JENA ECONOMIC RESEARCH PAPERS

2014 – 025

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www.jenecon.de

ISSN 1864-7057

The JENA ECONOMIC RESEARCH PAPERS is a joint publication of the Friedrich Schiller University and the Max Planck Institute of Economics, Jena, Germany. For editorial correspondence please contact markus.pasche@uni-jena.de.

Impressum:

Friedrich Schiller University Jena
Carl-Zeiss-Str. 3
D-07743 Jena
www.uni-jena.de

Max Planck Institute of Economics
Kahlaische Str. 10
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www.econ.mpg.de

Jena Economic Research Papers 2014 - 025

New Business Formation and the Productivity of Manufacturing Incumbents: Effects and Mechanisms

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October 2014

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Abstract

We analyze the effect of new business formation on the productivity of incumbent manufacturing establishments. We obtain robust empirical evidence of productivity improvements that are due to the emergence of new businesses in the same industry, that is, on the output market. This effect is spatially limited to the respective region. Regional competition from new businesses on the input market and cross-industry effects are not related to incumbents' productivity changes. The effect that new competition has on incumbents is moderated by an incumbent's distance from the technological frontier; incumbents close to the frontier exhibit a more pronounced positive reaction.

JEL classification: L26, D20, O12

Keywords: New business formation, productivity, incumbent firms

1. The effects of new business formation on incumbent firms[1]

The Schumpeterian understanding of the effect of new businesses on economic development is usually termed "creative destruction," a process in which new firms displace incumbents.[2] Incumbent firms' reaction to new competitors, however, may be heterogeneous and depend on their characteristics and abilities. In fact, while some of the established suppliers will experience decreasing sales or even have to exit the market, others may react to the competitive challenge by improving their performance. Empirical studies that find a significantly positive impact of entry (and exit) on average productivity at the aggregate level of industries,[3] regions, or nations[4] cannot reveal the heterogeneity of individual reaction by incumbent firms to the threat posed by new competitors. In particular, such analyses cannot identify the extent to which the improvements are due to the performance of the newcomers or to that of the incumbents. This can be detected only at the micro-level of firms or establishments.

Apart from empirical studies by Aghion and Bessonova (2006), Aghion et al. (2009), and Czarnitzki, Etro and Kraft (2008) that investigate the effect of advanced, innovative, challenging entry on incumbent innovation and productivity at the firm level, empirical evidence is scarce.[5] When it comes to the effect of new businesses in general—not only

[1] The authors are grateful to the Research Data Center of the Institute for Employment Research (IAB) in Nuremberg, Germany, for hospitality and assistance during research visits. We gratefully acknowledge fruitful comments from Martin Andersson, Alex Coad, and Tatiana Plotnikova.

[2] For formalizations of the concept of creative destruction (Schumpeter 1911/34, 1942) see Aghion and Howitt (1992, 1998) and Aghion, Howitt and Mayer-Foulkes (2005).

[3] E.g., Baldwin (1995), Caves (1998), Disney, Haskel and Heden (2003), Foster, Haltiwanger and Syverson (2001), and Foster, Haltiwanger and Krizian (2006).

[4] E.g., Bosma (2011), Bosma, Stam and Schutjens (2011), Callejon and Segarra (1999), and Carree and Thurik (2008).

[5] Iacovone (2012) analyzes the effect of increased foreign competition due to trade liberalization on the productivity of Mexican establishments. The study does not deal with the effect of new business formation and, although it is based on micro-data, does not distinguish between the performance of incumbents and that of newly founded firms. What is interesting for our analysis is that Iacovone (2012) finds that those establishments that operate close to the technological frontier show the strongest improvements in labor productivity.

particularly innovative or competitive firms—on the performance of incumbents, empirical evidence is even more limited. We are aware of only one empirical study (Andersson, Braunerhjelm and Thulin 2012) that analyzes the effect of new business formation in general on incumbents' productivity at the micro-level of firms. One important limitation of this study, however, is that it only incompletely accounts for the relevant time lags due to limited availability of time series data. More importantly, the study does not account for incumbent characteristics that might affect their reaction to new competitors.

Based on panel datasets that provide long time series of data, this paper analyzes the effects of new business formation on incumbents' productivity as well as the mechanisms through which these effects manifest. We make at least four contributions to the literature. First, we identify that a 1 percent increase of the rate of general entry—not only that of particularly challenging firms—in the incumbents' industry contributes to an average 0.22 percentage points yearly increase in incumbent productivity. This effect, however, is statistically significant only for entries in the same region as the incumbent. In contrast to Aghion et al. (2009), Czarnitzki, Etro and Kraft (2008), and Iacovone (2012), our interest is in new competitors in general, not only high-quality entries, since the influence of general entry on incumbent's performance is still largely unexplored. Second, we attempt to disentangle the extent to which this effect is due to competition on the output market from the role played by competition on input markets such as the labor market. Third, we analyze how an incumbent establishment's distance from the technological frontier moderates its reaction to competition from start-ups. Fourth, since we find that the effect of start-ups on incumbent productivity is largely limited to the region where the new businesses emerge, we perform the analyses in a spatial framework, thereby accounting for regional characteristics and the possibility of interregional spillovers.

