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Firm Formation and Agglomeration under Monopolistic Competition

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Abstract

In the presence of agglomeration economies one might expect a relocation and concentration of industries. Then firm start-up activities may be assumed to reveal those effects. We introduce an empirical testable model inspired by the New Economic Geography and human capital externalities literature. The novelty of this paper is that it derives a measure of agglomeration economies founded on microeconomic analysis based on households' and firms' maximization behavior, namely the real market potential. Besides agglomeration forces, dispersion and human capital effects can be separated and explicitly controlled for. The paper sheds new light on the general mechanisms of intra-industrial agglomeration forces because it explicitly considers the regional distribution of economic activities. It offers clear evidence for the empirical relevance of the New Economic Geography.

Keywords: New Economic Geography, Agglomeration, Externalities, Firm Formation

JEL classification: L 13, O 41, R 11, R 3

1 Introduction: Spatial Industrial Dynamics

Firm growth and firm formation are often seen as a crucial factor for economic growth and development. From a policy perspective, firm growth is expected to: favour regional labour demand; raise local income and welfare; and reduce unemployment. Clearly, a fashionable policy aim is therefore to foster steady (regional) firm formation. However, in the presence of agglomeration forces and positive externalities a geographical industrial concentration might occur. This, in turn, makes a few privileged regions better-off, while other regions may lose. Then a clear result is regional disparities, which are usually not in line with overall policy aims. The reasons for the emergence of such agglomeration forces are: urbanization (Jacobs 1969) and location (Marshall-Arrow-Romer) externalities; human capital externalities (Romer 1990; Lucas 1988); and increasing returns to scale. Duranton and Puga (2004) discuss and review several micro-based mechanisms of the occurrence of increasing returns (at least on an aggregate level). As a result, intra-industrial spillover effects may occur, and these are a crucial part of the New Trade Literature and the New Economic Geography (NEG).

On the other hand, dispersion forces, such as strong competition or the presence of (high) trade cost, may weaken agglomeration forces. Depending on the net balance of both effects, firms and sectors may be either equally distributed over regions or encouraged to agglomerate, so that, ultimately, multiple equilibria are possible outcomes. Both mechanisms are well known in the literature, and are explicitly addressed in the NEG literature launched by Krugman (1991). Therefore, solid empirical relevance on the NEG is essential to provide useful policy advice[1].

There is a large body of literature which aims to identify such centripetal and centrifugal forces of industries. The main contributions relating to the identification of externalities can be found in the work of Glaeser et al. (1992) and various works of Henderson (1995, 2003). Glaeser and Kerr (2009) provide evidence of several channels and types of urbanization and location externality in relation to firm formation. It is worth noting that their work does not rely on NEG models, and gives, therefore, more general evidence of externalities. Within an NEG setting, typically what is called a 'nominal wage equation' is considered and estimated[2]. This equation should support the empirical relevance of the NEG. In this context, Rosenthal and Strange (2004) summarize and discuss possible ways to measure and identify agglomeration forces. One of the ways outlined by these authors is to consider firm formation, and this is what we address in our analysis. The central question of this paper is, therefore, whether firm formation is based on the agglomeration forces and basic mechanisms of the NEG. We understand firm

[1] Our study has a limited scope, in that it does not test the NEG against competing theories (see, e.g., the discussion in Brakman et al., 2006).

[2] See Hanson (2005); Brakman et al. (2004); Mion (2003); Redding and Venables (2004); Ottaviano and Pinelli (2006); Niebuhr (2006).

formation as the change in the number of firms, respecitive establishments, in a specific sector that is located in a region. It therefore corresponds to the net change in newly established firms and firm exits.

The branch of firm growth literature typically applies wage levels and GDP per capita as crucial explanatory variables, as observed by Bergmann and Sternberg (2007). These measures are related to labour productivity and may, therefore, act as drivers for start-up activities[3]. Agglomeration forces are frequently captured by density measures, and are often treated in empirical models in an ad hoc manner. 0n the other hand, NEG models typically assume constant labour productivity, while differences in wages occur due to agglomeration rents. Then, using labour productivity measures, such as wages, to explain firm formation might be misleading, as one cannot be sure whether one is measuring labour productivity or agglomeration rents.

This intriguing issue is the point of departure for our research. We focus on sector-specific regional firm growth, but avoid using the problematic labour productivity measures as crucial explanatory variables. Instead, we derive a model of firm formation which explicitly considers agglomeration and dispersion forces. The conceptual theoretical ideas find their origin in Baldwin (1999). It is a micro-founded approach of household utility maximization and, also includes the firm's maximization problem. The resulting model states that it is not GDP per capita or wages, which explains firm formation, but the firm's real market potential measured as the expected GDP per firm. Finally, it features agglomeration and dispersion forces on an aggregate level, so that it is not necessary to include agglomeration measures ad hoc. Head and Mayers (2004a) test, on a micro-level, the effect of the real market potential on a firm's location decision, and find significant effects. In this paper, we address the question whether the suggested real market potential explains firm formation on a macro-level.

The paper is organized as follows. Next, Section 2 outlines the theoretical background, and derives the basic theoretical equation of regional sector-specific firm growth. Section 3 contains the empirical specification, introduces the database, and motivates additional control variables. Then, the estimation results are presented and discussed in Section 4. The paper ends with a conclusion in Section 5.

2 Theoretical Framework

The determinants of firm entry and firm formation are frequently addressed in the regional economics literature. Usually, regional unemployment, human capital, branch-specific needs, labour productivity, urbanization, and location externalities explain firm establishment on a regional level. The model developed in our study explicitly considers location externalities. It is grounded in, inter alia, the theoretical

[3] See Berglund and Briinniis (2001); Carree (2002); Gerlach and Wagner (1994); Ritsilii and Tervo (2002).

contributions of Baldwin (1999), who designed a model of neoclassical growth based on concepts from the New Trade Theory and NEG literature. The present paper presents the main specification of the empirical model from a theoretical perspective, but also offers some econometric applications to German regions. As the aim of this work is to study firm formation, we employ the Baldwin (1999) model, because it explicitly considers the channel of firm formation in the light of the NEG literature. Compared to other NEG models, this model explains firm's location decision on the basis of a comparison among different locations by averaging profits and costs that may be achieved in different locations. It is not influenced by the redistribution of labour which may lead to a shift in production and relocation of firms, as e.g. in the Krugman (1991) model. Also, this approach provides an intuitive explanatory variable that corresponds to the real market potential. It is empirically observable and can be described by the distribution of expenditures or consumers in space deflated by the number of competitors across space.

According to Baldwin (1999) the economy is assumed to consist of immobile households that can freely chose in which sector they want to work. They supply its labor capacity totally inelastic and therefore the labor market always clears. Households consume a variety of composite goods C from a horizontal diversified market and products A from a competitive sector. Households achieve utility from the (temporal) consumption of the C and A goods. Baldwin (1999) uses a Cobb-Douglas specification to represent the temporal utility. The inter-temporal utility of households is of the CES-type with an elasticity of inter-temporal substitution equal to 1, and a time preference B. Thus, households spend their income in either consumtion or savings. Savings are invested in a riskless assett to finance a research sector. The output of the research sector are patents and each patent represents an individual firm of the C industry.

We generalize the approach and introduce a set of horizontal diversified sectors i that provide distinct product types, such as cars or mobile phones. We employ the same utility structure as in Baldwin (1999) with the only distinction of a larger set of composite industries C_i. The parameters a_i and a_i denote industry-specific elasticities. The utility function of a representative household living in region s is given by[4]:

$$U = e^{()t} \ln(U_s)\, dt \qquad U_s = \prod_{i} C_{is}^{cx} \qquad C_{is} = (x_i^{rs})^{\frac{a-1}{a}} \tag{1}$$

$$_i = \quad _i \qquad a_i > 1 \tag{2}$$

where x_i^{rs} is the nth consumed quantity of region s of a particular firm located in region r producing in

[4] The model is the same as in Baldwin (1999) when I = 2, A = C_1 with σ_1 □ oo, C = C_2 with $\sigma_2 = \sigma$.

sector i, with N_i^w the total number of producers worldwide in that industry. A representative household maximizes its intertemporal utility and balances its income on savings and consumption. It also maximizes temporal utility subject to a budget constraint with an expenditure level E_s. The Marshallian demand curve of x_i^{rs} can be represented by[5]:

$$x_i^{rs} = \frac{(p_i^{rs})}{P_{is}} E_s 1 \quad (3)$$

where p_i^{rs} is the consumer price of the good concerned in s, and P_{is} is the perfect consumer price index of sector i in region s.

Sectors might offer rather homogeneous or heterogeneous commodities. Within the theoretical NEG framework, the sector assignment for 'competitive' and 'monopolistic' markets is given in advance. From an empirical perspective this is not very plausible. The crucial point here is whether households can distinguish products or not. If they do not distinguish products, then one will end up with one competitive sector and homogeneous goods. The advantage of the CES index is that it allows us to consider those goods in the case of an infinite positive substitution elasticity[6] a_i. Thus, we allow various producers to supply a homogeneous good, while households would consume the product with the lowest price. Then, a competitive sector results[7]. Therefore, the approach outlined here does not rely on the prior identification of sectors as 'competitive' or 'monopolistic'.

