which agglomeration dimensions matter for firm performance and which firms benefit the most from these dimensions.

In an effort to resolve the ambiguity surrounding the agglomeration-performance relationship, we took into account firm and region-level heterogeneity simultaneously and explicitly tested whether all firms benefit equally from different agglomeration dimensions. The value and timelines of our multilevel investigation is most evident in light of the recent special issue of Journal of Management (2011, volume 32, issue 2) that called for multilevel research that bridges the micro and macro levels of organizational analysis. Our central finding is that firm characteristics moderate the performance-agglomeration relationship in complex and non-linear ways. This central finding highlights the importance for researchers of considering both firm-level and agglomeration-level heterogeneity while studying the agglomeration-performance relationship.

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 level of face-to-face contact exert a large moderating effect on the relationship between agglomeration and performance. The strength of the internal knowledge base also moderates this relationship albeit to a much lesser extent. If we do not take these moderation effects into account, only regional knowledge intensity seems to influence firm performance. Including those moderation effects reveals a hidden
cache of relationships thus our results show that the idea that the performance of all firms is equally influenced by agglomeration effects is a clear fallacy (McCann and Folta, 2008). Interestingly, for many firms, the relationship 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 limiting our focus to the positive performance effects of agglomerations, ‘the medicine’ side of the story, as is often the case (Baptista and Swann, 1998; Bell, 2005; DeCarolis and Deeds, 1999; Molina-Morales and Martinez-Fernandez, 2003), and to pay due attention to their negative effects, ‘the poison’ side of the story, 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
We also find qualitative differences between different kinds of agglomeration effects. Model 2 reveals that when only region level variables are considered, it is knowledge intensity rather than urbanization or specialization that influences firm performance. This finding implies that regardless of how many industries are in an agglomeration or the extent to which a region specializes in a particular industrial activity (Romanelli and Khessina, 2005), co-location creates performance improvements only when co-located firms are capable of producing new
knowledge. The implication is that it is not co-location per se that generates performance effects but rather capable firms co-locating.

Also striking is the fact that the effects of knowledge intensity on performance mirror the effects of urbanization and specialization effects. Firms that benefit from the latter two are hurt by the former and vice versa. As such, it seems fruitful to distinguish between the traditional agglomeration effects resulting from urbanization and specialization (Glaeser \textit{et al.}, 1992; Henderson, 1997; Phelps, 1992) and the more novel ideas of knowledge and R&D externalities (Audretsch and Feldman, 1996; Feldman, 1999; Malmberg and Maskell, 2002). Extant research often conflates these into single concepts such as clusters and industrial districts (Gordon and McCann, 2000; Storper and Venables, 2004). Given that different firms benefit from different types of agglomeration effects, disentangling them is both fruitful and necessary.

\textbf{Theoretical Implications}

Even though our results are clearly supportive of the augmentation of agglomeration theory with firm-level arguments, they also revealed a few surprises. While we find support for three of our hypothesized relationships, three of our statistically significant results run counter to our hypotheses and three of our hypothesized relationships (although in the hypothesized direction) are statistically insignificant. These results point to the fact that the performance-agglomeration relationship is more complex than our current theories can explain.

Our finding that for a given type of agglomeration, different combinative capabilities have divergent effects indicates the need to pay closer attention to different kinds of combinative capabilities within the knowledge based view of the firm. Moreover, the fact that different combinative capabilities are beneficial in different types of agglomerations indicates
the need to more carefully theorize about what kind of resources are offered by a given type of agglomeration and what capability is required to benefit from those resources.

The combinative capabilities reflected in a firm’s organizing principles are evidently qualitatively different from the combinative capabilities resulting from the firm’s internal knowledge base and local connectedness. A possible explanation for the differences we find might lie in the different stages of the process of benefitting from regionally available resources. Local connectedness seems particularly relevant to whether important external resources can be identified and accessed. The internal knowledge base of a firm subsequently influences the extent to which the firm can absorb and internalize those resources. Finally a firm’s organizing principles influence the dissemination and utilization of that knowledge within the firm’s boundaries. So instead of viewing all three as indifferent sources of combinative capabilities, it seems fruitful to treat these as distinct types of combinative capabilities that play a role in different stages in the value creation process through combination of internal and external resources (Van den Bosch et al., 1999). As such, we conjecture that benefitting from agglomeration resources is a sequential, three-step process of finding, internalizing and utilizing the resources (see also Arikan, 2009a).