The remainder of the paper is organized as follows. Section 2 describes different mechanisms by which new business formation is

expected to influence the productivity of incumbent firms. Methodology, data, and variables are introduced in Section 3. The results and their interpretation are presented in Section 4, and the final section (Section 5) discusses the findings and identifies some important avenues for further research.

2. New business formation and the productivity of incumbents

Schumpeter (1911/1934) identified the distinctive role entrepreneurs play as dynamic innovators who create important impulses for market development. By introducing new products and methods of production, innovative start-ups can exert considerable competitive pressure on incumbent suppliers, forcing them to either improve their productivity or leave the market. The intensity of this competitive pressure depends to a large degree on the innovativeness or newness of the entrants' products and services, as well as their production methods. Thus, entry of innovative businesses led by well-prepared entrepreneurs who have the requisite knowledge and necessary resources can be expected to have a stronger effect on and, particularly, induce larger increases in incumbent productivity than entry by non-innovative businesses run by persons who lack appropriate skills and unable to access relevant means of production. To capture the effects of entrepreneurship from the Schumpeterian perspective and to test the above-mentioned hypothesis, some empirical studies employ a number of methods for identifying advanced entries that can be assumed to exert a particular challenge on incumbent firms. For example, Czarnitzki, Etro and Kraft (2008) use a subjective classification of this challenging quality of new businesses, Iacovone (2012) considers the general import competition from foreign firms as particularly challenging, and Aghion et al. (2009) use greenfield entry of multinational firms into a nation's market as an indicator.

In contrast to these studies that attempt to analyze the effect of particularly challenging entry, we use a general measure of new business formation that is not concerned with identifying such challenging new

businesses in order to test whether the Schumpeterian innovative interaction also holds for competition from "ordinary" firms. Since previous research on the effect of overall entry finds that this effect is to a large degree concentrated in the region in which the newcomers are located (for an overview on the empirical evidence, see Fritsch 2013), we particularly investigate incumbent productivity change in such regions but also test for interregional spillovers.

Why there should be such a regional concentration of the effects of entries is not entirely clear. Analyzing networks of entrepreneurs, Schutjens and Stam (2003) find that the market scope of the majority of new business founders is largely local or regional. This pattern of focusing on the regional market and developing regional business relationships appears to be typical, particularly during the first three years after start up.[6] Being familiar with a region allows entrepreneurs to exploit their knowledge of the regional market environment, in particular, to identify regional opportunities and take advantage of them (Dahl and Sorenson 2012). With regard to the reaction of incumbents, Bosma, Stam and Schutjens (2011, 402) argue that "challenges by new competitors are better recognized if entry occurs in close proximity to the incumbents …." Although it has been found that many new firms have considerably lower productivity than incumbents (Bartelsman and Doms 2000), Baumol, Panzar and Willig (1988) claim that just the threat of entry can suffice to increase incumbents' efficiency.

However, even given that it is the competitive threat of entry that induces improved incumbent productivity, it continues to be unclear as to whether it is competition on the output market or on the input markets, such as the labor market or the market for floor space, that is most relevant. Since increased demand for inputs by entries leads to higher input prices it may also exert a pressure on the incumbents for increased productivity. Such changes in the demand for inputs are also likely to be

[6] For example, studies on firms' export behavior find that most exporters start selling locally and enter export markets only after some time (Sheard 2014).

concentrated in the respective region. We test for the effect of competition on the output market by using the entry into the same industry as the incumbent. Entry in all other private sector industries is then taken as a proxy for the competition on the markets for inputs. Higher levels of new firm formation in other private sector industries also can be expected to lead to higher competition and proficiency within these industries, which might benefit incumbents as they will have more efficient inputs available that may lead to improved productivity.[7]

Based on these considerations we expect:

Hypothesis 1: Manufacturing incumbents' productivity change is positively related to regional entry into the same industry.

Hypothesis 2: Manufacturing incumbents' productivity change is positively related to the regional entry into all other private sector industries.

Hypothesis 3: The effect on incumbent's productivity is stronger for entry in the same region than for entry in adjacent regions.

Our analysis at the individual-establishment level has the advantage that we are able to identify specific characteristics of incumbents that are either conducive or instead impede their reaction to new competition. Specifically, we test the role of distance from the technological frontier, a concept often discussed in the literature (Howitt and Mayer-Foulkes 2005; Acemoglu, Aghion and Zilibotti 2006). According to this idea, the threat of entry encourages incumbents close to the technological frontier to try to escape the competitive threat by engaging in relatively intensive innovation that leads to increased productivity (escape-entry effect). In contrast, incumbents that operate farther away from the technological frontier may have little hope of competing successfully even if they do innovate. In line with these considerations, Aghion et al. (2009)

[7] That new business formation has cross-sector effects has been demonstrated by Andersson and Noseleit (2011), who investigate the effect of regional start-ups on employment change in incumbents in the same sector as well as in other sectors. Distinguishing between manufacturing and low- and high-end service sectors, they find that new business formation in each of these sectors affects employment in the same sector but also in other sectors.

found that “incumbent productivity growth responds more positively to technologically advanced entry in industries close to the technological frontier than in industries farther below the frontier” (Aghion et al. 2009, 27). Accordingly, our fourth hypothesis states:

Hypothesis 4: The effect of regional entry on incumbents’ productivity change is moderated by the incumbent’s distance from the technological frontier. Faced with new competitors, incumbents close to the frontier exhibit a more pronounced productivity increase than those farther away.