As we are interested in the location of firms, we now turn to the expected market of an individual firm. The world demand $x^r{}_i$ of a single product n manufactured in region r is simply the sum of $x^{rs}{}_i$ over all s regions. For the sake of simplicity, we utilize the concept of the 'iceberg transportation costs' T_{rs}, with $p_i^{rs} = T_{rs} q^r{}_i$, where $q^r{}_i$ is the mill price of a producer. The concept of iceberg trade costs states that a part of the shipped goods is melted away. Therefore, producers have to ship $x^{rs}{}_i$ times T_{rs}. Using these definitions, the gross demand of region s for a good produced in r is represented by:

$$x_i^{rs} = \frac{T_{rs} \quad (q^r{}_i)}{P_{is}} E_s$$

[5] See Brakman et al. (2001).

[6] For simplicity, we assume that σ_i is constant within the industry, and therefore identical for all firms in the relevant market.

[7] Let $y_i = \frac{1}{b} l_{ik}$ the production technology of a potential competitive market, where l_{ik} is the labour requirement of the kth firm. Total labour requirement L_i equals $N_i l_{ik}$. Substitution in the CES function of that particular industry yields $C_i = \frac{1}{b} L_i N_i^{\frac{1}{a-1}}$. Taking $\lim_a$ C_i yields $C_i = \frac{1}{b} L_i$, which is the typical production technology of the competitive sector in the world of NEG.

We introduce the freeness of trade[8], with ϕ_{rs} $T^{\mathbf{I}}_{rs}$. Finally, gross world demand is given by:

$$x^r{}_i = \ {}_i (q^r{}_i) \ \sum_{s}^{R} \phi_{rs} \frac{E_s}{P^{\mathbf{I}}_{is}} \tag{4}$$

Each firm faces a potential world demand, as long as there are no constraints on trade. McCann (2005) shows for iceberg trade costs in this kind of NEG models that the consumer price increases more than proportional with an increase in distance whereas empirical evidence suggests a concave price increase. In our case this 'theoretical inconsistency' would discount distant demand much stronger than expected in reality.

So far, we can derive gross world demand of a single firm $x^r{}_i$ based on household utility maximization. This is not just the demand for the products of an existing firm. It can also be seen as the expected demand or market of a potential entry firm in region r. In the following part, we will consider the firm's maximization problem to produce and supply that quantity.

Following the NEG framework, we adopt the concept of Chamberlain's monopolistic competition. According to Baldwin (1999) there is a variable input requirement of labour proportional to output. Let ${}^r_i = \frac{\mathbf{I}}{b} l_i$ be the production technology of a representative firm in region r, where l_i is the labour requirement. It should be noted that labour productivity is constant and equalized over all regions. Labour earns the exogenous wage rate w^r_i. There might be a fixed cost requirement $1r^r_i$ to produce at all. This fixed cost, or operating profit, is used to pay a dividend to shareholders, which are the households of the region where the firm is located (following Baldwin 1999). Thus, one might see it as a profit or return on assets. The $1r^r_i$ is getting important for the understanding of the location decision later on.

Maximizing profits with respect to quantity, while allowing some price-setting opportunity for each supplier, yields the standard pricing rule $q^r{}_i = a_i \mathbf{j} (a_i - \ ) \ b_i w^r_i$ for monopolistic competition. The price equation can be simplified using a theoretical conceptualization. Baldwin (1999) postulates two assumptions that make the model analytically tractable. First, workers are regionally immobile, but they can choose the industry in which they work. Second, there exists the competitive sector A where no transportation costs occur, and which is of the homogeneous producer type. Both assumptions allow us to normalize nominal wages $w =$ of the competitive sector. Because households can choose the sector in which they want to work, nominal wages over all sectors also becomes equalized. We follow Baldwin and assume that at least one of the C_i sectors is competitive and offer the property of no-transportation-costs. We can derive the pricing rule $q^r{}_i = a_i \mathbf{j} (a_i - \ ) \ b_i$. The industry-specific mill price of a firm offers a

[8] ϕ_{rs} tends towards 0, when trade costs increase. It takes the value 1, when trade is totally free.

constant mark-up on marginal cost[9].

In comparison, in trade theory, typically the price of the regional final product is normalized. In the present model this is comparable to a normalization of P_{is}, letting differences in nominal wages occur. Such a price normalization is the starting point to achieve the nominal wage equation, which is frequently applied in empirical work. In our analysis, we reverse the procedure and normalize nominal wages, such that the price of the final product P_{is} varies regionally.

So far, labour mobility through migration has not yet been taken into consideration. Neglecting migration greatly simplifies the labour market without the loss of general agglomeration and dispersion effects in the NEG sense (for a discussion of different theoretical models, see Baldwin et al. 2004). The assumption of immobile workers is, however, not found in reality. Migration affects economic outcomes, while regional differences in economic development drive further migration. In particular, group-specific migration patterns, such as the brain drain, will affect economic performance in the future. In the outlined model, migration is not yet included, so that our analysis is limited in this respect. Shifts of the labour force from one region to another would lead to a shift in expenditures E_s. From the literature on migration, we know that net migration typically occurs from 'poor' to 'rich' regions (see Nijkamp et al. 2011). In our model, migration flows would then shift expenditures from low to high performing regions, which in turn would induce agglomeration forces (so called demand-linked circular causality). By leaving out migration flows, however, we would thus underestimate the impact of the real market potential and its accelerating effect due to trans-regional labour mobility. The model of Baldwin (1999), however, still includes demand-linked circular causality because firms are the mobile factors, and the operating profits are paid to households locally, which raises regional income.

Using the pricing rule, zero profits, market clearing, and equation (4), we can now derive a coherence between operating profits π^r_i and output x^r_i, which is given by[10]:

$$\pi^r_i = {}_i a_i \frac{}{(a_i - \ )^{b_i}} \sum_s^R \phi_{rs} \frac{E_s}{P_{is}} \quad (5)$$

It should be noted here that the mark-up on marginal cost to cover π^r_i disappears in the case of $a_i \to \infty$ (competitive market). A firm's operating profit π^r_i located in r depends on the world distribution of expenditures, prices, and trade freeness[11]. E_s / P_{is} is a measure of real expenditures e_{si} in region s. The sum term is called the real market potential (Head and Mayer 2004b), which features the market-

[9] In contrast, Ottaviano et al. (2002) derive a model of variable mark-ups grounded on a linear utility specification.

[10] Solve $G = 0 = q^r_i y_i - \pi^r_i - b_i y_i$ for π^r_i.

[11] Every firm within an industry and region faces the same problem, so that we drop the index for the nth firm in the remaining part of our analysis.

access and market-crowding effects (see Baldwin et al. 2004, chapter 6). Redding and Venables (2004) split this term and relate the nominator to nominal market access and the denominator to supplier access. They discuss the effect of both measures on wages.

In the next step, we focus on P_{ir}, the (unobservable) price index. In the empirical literature this price index is often assumed to be constant over all regions, because data on regional prices are typically not available. It follows that nominal rather than real expenditures are considered. The nominal market potential is frequently used in empirical studies that investigate the implications of the NEG[12]. However, in our case with the theoretical fixing of nominal wages to unity, the price index simplifies which is the advantage of Baldwin's (1999) model. Using the household expenditure function[13], we find a coherence between P_{ir} and the regional distribution of firms of that industry[14], namely:

$$P_{ir}^{\,\mathrm{I}} = \frac{a_i}{(a_i - \;)} b_i^{\;\mathrm{I}} \sum_{r\,\mathrm{I}}^{R} N_r \phi_{rs} \qquad (6)$$

This is an interesting and striking feature of Baldwin's (1999) model. The industry-specific regional price index appears to be a generalized average depending on the trade cost and the firms' distribution. In contrast, in the model of Krugman (1991) the regional nominal wage rate is included in the sum. Using the approach of Baldwin (1999) instead, we can proxy the unobservable price index using the observable distribution of firms. Brakman et al. (2006) show other ways to approximate the price index. First, it can be achieved with the help of the regional wage distribution. Secondly, one can apply another modelling strategy which relies on non-tradable services. We stick to our measure which is the distribution of firms within sectors as an alternative approach. The simplification builds on the assumption that firm's price is that high that it covers wages and π_i^r, i.e. it covers average costs. If there should be an additional premium then the actual price is higher than the theoretical one. In such a case, the regional price P_{ir} is actually higher and therefore P_{ir} will be misspecified. Substitution of (6) in π_i^r of (5) yields:

$$\pi_i^r = \frac{i}{a_i} \sum_{s}^{R} \phi_{rs} \frac{E_s}{\sum^{R} \phi_{\;s} N_{\;i}} = \frac{i}{a_i} \sum_{s}^{R} \phi_{rs} e_s \qquad (7)$$

Within a sector, the firm's operating profit depends solely on the spatial distribution of expenditures and firms. Focus on the real market potential of a single region and for the moment ignore from trade

[12] See Niebuhr (2004).

[13] Minimizing household expenditures in any region s for a sector i yields the expenditure function $e\left(p_s, C_i^s\right)$ for this sector, $e\left(p_s, C_i^s\right) = P_{ir} C_i^s = C_i^s \left(\sum_N \left(p_i^{sr}\right)^{1-a} \right)^{\frac{1}{1-a}}$. To buy one unit of C_i^s a household has to spend P_{ir} units of 'money'. Using the pricing rule and the coherence between the consumer price p^{rs}_i and the mill price q^r_i yields the price index P_{ir}.