The above is not sufficient to account for the heterogeneity in our findings, as we find differences in the role played by these combinative capabilities between types of agglomerations. Interpreting these differences in light of the above, we conjecture that the nature of the resources offered by different types of agglomerations may differ, thereby putting emphasis on different parts of the above-mentioned three-step process, and on different combinative capabilities. For example, the dissemination and utilization component of combinative capabilities (i.e. organizing principles) may be particularly important in urbanized and/or specialized agglomerations, whereas the resource identification and access component may be key in knowledge intensive areas. This suggests that the potential
beneficial resources in urbanized and specialized areas are relatively easy to identify and internalize and that value creation hinges particularly upon the utilization aspect. In knowledge intensive areas, however, resource identification and access is the critical component of combinative capabilities. This interpretation is in-line with the argument that the benefits of urbanization and specialization largely come in the form of pure externalities that are potentially available to all firms, making the utilization aspect key, whereas the benefits of knowledge intensive areas are dependent on (social) interactions with knowledge creating organizations in the region, giving central stage to the identification aspect (Gordon and McCann, 2000).

To validate these interpretations, fine grained studies of resource identification, accessing, internalization and utilization within different types of agglomerations are necessary. Nonetheless, our findings clearly point in this direction and strongly denounce the idea that different types of agglomerations offer similar resources from which all firms can equally benefit.

Policy Implications

Agglomeration and clustering policy is predominantly based on the idea that stimulating agglomeration is beneficial for the firms within those regions (Braunerhjelm and 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., specialized agglomerations), 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 instead be customized to the firm-level composition of the region that is being targeted with the policy.

**Managerial Implications**

Managerial implications from our findings pertain to the strategic importance of (re)location and decisions. Our results imply that 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 and Chung, 2004). 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 context 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 (Romo and Schwartz, 1995).

Taking the above into account it comes as no surprise that the findings of earlier studies, which often did not take firm and/or agglomeration heterogeneity into account, reveal conflicting results. 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 and Schiffauerova, 2009; McCann and Folta, 2008). It seems highly fruitful to reconsider the
analyses from earlier firm-level agglomeration studies and take cross-level interaction effects into account. Doing so will allow us to assess the generalizability of our research and is likely to yield a treasure trove of results.

REFERENCES


<table>
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<th># Firms sampled</th>
<th>Response (%)</th>
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<tr>
<td>Rotterdam</td>
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<td>4818</td>
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</tr>
<tr>
<td>Groningen</td>
<td>12</td>
<td>2128</td>
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<tr>
<td>Eindhoven</td>
<td>16</td>
<td>3763</td>
<td>289 (7.7%)</td>
</tr>
<tr>
<td>Apeldoorn</td>
<td>14</td>
<td>2217</td>
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<td>Arnhem</td>
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<td>271 (8.3%)</td>
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<tr>
<td>the Hague</td>
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<td>3117</td>
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<td>3355</td>
<td>179 (5.3%)</td>
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<td>28637</td>
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<td>Min.</td>
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<td>------</td>
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*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

<table>
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<td>-0.06*** (0.00)</td>
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* Standard errors in parentheses
† p < .10
* p < .05
** p < .01
*** p < .001
FIGURE 1
Multilevel interaction between firm size and urbanization effects

Figure 1a

Figure 1b
FIGURE 2
Multilevel interaction between firm size and specialization effects
FIGURE 3
Multilevel interaction between firm size and knowledge intensity effects
FIGURE 4
Multilevel interaction between internal knowledge base and knowledge intensity effects

Figure 4a

Figure 4b
FIGURE 5
Multilevel interaction between face-to-face contacts and urbanization effects

Figure 5a

Figure 5b

-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5

Level of regional urbanization

Firm productivity

f-2-f interaction intensity

No f-2-f interaction

Medium f-2-f interaction

High f-2-f interaction
FIGURE 6
Multilevel interaction between face-to-face contacts and knowledge intensity effects

Figure 6a

Figure 6b
**FIGURE 7**
Overview of results

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