Previous analyses of the effect of entry on productivity at the national, industry, or regional level find that a productivity increase often becomes visible only after several years, suggesting that positive effects of competition only manifest after some time (Caves 1998; Brixy 2014). Studies of the effect of new business formation on employment growth find statistically significant time lags of eight to ten years (Fritsch 2013). Similarly, Geroski (1995) argues that capturing the long-run effect of entry is important since entrants require time to establish and reach a competitive level similar to that of incumbents. Based on these observations, it appears that not using longer time lags for levels of entrepreneurship in an empirical analysis of its effects is a serious shortcoming. And yet, remarkably, some previous work on the effect of entry on incumbent productivity only incompletely accounts for such time lags. For example, Aghion et al. (2009) only considered entry in the previous period; Andersson, Braunerhjelm and Thulin (2012) include lags of the start-up rate of four years due to data limitations.

3. Methodology

3.1 Spatial framework and data

We analyze the relationship between new business formation and incumbent productivity in 71 West German planning regions.[8] German

[8] There are actually 74 planning regions in West Germany. For administrative reasons, the cities of Hamburg and Bremen are defined as planning regions even though they are not functional economic units. To avoid distortions, we merged these cities with adjacent

planning regions are functionally integrated spatial units slightly larger than conventional labor market areas in the United States, and contain at least one core city and the surrounding area. The analysis is restricted to incumbents and new businesses in the western part of Germany for two reasons. First, the ongoing transformation process in East Germany after the fall of the socialist regime in 1990 had a strong influence on economic processes in that part of the country, making it a special case and hardly comparable to West German regions (see Fritsch 2004; Kronthaler 2005). Second, the available time series for new business formation in East German planning regions is considerably shorter than that available for West Germany, thereby limiting the scope of the analysis.

The data for the productivity of incumbent manufacturing establishments are from the IAB Establishment Panel, a yearly survey conducted by the Institute for Employment Research (Nuremberg), a research unit of the German Federal Employment Agency. This survey provides information on a representative sample of private-sector establishments from 1993 to 2011. Performing the analysis at the establishment level is important for identifying regional effects.[9] We limit our analysis to the productivity of manufacturing establishments for two reasons. First, this avoids problems related to measuring productivity in the service sector.[10] Second, the data for the manufacturing establishments include subjective perceptions as to the state of the machinery and equipment that we can use as a proxy for the incumbent's distance from the technological frontier. It seems plausible that the state of manufacturing incumbents' machinery can be regarded a significant determinant of their technological position. An establishment is considered an incumbent if it was founded at least 10 years ago. The IAB

planning regions. Hamburg is merged with the region of Schleswig-Holstein South and Hamburg-Umland-South. Bremen is merged with Bremen-Umland. Thus, the number of regions in our sample is 71.

[9] In a firm-level analysis, the effects cannot be clearly assigned to regions in the case of firms with plants in several different regions.

[10] For an overview of such potential problems see Bosworth and Triplett (2003), McLaughlin and Coffey (1990).

Establishment Panel is unbalanced due to changes in the establishments participating in the survey. One limitation of the data is that we have no reliable information as to why an establishment is no longer in the panel and thus we cannot identify those establishments that have been closed down.[11]

Data on new business formation for the different manufacturing industries and sectors in the West German planning regions were obtained from the Establishment History File of the German Social Insurance Statistics. We use the specific classification of the Establishment History Files (WZ1973), which, even though similar to the NACE system, is not perfectly comparable.[12] The degree of aggregation is comparable to the two-digit level and should, therefore, include related industries. The identification of start-ups is based on newly emerging establishment numbers and on workflow analysis (for details, see Hethey and Schmieder 2010). The data originate from the notification process of the social security system and the internal procedures of the Federal Employment Agency. This database only contains establishments with at least one employee (for a detailed description, see Spengler 2008). Therefore, businesses that are run by just the founder with no dependent employees (solo self-employment) are not included.

3.2 Variables

The *dependent variable* for all estimations in our analysis is the *productivity change (*ΔP*)* of incumbent manufacturing establishments over a one-year period. Hence, productivity change is given by

$$\Delta P = \ln \mathrm{P}_{\mathrm{t}=0} - \ln \mathrm{P}_{\mathrm{t}-1} \ .$$

Productivity is measured in terms of value added per employee. Value added is an incumbent's sales minus intermediate inputs and external

[11] For a detailed description of the data, see Fischer et al. (2009) and Kölling (2000).

[12] For further information about the WZ1973 classification, see Amend and Bauer (2005).

costs in the respective time period. On average, the manufacturing establishments in our sample realize a yearly productivity increase of 1.4 percent (see Table A1 in the Appendix).