[14] For related technical details, see Baldwin et al. (2004) chapter 2 (appendix 2.A) and chapter 6.

cost. Then we will have RM $P_r = EjN$. If the market has a size of E = and there are 10 firms, then each firm will have an operating revenue of 10. This makes the interpretation of the real market potential measure quite realistic: It is the expected market share of a single firm, and this market share depends on the location of the firm and the competitors' distribution. We now discuss the central forces from a firm's perspective. If transportation costs rise, the demand from other regions will decrease (¢$^{i}_{rs}$ = T^{I}_{rs}). If these are infinitely large, supply/demand evidently takes place in the home region. However, if a region and its surrounding regions possess a high stock of firms, the denominator goes up, letting demand and therefore $1r_{i}^{r}$ decline. This pushes firms to other regions where less competition is expected (market crowding, dispersion force). If a firm is far away from such industrial concentrations, the denominator gets smaller, and $1r_{i}^{r}$ rises because of the discounting influence of ¢ (protection against competition). In contrast, being located in bigger markets in terms of expenditure levels raises $1r_{i}^{r}$ (home market effect, agglomeration forces)[15]. Unfortunately, the effects cannot be unambiguously separated because of the sum in the denominator. The strength of agglomeration and dispersion forces depends on, besides other things, the level of trade cost. In the light of the criticism of McCann (2005) regarding trade costs, this model would discount remote regions stronger than expected in reality. However, the general direction of the outlined effects remain. They are similar to the discussion of the nominal market-access and supplier-access effects on wages (Redding and Venables 2004). Here, however, these effects relate to firm's profits.

The operating profit $1r_{i}^{r}$ itself is (partly) unobservable, although the explanatory part is. Thus, it is therefore unfeasible to include $1r_{i}^{r}$ in an empirical model as a dependent variable, at least as long as there is no proxy available. Clearly, this operating profit is essential for the firm's location decision. A firm has an incentive to locate in a region where $1r_{i}^{r}$ – and especially its present value of such an income stream PV ($1r_{i}^{r}$) – is maximized. According to Baldwin (1999), $1r_{i}^{r}$ is a profit for shareholders of the firm, i.e. the local households.

NEG models typically consider a so-called short-run and long-run equilibria. In the short-run equilibria all markets clear and zero-profit conditions hold for a given distribution of expenditures, factors and firms. However, factor payments, i.e. differences in PV ($1r_{i}^{r}$), might be present raising incentives for relocation and, then, the mobile factors move. The relocation stops in the long-run equilibria when either factor prices are equalized and no incentives for further relocation are given. In this case dispersion of economic activities is the long-run outcome. Contrary, factor prices may differ but there are no incentives for further relocation of firms; full agglomeration appears. Another property in the long-run equilibria is that the number of firm entries are as high as firm exits. However, temporary shocks and a changing

[15] For a theoretical discussion, see also Behrens et al. (2004).

economic environment make it less likely that an economy is in the long-run eqiulibrium. We therefore consider in our analysis the short-run equilibria and analyse possible redistribution of firms in space.

Following Baldwin (1999) a firm entry takes place in the region where the present value less costs of invention / relocation offers the highest value and is positive (known as 'Tobin's q'). In the long-run equilibrium the present value to time t can be computed by $1r^{r}_{i\ lo\ g}$ deflated by the depreciation rate of firms 6 plus the interest rate r. The optimal allocation of spending and savings of households over time is derived by the intertemporal utility specification. It pins down the interest rate r to B1 the time preference of households. The long-run present value $PV_{lo\ g}$ can be computed by $PV_{lo\ g} = 1r^{r}_{i\ lo\ g}\mathbf{j}\ (6_i + B)$. This relation is only valid in the long-run equilibria, when all variables settle down at their respective long-run values. Therefore, in the short-run, the present value can be higher or lower for a given distribution of firms and expenditures in space.

Firm formation or relocation is costly because a new firm has to be 'invented'. In the case of relocation a firm depreciates in one region and has to be rebuild in another region. The model abstracts here and assumes that research activities are necessary to construct a new firm. At this stage Baldwin's (1999) model adopts channels of the innovation literature that relates to the so-called knowledge-production-function (Griliches 1979). According to Baldwin (1999), it needs $a_{F\,i}$ units of labour of a research sector to invent / construct an individual firm. Because of the normalization of wages, $a_{F\,i}$ represents the replacement cost of Tobin's q. Thus:

$$\text{Tobin's q} \ \frac{PV\ (1r^{r}_{i}.}{a_{F\,i}} \tag{8}$$

If this condition holds, we may expect a firm start-up in a particular region r. Tobin's q therefore relates to the location decission: a potential entrant considers the different expected returns that can be achieved in the distinct regions and choses the region with the highest value. Because we cannot garanty being in a long-run equilibria, we implicitly assume that the comparison of current $1r^{r}_{i}$ 'll r is a valid proxy for the present value. Put differently, if a region is in favour of an inflow of firms, in the short-run, the current $1r^{r}_{i}$ will be larger compared to other regions $1r_i{}^{r}$ and than the expected long-run profit. The current value of $1r^{r}_{i}$ will converge to the long-run value which also means that the discounted income stream is higher in the short-run than the expected long run present value $PV_{lo\ g}$; but it will converge against this value along the balanced growth path. In the model of Baldwin (1999) existing firms expand capacity, that secures zero profits, if Tobin's q is larger 1; we do not consider this fact in the analysis. The mass of new firms locating in a specific region is connected to the single location decision, and therefore relates to Tobin's q:

$$N^{ew}_{ir} \quad \frac{PV\ (1r_i{}^{r})}{a_{F\,i}} \quad \frac{PV\ (_{\underline{cx}}\ "\pounds^{R}_{s}\ \phi_{rs} e_s}{a_{F\,i}} \tag{9}$$

The sum term $"£ \, ¢_{rs}e_{is}$ is a measure of the real region-specific market potential. Bergmann and Sternberg (2007) state that agglomeration forces are directly linked to regional demand. Since $1r_i^r$ relates to demand, our approach features those effects by using a microeconomic approach. However, Bergmann and Sternberg (2007) notice that the identification of agglomeration forces is frequently captured by local wages[16] or per capita income[17] in an ad hoc way. Here the crucial explanatory variable is derived from a general model and based on the firm's profit maximization and its resulting real market potential.

As was mentioned earlier, firms leave the market at a constant rate 6_i. In the case of no firm relocation, the number of new firms must be identical to the number of firm exits. Then denser markets would have a higher firm entry rate. We therefore consider firm formation as the stock change that accounts for firm exits as well and that gives the fundament of the empirical model.

$$dN_{ir} = N_{ir}^{ew} - 6N_{ir} \qquad (10)$$

$$= \frac{PV\left(\underline{cx} \; "£^{R}_{s} \, ¢_{rs}e_{s}\right)}{a_{Fi}} - 6N_{ir} \qquad (11)$$

To summarize so far. We derived a micro-based equation that could explain market entries in industries at any point in time. The overall economy does not have to be in the long-run equilibrium. The crucial explanatory variable is the real market potential (RMP_{ri}) and innovation costs a_{Fi}. The market potential can be computed by the expenditure and firm distribution over regions. Then, regional differences in the RMP_{ri} within a sector can explain firm formation, while controlling for the necessity to compensate for depreciation. Especially a higher value of the real market potential within an industry yields higher firm entries rates.

In the case of a competitive sector, $1r_i^r$ is 0 in the long-run. Furthermore, a_i tends to go to infinity. However, in the short-run there might be an additional premium, as long as the distribution of suppliers is not in the long-run equilibrium, letting $1r_i^r >$. Then, the market potential is a valid instrument to capture firm entry processes in the case of competitive markets.

If the firm's innovation is costly, then labour input in the research sector is a relevant factor. In the literature, human capital is usually accepted and interpreted as an engine of innovative processes. Our derived model neither relies on this assumption nor does it take directly into account measures of human capital. This clearly provides some flexibility in an empirical analysis, as $1r_i^r$ has to rise if the research costs are higher to meet Tobin's q. As noted earlier, $1r_i^r$ gets larger when a_i takes relatively lower values (>1). In that case, the monopoly power of single firms will rise. Free market entry reduces monopoly

[16] See Berglund and Briinniis (2001); Gerlach and Wagner (1994).
[17] See Carree (2002); Ritsilii and Tervo (2002).

power such that monopolistic competition results. Therefore, we may conclude that small a_i estimates are related to higher values of π_i^r, and this, in turn, relates to more human capital-intensive research rather than to monopoly power price-setting opportunities. To address this issue explicitly, we add an additional variable to the model: namely, the average share of employed human capital s_H. Because of the introduction of the research sector, our model becomes more general compared with Krugman's (1991) formalization, as it introduces the possibility of human capital spillovers. At this stage of analysis we refrain from modelling endogenous growth, and we assume that, in the long run, the firm stock takes a fixed value. As mentioned in the introductory section, there are several reasons for agglomeration forces. One of these is externalities grounded on human capital (see Romer 1990; Lucas 1988). The present model allows us to distinguish various agglomeration forces. In the next section, we address the regional sectoral firm stock growth empirically, and present the empirical specification.