To test for the relevance of competition to productivity on both output and input markets, we run separate models; one with the level of new business formation in the same industry as the incumbents and another with the level of new firm formation in all other private sector industries respectively. The start-up rate is the number of newly set up establishments in a certain region, industry, or sector and time period divided by the regional workforce (number of employees) to control for differences in the economic size of regions.[13] The start-up rate is included in the panel regressions as a moving average of the 10 years that preceded the incumbent's productivity change. To test for *regional new competition in the input market* as a mechanism for how new business formation influences incumbent productivity we use as the main explanatory variable the *aggregate regional start-up rate in all other private sector industries*, that is, excluding the industry with which the incumbent is affiliated. This approach is based on the assumption that firms belonging to different industries do not compete in the same output markets.

For all estimations, a number of variables for establishment characteristics are included in order to control for establishment-level determinants of productivity change. The IAB Establishment Panel data contain information about the establishments' subjective view of the overall technical state of their plant and machinery. We use this information as a proxy for an incumbent's *distance from the technological frontier.* The evaluations are available as an ordered categorical variable ranging from 1 (= state of the art) to 5 (= obsolete). Hence, higher values of this variable represent longer distance from the technological frontier. We control for the *size* of an incumbent establishment, as measured by

[13] This methodology is in accordance with the labor market approach (Audretsch and Fritsch 1994).

the total number of employees, in order to account for economies of scale. To capture the level of an incumbent establishment's *human capital*, we include the share of employees with a tertiary degree out of the total number of employees. Since a high level of human capital may enhance the ability to absorb knowledge spillovers (von Hippel 1988; Cohen and Levinthal 1990), we expect high human capital to have a positive effect on productivity change.

A large body of literature supports the idea that *export* activities are conducive to productivity growth due to two alternative, but not mutually exclusive, mechanisms. The first mechanism refers to self-selection of relatively productive firms into exporting; the second mechanism is learning-by-exporting, which may be spurred by relatively intense competition on international markets.[14] We follow a suggestion by Castellani (2002) and include a measure for export-intensity, namely, the share of foreign sales out of total sales. Finally, to account for the *initial productivity level*, we include an average of the absolute levels of productivity in the period t-2 and period t-3.

Population density (total population per square kilometers) is included as a "catch-all" variable for diverse factors at the regional level such as market thickness and level of input prices. One can generally

[14] With regard to the first mechanism, Wagner (2007) considers the additional costs involved with international sales as the main reason for self-selection. A great deal of empirical evidence shows that exporters have higher productivity than non-exporters and, more importantly, exporters have higher productivity growth rates than non-exporters. See, for example, Baldwin and Gu (2003), Alvarez and López (2005), Fernandes and Isgut (2005), Arnold and Hussinger (2005), Greenaway, Gullstrand and Kneller (2005), and Sheard (2014). The second mechanism, namely, learning-by-exporting, considers that knowledge gains from international buyers and competitors benefit the performance of exporting firms. Empirical evidence in support of this hypothesis, however, is mixed, as pointed out by Fernandes and Isgut (2005) and Wagner (2007). Motivated by these contrary findings, Castellani (2002) conducted a study on export behavior and productivity growth, finding that export activities are positively associated with productivity growth if a measure of export intensity is considered, such as share of foreign sales out of total sales. If only a dummy variable for foreign participation is included, no impact on productivity is found. Therefore, Castellani (2002) claims that in order to capture the benefits of internationalization it is not enough just to enter a foreign market, but that a significant level of exports must be reached, concluding that the higher the export orientation, the higher the firm's productivity growth.

Table 1: Definition of variables

Variable	*Definition*
Regional-industry-level variables	
Regional start-up rate in same manufacturing industry $_{t-1}$	10-year (*t-1 - t-10*) moving average of the number of start-ups in the same manufacturing industry and region over the regional workforce.[b]
Regional start-up rate in all other private sector industries $_{t-1}$	10-year (*t-1 - t-10*) moving average of the aggregate number of start-ups in other manufacturing industries, the service sector and other private sector industries.[b]
Establishment-level variables	
Incumbent's productivity change $_{t=0}$	Productivity change in the manufacturing incumbent establishments.[a] $\Delta P = \ln P_{t=0} - \ln P_{t-1}$
Distance from the technological frontier $_{t-1}$	Overall technological state of the plant and machinery; ordered categorical variable from 1 (= state of the art) to 5 (= obsolete).[a]
Size $_{t-1}$	Number of employees.[a]
Human capital $_{t-1}$	Share of employees with a tertiary degree.[a]
Export intensity $_{t-1}$	Share of the total sales to foreign countries.[a]
Initial productivity level $_{t-1}$	2-year (t-2 - t-3) moving average of the level of an establishment's productivity.[a]
Change in investments $_{t-1}$	Difference in investments (t-1 - t-3).[a]
Change in number of employees $_{t=0}$	Difference in the number of employees (t=0 - t-1).[a]
Regional-level variables	
Population density $_{t-1}$	Total population per km^2.[c]
Industry-level variables	
Sales change $_{t=0}$	Difference in the total sales of the industry, t=0 - t-1 [c]
Data sources: a: Establishment Panel; b: Establishment History File; c: Federal Statistical Office.	

assume that high-density regions are characterized by a relatively higher level of competition, which should work as pressure for increasing performance among incumbents. High population density may also offer the possibility of benefiting from economies of scale because of the larger demand. We did not include a variable for the level of human capital at the

regional level, such as the share of employees with a tertiary degree, due to its high correlation with population density. [15]

Finally, an incumbent's productivity might also be influenced by specific characteristics of its industry, such as technological opportunities. To capture such effects we include the yearly *change in the sales of an industry*. The amount of sales in manufacturing industries follows the WZ1973 classification and was obtained from the German Federal Statistical Office. The change in the sales by industry is considered at the same time as incumbent productivity change as it is also intended to control for the fact that productivity growth may be the result of a simultaneous general growth of the specific industry in which the incumbent operates.

Our fourth hypothesis is that an incumbent's distance from the technological frontier moderates the effect of new competitors on productivity change. To test this hypothesis, we include an interaction term of the start-up rate and an incumbent's distance from the technological frontier. Table 1 contains a summary of variables included in the analysis. Table A1 in the Appendix sets out descriptive statistics and Table A2 shows the correlation coefficients.

3.3 Estimation of the effects of entry on incumbent productivity

To assess the relationship between the different forms of regional new business formation and a change in incumbent productivity we employ OLS panel regressions with establishment-level fixed effects in order to control for unobserved incumbent-specific characteristics, which also cancels out time-invariant characteristics of the respective industry and region. As mentioned, we run individual estimations to test for each of the possible mechanisms considered in our analysis (see Section 2). The baseline empirical model is

[15] Including this variable in the estimation did not change the results or add significant information to our findings.

$$\Delta lnP_{i,r,s,t}^{inc} = \alpha + \beta_1 regional\ start\text{–}up\ rate_{s,r,t} + X_{i,t-2} + Z_{r,t-2} + W_{s,t-2} + \mu_r + \lambda_t + \varepsilon_{r,t}$$

where:

- $\Delta lnP_{i,r,s,t}^{inc}$ is the productivity change of the incumbents, *i* denotes an incumbent establishment, *r* the region, *s* the industry, and *t* the year of observation;
- $\beta_1 regional\ start-up\ rate_{s,r,t}$ is our main explanatory variable and represents the 10-year (from t-1 to t-10) moving average of the number of start-ups in a specific manufacturing industry s, in region r, at time t, normalized by the regional workforce. To test for the input market competition mechanism, this variable is the regional start-up rate in all other private sector industries.
- $X_{i,t-2}$ is a set of control variables at the establishment level;
- $Z_{r,t-2}$ is a set of control variables at the regional level;
- $W_{s,t-2}$ represents control variables at the industry level;
- μ_i are an incumbent establishment's specific fixed effects;
- λ_t are year dummies to control for developments at the macro-level;
- $\varepsilon_{r,t}$ is the error term.

All variables, except the indicator for the distance from the technological frontier, are included in log form so that the coefficients can be interpreted as dimensionless quasi-elasticities that allow directly assessing the relative importance of the different effects and making comparisons between the different models. The coefficient of our main explanatory variable, the regional start-up rates in the manufacturing industry of the incumbent or in all other private sector industries, represents the relative productivity change that can be attributed to the competition imposed by new business formation in the output or input market, respectively.

4. Results

The results of the estimation of our baseline model (Model I in Table 2) show that a 1 percent increase in the regional start-up rate in a manufacturing industry leads to a 0.22 percentage points higher productivity growth of the regional incumbents in that industry. This finding has two implications that are in accordance with our Hypothesis 1. First, it demonstrates that new competitors in general—not only advanced entries—pose a significant competitive threat to incumbents that induces attempts to enhance productivity. Second, this finding suggests that competition on the output market is a mechanism through which new business formation influences the performance of incumbents.

Before testing if the effect of regional entry on incumbents' productivity change is moderated by the incumbent's distance from the technological frontier (Hypothess 4), we start analyzing the independent effect of this variable, namely, how an incumbent's distance from the technological frontier influences its productivity change (Model I in Table 2). In all estimations we take the frontier (category 1 = state-of-the-art machinery and equipment) as the point of reference for measuring distance from the technological frontier. The positive and statistically significant coefficients estimated in the regression suggest that establishments with machinery in categories 3 are able to accomplish higher positive productivity changes than those with machinery in category 1 that indicates a position at the frontier. One possible explanation for this finding is that pushing the frontier ahead is more difficult than catching up to it. Accordingly, incumbents with machinery and equipment in category 3 seem to find it easier to improve their productivity, possibly by learning from the leading firms or by acquiring state-of-the-art machinery. However, this situation, which is in line with findings by Aghion et al. (2009), only holds for incumbents with machinery in category 3. For the category with the least modern machinery (category 5), the estimated coefficient is significantly negative. This result suggests that incumbents in the bottom

Table 2: The effect of regional start-ups at the manufacturing-industry level on productivity change of manufacturing incumbents