3 Data, Empirical Approach, and Hypotheses

This section focuses on data, formulates hypotheses, introduces the concept of measuring the real market potential, and highlights further control variables. The main goal is to lay the foundation for deriving the empirical model based on the German regions.

The German Establishment History Panel provided by the Institute for Employment Research (IAB) collects information on the number of firm establishments and other establishment-specific and regional-related information about German regions. It covers the total population of all German establishments which employ at least one person covered by social security. The period considered is 1999 to 2006. Because this data set considers explicitly establishments and not firms, we relate the present model to establishment start-ups.

We apply the German industry classification WZ 93 on a two-digit level. We first limit the sample, and drop the entire public sector (WZ 93>74). Furthermore, we drop sectors which are based on natural resources (WZ 93<15). The reason for the relatively rough classification of sectors is that it captures vertical linkages in production within each industry, and therefore better suits such a macro-model. In total, we consider 43 distinct sectors. Regional data, in particular on GDP, is taken from the GENESIS regional database provided by the German Federal Statistical Office. The NUTS-3 regions are aggregated to 96 regional policy regions[18], out of which 22 belong to eastern Germany. The main criterion for the aggregation of regions is based on commuting flows. This aggregation overcomes strong local

[18] This aggregation scheme is provided by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR).

spatial autocorrelation due to a common labour market area, and captures local sector-specific linkages of neighbouring NUTS-3 regions. With 96 regions and 43 distinct industries, the data set contains 4128 cases.

We obtain a model of regional industry-specific firm formations based on the spatial distribution of real expenditures. This aggregate model is based on the individual decissions of firm entries. Let $_r^*$ be the unobservable benefit that relates to Tobin's q of an individual entrant to locate in region r in a specific industry, x_{ri} a relevant explanatory part, and u_r an error term, with $_r^* = f3x_r + u_r$. The entrepreneur then has to choose in which region he or she will start the business. Assuming that the covariance matrix □ of the error terms for this discrete decission follows some statistical distribution (see later), and is not restricted to a diagonal matrix, we would get:

$$\square = \begin{matrix} a_{11} & & a_{1} \\ & \ddots & \\ a_{1} & & a \end{matrix} \qquad (12)$$

With regard to this model, it is reasonable to assume that a_{ij} decreases with distance (for $i \neq j$): that is, a_{ij} is higher compared with a_i, when the distance between i and j is shorter than from i to k. We therefore add a spatial error process, which, first, gives □ a structured form; and, second, reduces the number of parameters to estimate. The error term for the discrete entry decission can now be written as $u_r =).Wu + E_r$, where E_r N (1a), and W represents a spatial weight matrix. Therefore what is called a 'spatial error process' has to be introduced. We expect that this pattern is also valid for our macro-model, and therefore we introduce such a spatial process: namely, $u_{ir} =).W_x u + E_{ir}$. We relate equation (11) to the following empirical specification:

$$dN_{ir} = f3_{i} + f3_{1i} \ln e_{ir} + f3_{2i} \ln W_x e_{ir} + f3_3 N_{ir} + f3_4 x_{ir} + \square_i + u_{ir} 1 \quad u_{ir} =).W_x u + E_{ir} \qquad (13)$$

An issue often discussed in spatial econometrics is the influence of the explanatory variables of other regions on the outcome of a single region. In that case, a weighted average of variables X of all other regions is added to the regression model. In our case this is the foreign demand $W_x e_{ir}$.

On the left-hand side is the change in establishment stocks between 1999 and 2006; this is not the regional (sector-specific) growth rate. Using the growth rate defined as $dN_{ir} j N_{ir}$ implies an infinitely high growth rate for empty regions, and a loss of all firm entries in empty regions. To reveal market crowding or home market magnitudes, it is essential to focus on empty regions as well, since an 'empty' region is a valid theoretical outcome. We also refrain from taking the log of dN_{ir} for the same reason.

The sum term $\sum_{s}^{R} \phi_{rs} e_{is}$ of π_i^r is employed as the proxy for $PV(\pi_i^r)$ and needs more attention to derive a meaningful empirical specification. The consumption share of GDP allocated to a specific branch is scaled by $_i$, the parameter of the utility function. Unfortunately, ϕ_{rs} is industry-specific since it contains a_i in its calculation, which is a problem from an empirical point of view. However, we know, by definition, that ϕ_{rs} This offers a strategy to approximate trade cost: if one assumes that closer regions have higher ϕ_{rs} values compared with distant regions (that means lower trade costs), we may use a distance-based weight matrix W. This is the typical way to approximate trade costs in empirical studies which test the relevance of the NEG[19]. There are several methods to approximate ϕ_{rs} presented by BrOcker (1989), Brakman et al. (2006), and Head and Mayer (2004b). The latter authors use trade flows between regions. Unfortunately, there are no trade flow data on a regional and sector level available, so we cannot follow this approach. Other approaches consider physical distance or neighbourhood relations to estimate ϕ_{rs}. We follow the approach of BrOcker (1989) which is based on a distance-decay function. The construction of W_x is given in the Appendix. We apply three different weight matrices: $W_{.1}$ discounts distance only to a very limited extent, while $W_{.5}$ discounts a moderate distance effect, and $W_{.9}$ highly discounts distance.

Assuming a constant savings rate over all regions, regional expenditures E_r can be approximated by total regional GDP. Since we relate π_i^r to household demand, we refrain from using gross value added. We approximate any e_{is} by deflating nominal expenditures E_s with the distance-weighted firm distribution $W_x N_i$. We may now employ the weighting matrices which contain the value 1 on the main diagonal[20] to calculate e_{is}. These W_x matrices are not row-standardized for the computation of e_{is}, because this calculation is not based on an average but on a potential.

So far, we have computed real expenditures e_{is}. We now consider $\sum_{s}^{R} \phi_{rs} e_{is}$. We can rearrange the term to $e_{ir} + \sum_{s \neq s}^{R} \phi_{rs} e_{is} = e_{ir} + W_x e_{ir}$. Thus, we can distinguish increases in home and foreign demand, as is frequently analysed in the trade literature. The coefficient of the home region for the market potential e_{ir} should be positive when agglomeration forces dominate competition effects. A firm prefers to locate in a region where it can increase its real market potential. It might be insignificant for competitive markets. If trade is not prohibitive, we can consider that $W_x e_{is}$ capture foreign demand. W_x is one of the weight matrices as described above[21]. In the regression model we take the logarithm of both variables. The effect of foreign demand is expected to be positive. However, if the effect of e_{is}

[19] See Niebuhr (2004).

[20] The 1 values are necessary, so that the stock of firms of the home region also enters the calculation of e_{is}. We do not consider an internal distance as, for example, in Brakman et al. (2006).

[21] The w_{rr} elements of the main diagonal are set to zero to compute We_{ir}.

in any other region s is dominant over the potential $W_x e_{ir}$, the effect of the potential $W_x e_{ir}$ could be insignificant. For the empirical specification we employ the log of both measures for home and foreign demand, viz. $\ln e_{is}$ and $\ln W_x e_{ir}$, respectively.

A general concern relates to issues of endogeneities. The explained variable is the change in the stock of firms in regions and it is explained by the current, spatially discounted stock of firms. If there was a 'growth pole' sector in a particular region in the past, this region would currently have a higher stock of firms to the time we are observing the industry and region. Because this higher stock enters the calculation of e_{is} with its spatially discounted value, the general problem of reverse causality is partly reduced.

Collecting all these terms now leads to the basic regression model as outlined above, and which will be empirically estimated. We now want to introduce additional variables that control for other (productivity) effects. As mentioned in the theoretical model, considering solely e_{ir} provides evidence concerning whether the real market potential influences establishment formation. 0n the basis of theory, we expect, on average, a positive effect of e_{ir} variables. However, it does not allow us to focus on agglomeration and dispersion forces directly, because both effects coincide in e_{ir}. Therefore, we add the number of established firms in the particular region – defined N_{ir}. If the home market effect dominates, then the effect of the market potential should overshoot depreciation such that dN_{ir} is positive. To some extent, N_{ir} also captures competition effects (Porter externalities, market crowding). If N_{ir} rises, regional competition rises. When the market-crowding effect dominates, the estimate of the market potential might be smaller, or even negative. Thus, both signs may occur.

Theory – especially in a New Economic Geography context – suggests that a firm has to be 'invented'. The role of human capital in research activities is widely accepted. In our case, s_H denotes the regional sector-specific human capital input, measured as the intrasectoral regional share of employed people holding a university degree. Brunow and Hirte (2009) point out, that at least for Germany, there may be a bias in that measure, because not every person holding a university degree works in a job that requires such a degree. On the other hand, some employees without a formal qualification hold a position which typically requires a degree. The notion of formulating human capital measures is closely related to the definition of actual and required education in the overeducation literature (Duncan and Hoffmann 1981; De Groot and Maassen van der Brink 2007). However, because of data availability, we stick to the formal qualification measure. s_H also relates to the knowledge spillover theory of entrepreneurship[22]. Audretsch et al. (2010) point out that some firm-specific R&D activities lead to new firm formation, because not all internal knowledge is solely used within that firm; rather it spills over. Griliches (1992) supports

[22] See Acs et al. (2004, 2005).

this spillover theory, as he states that individuals or firms share (their) knowledge with each another. In contrast, Minniti and Levesques (2010) state that entrepreneurs either invest in R&D and develop a new product or enter as imitator into the market, and find a niche for a quite similar product. This fact fits well with the underlying theoretical idea: new firms enter the market and offer a diversified product. Those imitators or researchers could be current employees. Thus, s_H does not solely measure human capital spillovers, but it also captures aspects of a knowledge-based entrepreneurial milieu. We add s_H as a control variable, but refrain from taking the logarithm of s_H. The reason is that some regions are without a particular sector, or do not employ human capital. Taking the logarithm implies a loss of valuable information about those sectors and regions. It is thus essential to focus on $s_H =$, because it is a valid case in interregional comparison. Bode (2004) provides some evidence for Germany that human capital spillovers are rather localized. The applied regional classification yields larger aggregated regions, so that we may expect that most human capital spillovers occur within a region. For these reasons we do not introduce a spatial proxy of employed human capital of surrounding regions (i.e. $W_x s_H$). If the intrasectoral regional share of human capital increases we, expect a positive effect on establishment formation.

We further add the variables ernpt and rnonopol to distinguish whether there is no, or at least one, establishment of that sector located in that region. An empty region might be of advantage, in that it gives monopoly power to a newcomer. An incumbent might have some monopoly power, and therefore enjoy higher profits. This, in turn, attracts other firms into that region to share those profits.

There is also a wide body of literature on diversity effects (Jacobs, 1969, externalities, or urbanization externalities). Audretsch et al. (2010) discuss the importance of the diversity of individuals to focus on diversity in the sense of Jacobs externalities. Those linkages capture individual linkages and the relationship between agents, for instance, employees. Brunow and Hirte (2009) capture diversity effects based on the distribution of firms rather than on individuals. They argue that this captures inter-industrial linkages and technological spillovers. In the study presented here we employ two definitions of diversity to capture both effects. The variable DIV_H relates to intra-regional diversity of high-skilled employment between industries, because we expect that individual linkages and the (knowledge-based) entrepreneurial milieu are important for establishment formation. A second variable DIV relates to technological spillover effects and is defined in terms of the distribution of firms between regional established sectors. DIV_H and DIV are computed here by a negative Herfindahl index, as Combes et al. (2004) suggest[23]. The more diverse employment between sectors is, the higher are both diversity measures. Another frequently

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[23] $DIV = -\ln\left(\sum_k^K s_k^2\right)$, with s_k the proportion of employment or establishments in sector k.

applied urbanization measure is the log of the total number of regional sectors, ln ind.

Regional heterogeneity is typically controlled for by means of dummy variables. The inclusion of regional dummies is invalid in our case, as it assumes that each sector located in the specific region exhibit the same (unobserved) location-specific effects. Put differently: because of the location the average firm entry rate would be the same for all established sectors, which is an inappropriate assumption. What is needed is an industry-location-specific effect which estimation requires a panel of industries over time and space. From an econometric point of view, given only a cross-section over regions within each sector, industry-location-specific effects cannot be estimated. In the current data set all region-specific determinants are collinear with location-specific effects[24]. With respect to economic content, our analysis is based on an intra-industrial regional comparison. Then the inclusion of regional dummy variables takes out all the between-location information within sectors; but this is the variation we are interested in. If there are interindustrial linkages within regions, and some industries exhibit the same growth direction, it is worth controlling for it explicitly. This heterogeneity might be captured by a location-specific effect, but it then ends in the problems described above. Therefore, we add a variable g_r as the average firm entry rate of all other sectors within a region. We also introduce dummy indicators on whether the region may be seen as an agglomeration, or an urban or a rural area. These dummy indicators appeared to be always insignificant, and therefore we did not include them so as to have a parsimonious model.

Another established control variable is the (average) firm's age. There are some limitations in our data set regarding the construction of an age measure. Therefore, we add the intra-industrial regional share of firms of age 20 or more, s_{old}. An established region might have lower firm-entry perspectives, since industry is fostered, and firms hare already relatively productive, so that potential newcomers face strong competition, and therefore do not enter that region. On the other hand, a higher average age might attract new firms because of the outsourcing of established firms or agglomeration forces. Hence, the effect of age is unclear a priori.

Since our research field is Germany, a dummy variable East indicates whether the region is part of eastern Germany. Berlin is seen as an eastern German region, even though there is some evidence that Berlin has some special characteristics, apart from its capital status.

The literature on firm start-ups often uses population density as a measure of urbanization and agglomeration forces[25]. In a densely populated region one may expect higher firm formation. We capture those effects explicitly in e_{ir}. In such regions, typically total GDP is higher, because there is a higher

[24] We checked location-specific effects in the econometric model. Variance inflation factors of most included variables are up to 300 which is expected as most variables are measured at the regional level and are therefore collinear with the location-specific effects.

[25] See Armington and Acs (2002); Audretsch and Fritsch (1999); Brixy and Grotz (2007); Fritsch and Falck (2007); Reynolds et al. (1994); Sternberg and Bergmann (2003); Sutaria and Hicks (2004).

stock of wage earners. Thus, demand for products and e_{ir} increases in these areas. Clearly, our measure already controls for agglomeration forces from a micro-perspective.

Table 1: Descriptive statistics and correlation of model variables

Descriptive Statistics of Variables						
		$\ln e_{ir}$			$\ln W_x e_{ir}$	
	$W_{.1}$	$W_{.5}$	$W_{.9}$	$W_{.1}$	$W_{.5}$	$W_{.9}$
s.d.	0.6777	0.6512	0.5722	0.0844	0.2744	0.5132
min	-1.5883	-1.9497	-2.8311	-0.2471	-1.6195	-2.8886
max	2.1289	3.0488	3.8665	0.136	0.8971	2.8577
		Correlation table				
Cor($\ln e_{ir}$, $\ln W_x e_{ir}$)	0.0183	-0.1256	0.149			
dN_{ir}	0.0146	0.0475	0.1784	-0.0069	0.0561	0.107
s_H	0.1544	0.1573	0.0173	-0.0776	-0.1033	-0.1023
g_r	0.3974	0.2397	0.1161	0.2044	0.3175	0.3873
N_{ir}	0.6254	0.4606	-0.0308	-0.0128	-0.1019	-0.123
DIV	0.3525	0.1533	0.0713	0.4002	0.3526	0.3038
ln ind	0.5289	0.5559	0.3588	-0.2036	-0.1142	-0.0385
Descriptive Statistics of dN_{ir} and control variables						
	dN_{ir}	s_H	g_r	N_{ir}	DIV	ln ind
s.d.	3.085	0.0554	70.8407	10.9561	0.1832	0.0234
min	-46.0612	-0.3266	-168.491	-10.4167	-0.4728	-0.0621
max	28.8521	0.9161	100.9606	183.8401	0.2661	0.0355
		Correlation table				
s_H	0.0053	1				
g_r	0.1067	-0.2024	1			
N_{ir}	-0.2739	0.2043	0.1482	1		
DIV	0.0509	-0.1391	0.6398	0.1513	1	
ln ind	0.0307	0.1291	0.1471	0.2869	0.0875	1

N=4128; the data are de-meaned by the intra-sectoral means.

A descriptive overview of the main variables is given in Table 1. There is no mean reported, because the data are de-meaned on a sectoral level. The upper part of the table includes the standard deviation and the range of the market potential measures defined over the different weight matrices. It is worth noting that the correlation between home and foreign demand is quite small, except for $W_{.9}$, which highly discounts distance. The correlation among other regressors is not very strong, so that multicollinearity is not expected to affect our estimation results.

Finally, it should be noted that there are only 143 cases (3.5 per cent) where the dummy ernpt is valid. This means that most of the regions offer at least one establishment of a particular branch. In 89 cases (2.2 per cent), only one firm of a particular industry is located, and potentially has monopoly power.

The next section discusses estimation issues, before we present and discuss the empirical estimates.

4 Estimation Strategy

So far, we have derived a model of industry-specific firm growth as outlined in the previous sections. The present section discusses the estimation strategy. The general model based on the theoretical framework outlined above reads as:

$$y_{ir} = \beta_i x_{ir} + \gamma z_{ir} + \mu_i + u_{ir}, \quad u_{ir} = \lambda W_x u + \varepsilon_{ir} \tag{14}$$

There is a set of parameters to estimate which are industry-specific parameters (β_i) and others which are common for all sectors (γ). The model suggests that the e_{ir} measures are sector-specific. We have tested various specifications, and have come to the conclusion – based on statistical tests – that only the $\ln e_{ir}$ term (of the home region) varies, whereas the foreign demand term $\ln W e_{is}$ is unaffected. All other variables are also tested to be sector-specific, but it turns out that they belong to z_{ir}.

Because the model relates to industries, we expect that μ_i is correlated with some of the explanatory variables of x_{ir} or z_{ir}. This suggests the need to use a fixed-effects model. Therefore, we de-mean the data on an industry level, so that μ_i disappears. This transformation absorbs the $\,_i$ and a_i of equation (7).