		Model I	Model II	Model III	Model IV
Regional start-up rate in same manufacturing industry $_{t-1}$		0.219*** (0.0652)	0.285*** (0.0829)	0.226*** (0.0656)	0.274*** (0.0826)
Start-up rate in same manufacturing industry in adjacent regions $_{t-1}$		–	–	-0.0187 (0.0395)	0.0295 (0.0466)
Distance from the technological frontier $_{t-1}$	1	Reference			
	2	0.0440 (0.0293)	0.0507 (0.0305)	0.0439 (0.0293)	0.0509 (0.0306)
	3	0.0920*** (0.0326)	0.103*** (0.0345)	0.0918*** (0.0325)	0.103*** (0.0345)
	4	-0.0427 (0.0612)	-0.0892 (0.0769)	-0.0433 (0.0611)	-0.0885 (0.0770)
	5	-0.218*** (0.0570)	-0.235*** (0.0758)	-0.218*** (0.0569)	-0.235*** (0.0758)
Size $_{t-1}$		-0.0736 (0.0553)	-0.119 (0.0774)	-0.0735 (0.0553)	-0.119 (0.0770)
Human capital $_{t-1}$		0.0386** (0.0182)	0.0454** (0.0180)	0.0388** (0.0182)	0.0451** (0.0180)
Export intensity $_{t-1}$		0.000372 (0.0176)	0.00505 (0.0203)	-0.000103 (0.0176)	0.00553 (0.0204)
Initial productivity level $_{t-1}$		-0.836*** (0.0512)	-0.870*** (0.0565)	-0.836*** (0.0511)	-0.871*** (0.0563)
Population density $_{t-1}$		-0.81 (1.146)	-0.952 (1.160)	-0.837 (1.145)	-0.917 (1.143)
Sales change $_{t=0}$		-0.0014 (0.0278)	-0.00626 (0.0315)	-0.00122 (0.0279)	-0.00650 (0.0315)
Change in investments $_{t-1}$		–	-0.00409 (0.00417)	–	-0.00427 (0.00421)
Change in the number of employees $_{t=0}$		–	-0.238** (0.117)	–	-0.238** (0.116)
Number of observations		3,954	3,434	3,954	3,434
R-squared adjusted		0.271	0.278	0.271	0.278
Mean variance inflation factor (vif)		1.09	1.09	1.50	1.42
F-test		53.48	26.47	52.29	25.79
Log likelihood		-1089.7	-889.6	-1089.6	-889.4

Notes: All independent variables, except the measure for distance from the technological frontier, are included with their logarithmic values. Fixed effects panel regressions. Robust standard errors clustered at the level of planning regions in parentheses. *** Statistically significant at the 1 percent level; ** statistically significant at the 5 percent level; * statistically significant at the 10 percent level. Year dummies in all models are jointly significant at the 1 percent level.

category exhibit significantly lower productivity increases than those that see themselves at the technological frontier. Hence, being away from the frontier offers more room for productivity improvement, but only up to a

certain point. At a certain distance from the frontier, having obsolete or close to obsolete production technology makes it more difficult to realize productivity improvements than being at the frontier or relatively close to it. Probably, incumbents that are relatively far from the frontier face particular difficulty adopting new technologies, benefiting from knowledge spillovers, or learning from other firms in their region.

While the size of an incumbent, as measured by the number of employees, is not significantly correlated to productivity change in any model, human capital, represented by the share of employees with a tertiary degree, has a positive effect. This finding suggests that it is not the mere size in terms of number of employees that is important for being able to raise productivity, but human capital intensity. The significantly negative coefficient for the initial productivity level clearly indicates that establishments with relatively low productivity experience higher increases than those that have already attained a comparatively high level. In accordance with Clerides, Lach and Tybout (1998), we find no significant relationship between export intensity and productivity growth. Neither is there any statistically significant relationship between an incumbent productivity change and the development of total sales in the respective industry.

In a further step, we expanded the basic model by testing the extent to which productivity change results from a time-simultaneous change in the number of employees or from investments over the previous two years (t-2 to t-1) (Model II in Table 2). Investment in the previous periods was chosen because the effects of an investment may need time to manifest as productivity growth. We found a negative and statistically significant coefficient for change in the number of employees which indicates that the observed incumbent's improvement of productivity is related to a time-simultaneous decrease in the number of employees. This finding is in line with previous research which has shown that a frequent first reaction of incumbents facing new competitors is to reduce the number of employees (for details, see Fritsch 2013). It is remarkable, however, that including

change in the number of employees does not lower the effect of regional new business formation[16] suggesting that apart from reducing employment, incumbents show a genuine improvement in efficiency. On the other hand, change in investments is not statistically significant which may suggest that incumbents' increased productivity is not the result of new machinery, but possibly due to product innovation and reduced X-inefficiency, namely, efficiency gains due to competitive pressure (Leibenstein 1966).

Including the start-up rate in adjacent regions (Models III and IV in Table 2) as a further explanatory variable has no statistically significant effect. This result indicates that the competitive pressure exerted by new firms entering an industry is mainly concentrated in the same region and has no effect on incumbent establishments located in adjacent regions. Since the close correlation between the regional manufacturing start-up rates and the respective start-up rates in adjacent regions may be regarded problematic, we also run models that only include the start-up rate in the adjacent regions and not the start-up rate in the region where the incumbent establishments are located (see Table A4 in the Appendix). The non-significance of the start-up rate in the adjacent regions indicates that it is particularly the effect of new business formation in the same region that is important for explaining productivity change in the regional incumbents in accordance with our Hypothesis 3

One might argue that low productivity of incumbent establishments in a region could be seen as an entrepreneurial opportunity that induces entry into the respective industry. Such an effect would introduce a problem of reverse causality into our model. To avoid this potential problem we also ran models where we lagged the regional start-up rate in a certain manufacturing industry or sector by three more years, that is, we

[16] In fact, the estimated coefficients for the regional start-up rate become even considerably larger when the change in the number of employees is included into the model.