The industry-specific parameter β_i is unaffected by the Within-transformation of the data. Fritsch and Muller (2004) provide evidence that regional firm growth rates are industry-specific, so that different branches exhibit distinct patterns and determinants of establishment entries. This supports our approach of industry-specific parameter estimates. To deal with sector-specific slopes, we introduce sector-specific dummy variables with $\ln e_{ir}$. We estimate two types of model: the Baseline Model treats β common to all sectors, whereas the Dummy Slope Model denotes the dummy interaction model, where β_i is sector-specific. I.e. we estimate $\beta \ln e_{ir}$ in the baseline model and $\beta \ln e_{ir} + \sum_i \beta_i (d_i \ln e_{ir})$, with d_i is an industry-specific dummy indicator and β is the parameter of the reference industry.

As Anselin and Florax (1995) suggest, we have carried out various specification tests relating to a spatial pattern in the data. The test results are presented in Table 2. We apply the row-standardized weight matrices W_x and a binary weight matrix W_D to capture spatial effects. The first rows of the table relate to tests with the W_x matrices. Here, the same weight matrix is employed as the one that is used for the calculation of explanatory variables (e_{ir}, $W_x e_{ir}$), as reported in the top of the table. In the following rows a direct neighbourhood matrix W_D is used to calculate LM tests of spatial heterogeneity.

In all cases, the spatial lag and spatial error structure is confirmed, with robust LM tests. Following the test procedure of spatial patterns as suggested by Florax et al. (2003), the spatial-error specification is preferred over the spatial-lag dependence for both types of model and almost every weight matrix. So

Table 2: Spatial specification tests

	Weighting Matrix	Baseline Model			Dummy Slope Model		
		$W_{.1}$	$W_{.5}$	$W_{.9}$	$W_{.1}$	$W_{.5}$	$W_{.9}$
Moran's I	W_X	n.s.	0.02	0.04	n.s.	0.04	0.05
robust LM Error	W_X	33.49	77.91	66.49	47.34	156.67	117.78
robust LM Lag	W_X	40.16	55.21	50.86	57.11	85.86	84.72
robust LM Error	W_D	21.07	42.99	45.79	40.13	64.88	78.53
robust LM Lag	W_D	13.03	32.28	36.79	24.53	34.01	59.65
LM SAR	W_D	13.10	16.97	12.98	12.28	53.17	26.91
No. of variables		12	12	12	54	54	54

N=4128; Unmarked values are significant at the 1% level; n.s. - not significant.

far, this supports our prior theoretical proposition that spatial interdependencies of firm formation can be explained by the real market potential, and that unobserved local shocks affect neighbouring regions. In the last row of Table 2, an LM test is reported to test whether there is still a spatial pattern in the residuals from a spatial lag dependent model (Anselin, 1988). This LM SAR test is highly significant, indicating that a spatial lag dependence is not sufficient to capture spatial effects, and there is still a spatial error structure present.

Thus, the spatial error model is the preferred model based on theoretical considerations and statistical tests. The spatial error estimates will now be explored in the following section.

5 Estimation Results

In the previous sections, a theoretical model of establishment formation was introduced, and the estimation strategy presented. This section provides the estimation results of the empirical model using a spatial error model. Because of the different size of sectors we expect heteroscedasticity. For that reason Table 3 presents the results of a heteroscedasticity robust spatial error model estimated by Bayesian statistics using Gibbs sampling[26]. Bayesian models are usually estimated by means of Markov chain Monte Carlo (MCMC) techniques. A potential risk with these methods is that the resulting chains do not necessarily converge. However, diagnostic tests are carried out which support the convergence of the resulting Markov chains. For comparison, the restricted Maximum Likelihood estimates with the underlying assumption of homoscedasticity are provided in Table A1 in the Appendix. Because the Bayesian approach accounts for heteroscedasticity, it is the preferred method for estimation which we will evaluate hereafter.

The estimation results are presented in Table 3. It contains two main blocks, one for the baseline

[26] See LeSage and Pace (2009).

Table 3: Regional industry-specific firm growth with spatial error dependence

dep. variable	Baseline Model			Dummy Slope Model		
dN_{ir}	$W_{.1}$	$W_{.5}$	$W_{.9}$	$W_{.1}$	$W_{.5}$	$W_{.9}$
$\ln e_{ir}$	0.7373***	0.5357***	0.4413***	0.935***	0.8471***	0.796*
	[5.7724]	[5.3753]	[5.4323]	[3.3117]	[2.788]	[1.615]
Sector Slopes[I]				yes	yes	yes
$\ln W_x e_{ir}$	-0.5035	0.1234	0.0202	-0.4727	0.4522***	0.1896**
	[-1.1081]	[0.7586]	[0.2393]	[-1.2191]	[2.7948]	[2.2067]
N_{ir}	-0.1117***	-0.1001***	-0.085***	-0.1247***	-0.1169***	-0.0941***
	[-9.8512]	[-10.1081]	[-9.7969]	[-10.947]	[-11.559]	[-10.5574]
s_H	3.8325***	4.1929***	4.3756***	2.4805***	3.1195***	4.651***
	[4.7818]	[5.2331]	[5.3922]	[3.6272]	[4.2737]	[5.7201]
g_r	0.0033***	0.0034***	0.0042***	0.0032***	0.0036***	0.0041***
	[3.2778]	[3.2709]	[3.9962]	[3.8053]	[3.7696]	[3.9701]
rnonopol	0.6159**	0.664**	0.6975**	0.2944	0.4944*	0.6731**
	[2.0135]	[2.1027]	[2.1325]	[1.042]	[1.6072]	[2.0939]
ernpt	0.402**	0.588***	0.589***	0.1069	0.2739	0.5935***
	[1.86]	[2.5328]	[2.3614]	[0.4782]	[1.143]	[2.3826]
s_{old}	-0.6004**	-0.4122*	-0.4075*	0.3078	-0.0822	-0.2261
	[-2.1306]	[-1.4077]	[-1.3693]	[1.216]	[-0.3002]	[-0.7707]
East	-0.3328***	-0.3568***	-0.3193**	-0.0876	-0.1326	-0.2014
	[-2.6205]	[-2.3441]	[-1.8839]	[-0.8688]	[-0.9547]	[-1.1841]
DIV_H	0.1373	0.2497*	0.3322**	0.1999	0.261*	0.3347**
	[0.7487]	[1.3956]	[1.8631]	[1.2873]	[1.6407]	[1.9537]
DIV	0.1428	0.2358	-0.0665	-0.676*	-0.412	-0.7194
	[0.2462]	[0.3879]	[-0.1096]	[-1.3545]	[-0.7429]	[-1.172]
ln ind	1.0288	2.5809**	3.3525***	-0.5267	0.7417	2.4768**
	[0.7107]	[1.8169]	[2.3197]	[-0.4023]	[0.5695]	[1.7698]
).	-0.1692	0.1457***	0.3097***	-0.2414*	0.216***	0.3795***
	[-1.0122]	[5.3744]	[5.3546]	[-1.2992]	[7.4857]	[6.9222]
R^2	0.144	0.1423	0.1389	0.3583	0.3191	0.1997
adj. R^2	0.1417	0.14	0.1366	0.3499	0.3102	0.1893
a^2	4.1793	4.0877	4.0784	3.0584	3.2204	3.7357
Slope-Test				32.3879***	25.1832***	7.3633***

N=4128, T-values in square brackets, * p<.1; ** p<.05; *** p<.01; Baysian heteroscedasticity robust estimates; W_x Weight matrices based on distance ($W_{.1}$ - low , $W_{.5}$ - moderate, $W_{.9}$ - highly discounted distance); W_x is the same as in the column headings.

[I] Sector-specific slope parameters $f3_i$ for $\ln e_{ir}$ - see its distribution in Figure 1 model without sector-specific slopes, and another which controls for slope differences (dummy slope model). Within each block there are the different approaches to approximate ϕ_{rs}, i.e. the W_x matrices. For the sake of simplicity, we apply the same weighting matrix to determine e_{ir}, the sum term $W_x e_{ir}$, and the spatial error term $\lambda W_x u_i$.

Before we turn to the interpretation, we focus on the model selection and fit. Independent of the estimation strategy, all variables are jointly significant. The dummy slopes are jointly significant, such that the dummy slope model is preferred over the baseline model. The test values of a Wald-F test for slope coefficients are presented in the last row of Table 3. Additionally, the root mean squared error decreases in the dummy slope model compared with the baseline model, indicating that the model has a better fit. Therefore, we interpret the dummy models and present the baseline models for comparison. From a theoretical point of view, the dummy interaction model is also preferred.

An alternative strategy to capture differences in the slopes is to estimate a random coefficient model. However, since, by definition and in theory, each industry exhibits its fixed slope coefficient which relates to structural parameters, we prefer the dummy approach. Furthermore, we do not have to rely on the assumption of uncorrelatedness of individual slope effects and any explanatory variables in the dummy approach.

In our empirical application, it appears that there is no preferred model in the dummy slope approach, because all three different weight matrices relate to the influence of distance and trade costs on economic outcome. The estimated signs do not change between the models which employ different weight matrices W_x, as long as the estimates are significant. The reason for the differences in the estimated values stems from a different scaling of variables, especially for the e_{ir} measures.

The coefficient of the spatial error term, λ, is positive and significant, which provides evidence that local shocks affect neighbouring regions. It is, however, negative for W_1. In that case, distance is discounted only to a very limited extent, and therefore shocks of remote regions also influence local shocks. The significant positive values of λ state that neighbouring regions exhibit the same growth perspective on unmodelled shocks. We interpret this result as evidence of a potential geographical concentration of sectors.

The explanatory measures of agglomeration and dispersion forces are the two real market potential measures (home and foreign), and the existing stock of establishments, e_{ir}, $W_x e_{ir}$ and N_{ir}, respectively. The reported estimate of the $\ln e_{ir}$ measure is positive and significant. Therefore, the interpretation of the estimates of the market potential measures are in line with the theoretical model. An increase in the market potential of the home region and all other regions does increase establishment formation in that region. Note that the ln e_{ir} estimate relates to the reference group. The means of all sector-specific slope coefficients are: for $W_{.1}$ equal to 4 8; for $W_{.5}$ equal to 9544; and for $W_{.9}$ equal to 8 52, indicating that the reference group exhibits a relatively lower value for ln e_{ir} compared with the average sector. To obtain a better overview of the distribution of the dummy slopes, Figure 1 shows kernel density plots of the absolute values of the parameters for the three different weight matrices. Clearly contradicting the theory, there are sectors which exhibit a negative coefficient of ln e_{ir} Depending on the definition of W_x, 13 to 16 sectors belong to that group. Theoretically, establishments of those sectors would locate in regions where the expected profit is lower compared with that in other regions. These sectors appear to be: manufactoring of agricultural products, textile and shoe industries, wood sectors, and printing. Obviously, those industries locate close to their upstream sectors, which were excluded in advance from our sample in order to avoid transportation costs between vertically-linked sectors. However, the distribution of coefficients clearly suggests a bimodal distribution of slope coefficients. A total of 8 (9) sectors exhibit a parameter estimate of over 2. These sectors are, in particular: research sectors and service industries, including software development and financial industries. The mass of manufacturing sectors is in the range between 0 and 2, indicating that overall the theoretical model is appropriate. In Figure A2 in the Appendix we have also added the plot for the Maximum Likelihood estimates. In comparison to the preferred Bayesian estimates, the ML estimates have a wider range but the overall picture remains.

It is difficult to argue that this positive effect of the market potential is caused by the home market effect, because market-crowding effects are also included in the e_{ir} measures. For that reason, N_{ir}, the stock of already-existing firms is included in the regression, in order to separate dispersion from agglomeration forces partially. The estimates are negative and robust, indicating that, cetaris paribus, newcomers try to avoid competition but also that a higher stock of establishments needs a higher number of entries to prevent a loss of establishments. The two dummy indicators ernpt and rnonopol support the hypothesis that establishments try to avoid competition. However, the ernpt estimates are mainly insignificant, possibly because of the low frequencies of sector-specific empty regions. Entry rates are significantly higher in regions with only one established firm per sector. Thus, market crowding and sheltering from competition does take place. Taking all the results together provides evidence that agglomeration and dispersion forces are clearly present. Because N_{ir}1 ernpt and rnonopol explicitly consider market-crowding mechanisms, those effects are separated from the e_{ir} measures, indicating that the home market effect is present in the market potential measures e_{ir} and $W_x e_{ir}$, and dominates dispersion forces, at least in the market potential measures.

We now turn to the interpretation of the potential originating from human capital and urbanization externalities. The theoretical model states that firm formation is research-intensive. Our evidence clearly

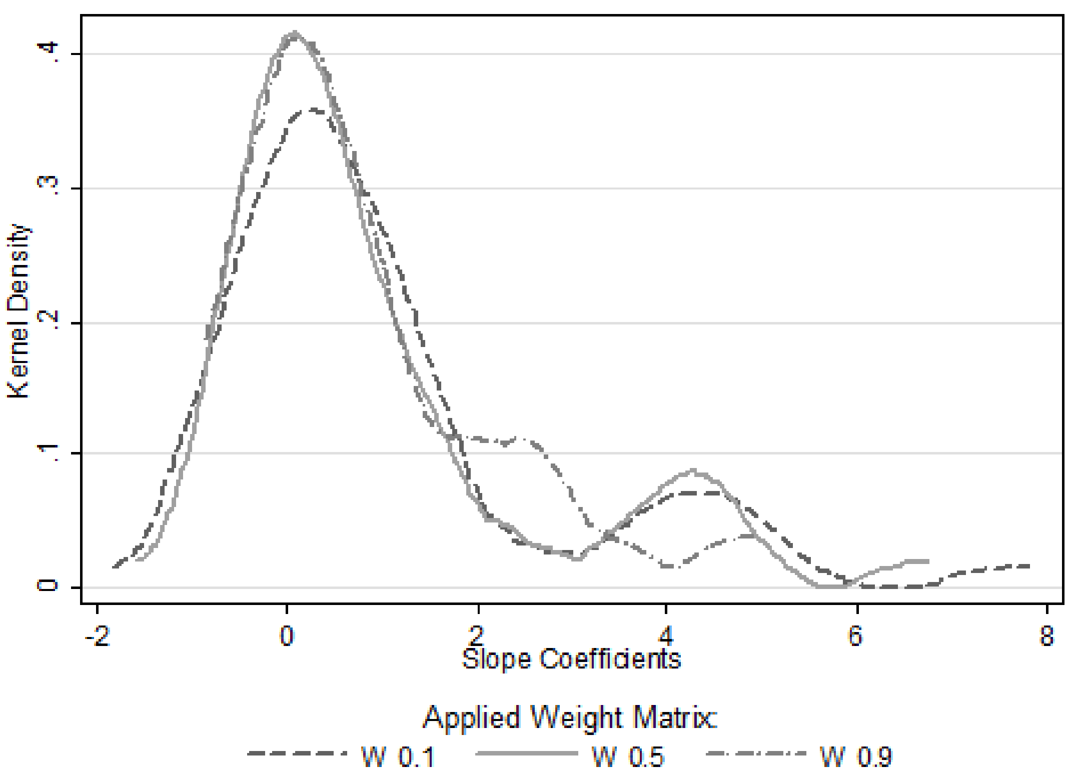

Figure 1: Bayesian parameter estimates

supports this assumption: the higher the intra-industrial regional employment share of persons holding a university degree, the higher the start-up processes. It also supports the existence of a knowledge-based entrepreneurial milieu. Additionally, the distribution of high-skilled employees over sectors matters for establishment formation in individual industries, considering DIV_H. Thus, a broader mixture of human capital between sectors promotes firm formation, providing evidence of urbanization externalities. The diversity of the industrial mix measured by the distribution of firms over sectors (DIV) gives mainly insignificant results. A region which offers a higher stock of established sectors (ln ind) offers an advantage with respect to upstream sectors and services. However, the effect is mainly insignificant.

Next, we can also find evidence that interindustrial linkages are present. If the growth perspectives of other regionally-established sectors increase, the higher is the firm formation of a particular sector. And, finally, the results are robust against modification and applied regression methods. Leaving out control variables does not change the general picture of the estimates.

To sum up, focusing on the real market potential clearly explains firm formation in regions. This is in line with standard NEG models, which state that the mass of varieties exhibit an externality on a branch level. Furthermore, controlling for competition effects and empty regions reveals market-crowding effects. 0ur empirical investigation proves the general relevance of human capital externalities and agglomeration forces, and supports their relevance in regional economics.

There are, however, some limitations of this study: we consider only the distribution and firm formation within Germanys industries. Duranton and Puga (2005) show that pure specialization of industries in space might change to functional regions. This takes place due to technological progress and a reduction of communication costs. Under certain situations, production units are located elsewhere than e.g. headquarters. A functional region appears if e.g. headquarters or production units of distinct sectors locate in a specific region. Such a shape in the economy is only partly captured on a very aggregate level by the growth rate of all other sectors, g_{-r}. It does not control for changes in the functionality of regions. Hewings and Parr (2009) consider production shifting within the US and also argue that a change in logistics and telecommunication technologies can explain disperse production within vertically integrated industries. In relation to that, Marsh (2012) or Feenstra (1998) argue that globalization and changes in international trade and regional specialisation occur due to technological progress and a reduction of trade costs. As a consequence, a shift of production or parts of production from a vertically linked industry from Germany to abroad, or the reverse, is not considered here. Kaminski and Ng (2005) provide a first picture of that disintegration process while considering the import and export behaviour of New Member States of the European Union. They show that from 1999 onwards a transition occurs and these countries start to export more than they import. As Germany is one of the closed countries to eastern Europe, it is likely to be affected by the increase of exports. Especially the role of multinational companies (such as firms of the automotive industries) shift production to the new member states and import intermediate products. This channel cannot be captured with data that only considers Germany.

6 Conclusion

This paper has developed an empirical approach to uncover the fundamental forces of the New Economic Geography literature for establishment formation. Based on the theoretical work of Baldwin (1999), an empirical approach was developed to explain regional sector-specific establishment formation. While, in the literature on firm start-ups, labour productivity measures, such as wages, are frequently applied, our study designed a real market potential measure based on the firm's expected average profit. The theoretical model is tested empirically using detailed German regional data. We find strong evidence that establishments will locate in regions where profit and their real market potential are higher compared with other regions. This is in line with the idea of agglomeration economies. The empirical estimates also support the presence of dispersion and competition forces. Regions with a high share of firms of a particular industry face a significantly lower firm growth rate. On the other hand, when intrasectoral competition in regions is less strong, new establishments enter the market in those regions.