Table 3: The effect of the aggregated regional start-up rate in all other private sector industries on productivity change of manufacturing incumbents

		Model I	Model II	Model III	Model IV
Regional start-up rate in all other private sector industries $_{t-1}$		0.626 (0.378)	0.671 (0.475)	0.626 (0.383)	0.682 (0.467)
Regional start-up rate in all other private sector industries in adjacent regions $_{t-1}$		–	–	0.000 (0.033)	0.066 (0.040)
Distance from the technological frontier $_{t-1}$	1	Reference			
	2	0.044 (0.030)	0.0515 (0.031)	0.044 (0.030)	0.050 (0.031)
	3	0.099*** (0.033)	0.106*** (0.035)	0.099*** (0.033)	0.108*** (0.035)
	4	-0.036 (0.061)	-0.090 (0.078)	-0.036 (0.061)	-0.088 (0.078)
	5	-0.207*** (0.054)	-0.233*** (0.073)	-0.207*** (0.054)	-0.231*** (0.073)
Size $_{t-1}$		-0.064 (0.058)	-0.105 (0.080)	-0.064 (0.058)	-0.105 (0.079)
Human capital $_{t-1}$		0.035* (0.019)	0.040** (0.019)	0.035* (0.019)	0.040** (0.019)
Export intensity $_{t-1}$		0.001 (0.017)	0.006 (0.020)	0.001 (0.017)	0.007 (0.020)
Initial productivity level $_{t-1}$		-0.837*** (0.051)	-0.868*** (0.056)	-0.837*** (0.051)	-0.869*** (0.056)
Population density $_{t-1}$		-0.947 (1.088)	-1.143 (1.117)	-0.947 (1.088)	-1.081 (1.132)
Sales change $_{t=0}$		0.006 (0.028)	-0.000 (0.031)	0.006 (0.028)	-0.001 (0.031)
Change in investments $_{t-1}$			-0.004 (0.004)		-0.004 (0.004)
Change in number of employees $_{t=0}$			-0.220* (0.119)		-0.220* (0.118)
Number of observations		3890	3379	3890	3379
R-squared adjusted		0.270	0.275	0.270	0.275
Mean variance inflation factor (vif)		1.14	1.12	1.39	1.32
F-test		66.83	27.53	69.67	27.48
Log likelihood		-1087.3	-900.7	-1087.3	-899.5

Notes: All independent variables, except the measure for distance from the technological frontier, are included with their logarithmic values. Fixed effects panel regressions. Robust standard errors clustered at the level of planning regions in parentheses. *** Statistically significant at the 1 percent level; ** statistically significant at the 5 percent level; * statistically significant at the 10 percent level. Year dummies in all models are jointly significant at the 1 percent level.

included the average start-up rate for the periods t-4 to t-10 instead of t-1 to t-10. An additional lag of three more years was chosen because it appears extremely unlikely, given the dynamic nature of today's markets, that an entrepreneur would recognize an opportunity based on low productivity of incumbents and then wait four years before starting a new venture. The results of these robustness checks (see Table A3 in the Appendix) do not reveal any substantial change of the main relationships.[17]

To test for the effect of competition on the input markets as well as cross-industry effects, we run the models using the start-up rates in all other private sector industries. We find that the effect of the regional start-up rate in all other industries in the same region and in adjacent regions is not statistically significant in any of the models (Table 3). The effect of the other explanatory variables remains stable (Table 2). This indicates that— contradicting our Hypothesis 2— additional competition by new businesses on the input side of the market does not act as a significant incentive for incumbent establishments to increase their productivity. One explanation for the insignificance of competition for input could be that new firms generally start at a rather small scale, not requiring considerable levels of inputs, such as, for example, employees, floor space, or capital.

Turning to our fourth hypothesis, which is that incumbent's distance from the technological frontier will have a moderating effect on reaction to competition, we included in our estimation an interaction term "regional start-up rate in manufacturing industry x distance from the technological frontier." We observe negative signs for this interaction term; however, they are not always statistically significant (Table 4). The results suggest that the farther away the incumbent is from the technological frontier, the lower the productivity-increasing effect of the start-up rate.

[17] We also included in our estimations the quadratic term of our main explanatory variable, regional start-up rate, in order to check for non-linear effects but no significant relationship was identified.