Another aspect of agglomeration economies is the presence of human capital spillovers (Romer 1990; Lucas 1988). The present approach features and controls for human capital externalities. We find evidence that those mechanisms are present. Because of the construction of the theoretical model, we can distinguish different agglomeration forces, and may conclude that the basic mechanisms of human capital theory and New Economic Geography can explain establishment formation.

We thus conclude that the real market potential is a crucial variable for explaining establishment formation, and that agglomeration and dispersion forces are highly relevant. Our empirical estimates thus render support for the basic principles of the NEG literature.

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Appendix

A Construction of the weight matrices W_x

An element of the spatial weight matrix W_x is given by:

$$w_{rs} = \exp(-d_{rs}T),$$

where d_{rs} represents the distance, and T is a distance-decay parameter. This distance-decay parameter T depends on the average distance of neighbouring regions and a normalized distance-decay parameter , which is in the range of 0 and 1. describes the influence of distance on regional dependence. The lower is, the slower the reduction of interregional interdependencies with distance. The link between and T is:

$$= \; - \exp {}^{TD},$$

where D is the average distance of all regions to their respective neighbours (see Niebuhr 2001). In our case D is 68.24 km, and is chosen to be 0.1, 0.5, and 0.9, respectively, to capture the range of two extreme and one moderate decay value.

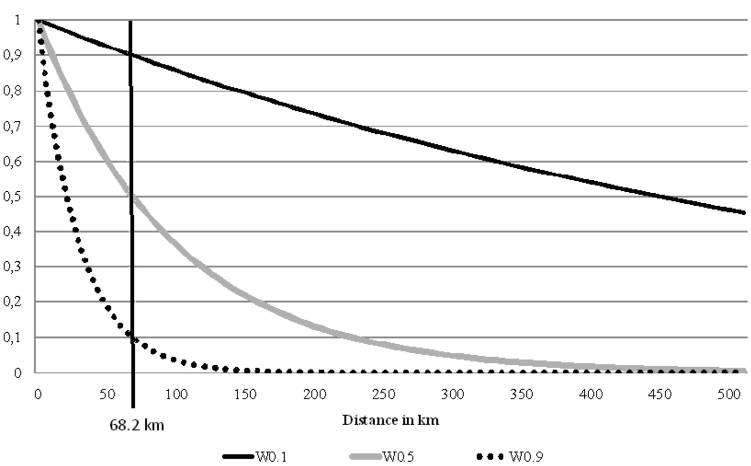

Figure A1: Coherence between w and distance between regions for various values

Figure A1 presents the coherence between , distance and the resulting w value. The key feature here is that for = 9 the approximated weight ¢$_{rs}$ is 0.1 when the distance is 68.24 km. That is, the

$W_{.9}$ matrix basically considers the home region, while values of other regions are highly discounted (high trade costs). At the other extreme, for = (low trade costs), the resulting weight w does not decline much with increasing distance. For a distance of about 450 km the weight is still 0.5. The moderate $W_{.5}$ matrix gives a weight w = 5 for the average distance to neighbours, that is, neighbouring regions enter with half the weight of their own region within the calculation.

Table A1: Regional industry-specific firm growth with and without spatial error dependence

dep. variable	Baseline Model			Dummy Slope Model		
d_{ir}	$W_{wo\mathbf{I}}$	W_{wo}	$W_{wo.}$	$W_{wo\mathbf{I}}$	W_{wo}	$W_{wo.}$
ln e_{ir}	1.0582***	0.7782***	0.626***	1.0839***	0.9536***	0.6865***
	[9.508]	[7.6756]	[6.5781]	[2.8937]	[2.2805]	[0.9602]
Sector Slopes[I]				yes	yes	yes
ln $W_x e_{ir}$	-1.1006*	-0.0395*	-0.0266*	-1.1005**	0.3929**	0.193**
	[-1.9095]	[-0.1956]	[-0.2487]	[-2.2156]	[1.9491]	[1.7351]
d_{ir}	-0.1235***	-0.1101***	-0.0924***	-0.1425***	-0.1349***	-0.1***
	[-22.9733]	[-22.3152]	[-19.2454]	[-28.8983]	[-28.4313]	[-20.9494]
$_H$	4.3745***	5.0717***	5.4485***	2.809***	3.729***	5.7354***
	[5.0634]	[5.8301]	[6.2617]	[3.7164]	[4.7495]	[6.7814]
g_r	0.0051***	0.005***	0.0061***	0.0037***	0.0044***	0.0059***
	[4.571]	[3.9899]	[4.7839]	[3.8337]	[3.7519]	[4.6563]
monopol	0.376	0.7016	0.8001	0.0365	0.4402	0.7918
	[1.3464]	[2.2313]	[2.463]	[0.1487]	[1.5356]	[2.4538]
emp y	0.4111**	1.0901**	1.1244**	0.25	0.7622	1.0909
	[2.1243]	[4.0285]	[3.7683]	[1.3794]	[2.9517]	[3.4735]
$_{old}$	-1.2145***	-0.9793***	-0.9024***	0.0915	-0.4409	-0.6506
	[-3.9978]	[-3.0429]	[-2.7676]	[0.3399]	[-1.4833]	[-2.0092]
E	-0.1883	-0.3459	-0.2873	-0.0445	-0.1477	-0.2116
	[-1.6327]	[-1.8727]	[-1.4129]	[-0.4451]	[-0.8204]	[-1.0292]
DIV_H	0.2674	0.4953	0.6647	0.2828	0.5035	0.6733
	[1.1344]	[2.1206]	[2.8675]	[1.3909]	[2.4259]	[2.9942]
DIV_N	0.1932	0.1008	-0.5839	-0.6257	-0.496	-1.4603
	[0.2663]	[0.1298]	[-0.7434]	[-0.9987]	[-0.6901]	[-1.8502]
ln in	0.6205	2.9992	4.5561	-0.5699	1.1612	3.5923
	[0.3236]	[1.6091]	[2.4975]	[-0.3442]	[0.701]	[2.033]
	-0.582***	0.133***	0.267***	-0.613***	0.24***	0.326***
	[-5.6055]	[14.1814]	[10.522]	[-2.6061]	[8.6303]	[5.6432]
R^2	0.1527	0.1484	0.1448	0.3701	0.333	0.2086
adj. R^2	0.1505	0.1461	0.1425	0.3619	0.3243	0.1983
^{2}	8.0615	8.1031	8.1371	5.9933	6.3463	7.5299
Slope-Test				34.8171***	28.1293***	8.9026***

N=4128, T-values in square brackets, * p<.1; ** p<.05; *** p<.01; ML Estimates with homoscedasticity; W_x Weight matrices based on distance ($W_{wo\mathbf{I}}$ - low , W_{wo} - moderate, $W_{wo.}$ - highly discounted distance); W_x is the same as in the column headings.

[I] Sector-specific slope parameters for ln e_{ir}.

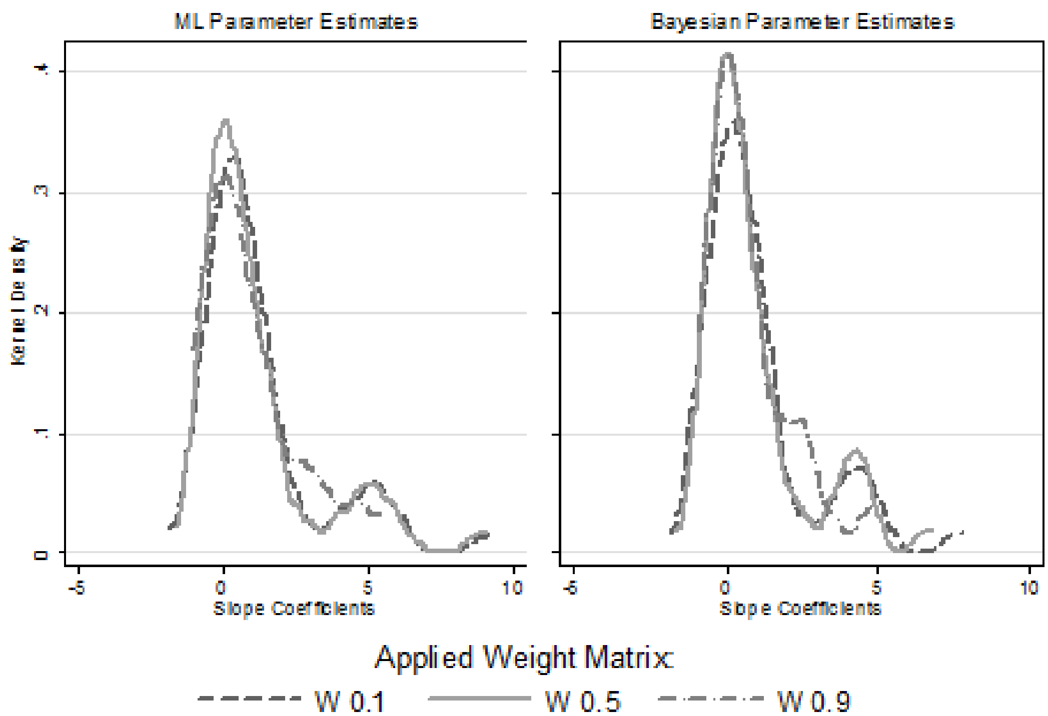

Figure A2: Two types of parameter estimates for three weight specifications