Table 4: The effect of regional start-ups on incumbents' productivity change conditional on their distance from the technological frontier

		Model I	Model II	Model III	Model IV
Regional start-up rate in same manufacturing industry $_{t-1}$ x distance from the technological frontier $_{t-1}$	1	Reference			
	2	-0.0585**	-0.0633**	-0.0582**	-0.0637**
		(0.0276)	(0.0296)	(0.0278)	(0.0296)
	3	-0.0339	-0.0498	-0.0336	-0.0506
		(0.0323)	(0.0383)	(0.0323)	(0.0386)
	4	-0.0467	-0.132*	-0.0463	-0.133*
		(0.0663)	(0.0741)	(0.0660)	(0.740)
	5	-0.232	-0.336*	-0.233	-0.336*
		(0.164)	(0.179)	(0.164)	(0.179)
Regional start-up rate in same manufacturing industry $_{t-1}$		0.262***	0.335***	0.268***	0.324***
		(0.0709)	(0.0884)	(0.0706)	(0.0873)
Start-up rate in same manufacturing industry in adjacent regions $_{t-1}$		–	–	-0.0166	0.0311
				(0.0391)	(0.0457)
Distance from the technological frontier $_{t-1}$	1	Reference			
	2	0.0528*	0.0608*	0.0526*	0.0610**
		(0.0308)	(0.0322)	(0.0309)	(0.0322)
	3	0.0962***	0.111***	0.0960***	0.111***
		(0.0345)	(0.0371)	(0.0345)	(0.0372)
	4	-0.0350	-0.0459	-0.0356	-0.0450
		(0.0628)	(0.0692)	(0.0626)	(0.0690)
	5	-0.219***	-0.221***	-0.219***	-0.220***
		(0.0571)	(0.0599)	(0.0569)	(0.0596)
Size $_{t-1}$		-0.0747	-0.115	-0.0746	-0.116
		(0.0550)	(0.0780)	(0.0550)	(0.0776)
Human capital $_{t-1}$		0.0395*	0.0466**	0.0397**	0.0463**
		(0.0180)	(0.0177)	(0.0180)	(0.0177)
Export intensity $_{t-1}$		0.000994	0.00629	0.000569	0.00680
		(0.0175)	(0.0203)	(0.0176)	(0.0205)
Initial productivity level $_{t-1}$		-0.838***	-0.873***	-0.838***	-0.873***
		(0.0514)	(0.0577)	(0.0513)	(0.0575)
Population density $_{t-1}$		-0.855	-1.003	-0.879	-0.965
		(1.153)	(1.156)	(1.151)	(1.139)
Sales change $_{t=0}$		-0.000578	-0.00527	-0.000418	-0.00551
		(0.0280)	(0.0318)	(0.0281)	(0.0318)
Change in investments $_{t-1}$		–	-0.00434	–	-0.00452
			(0.00407)		(0.00411)
Change in the number of employees $_{t=0}$		–	-0.240**	–	-0.240**
			(0.115)		(0.115)
Number of observations		3,954	3,434	3,954	3,434
R-squared adjusted		0.271	0.279	0.271	0.279
Log likelihood		-1086.9	-886.2	-1086.8	-885.9

Notes: All independent variables, except the measure for distance from the technological frontier, are included with their logarithmic values. Fixed effects panel regressions. Robust standard errors clustered at the level of planning regions in parentheses. *** Statistically significant at the 1 percent level; ** statistically significant at the 5 percent level; * statistically significant at the 10 percent level. Year dummies in all models are jointly significant at the 1 percent level. We abstain from reporting the largely meaningless high values of the variance inflation factor that are caused by the high correlation between the interaction term and the respective constitutive variables. For the vif values without the interaction variable see Table 2.

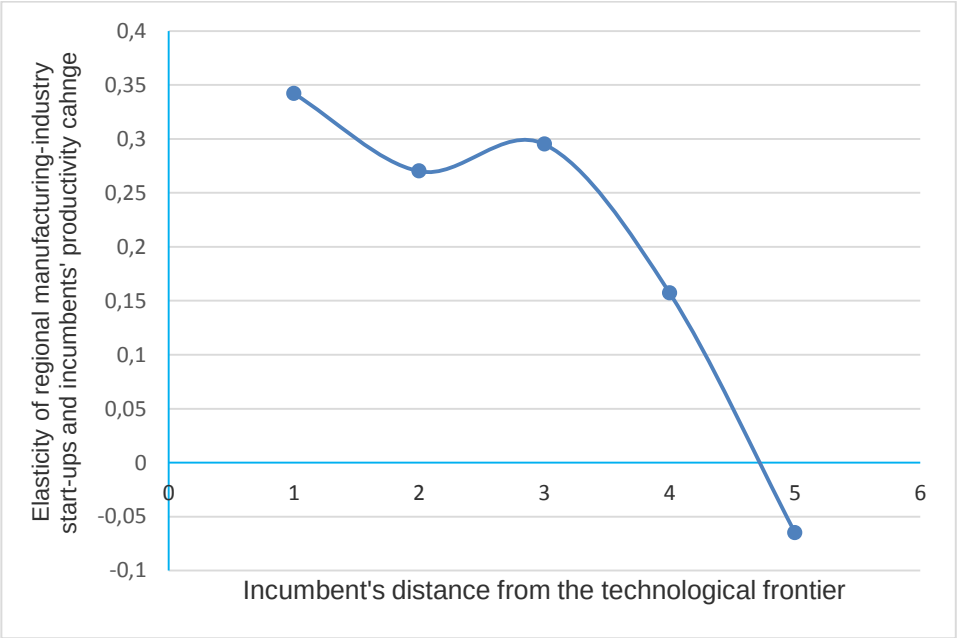

Figure 1: Marginal effect of regional start-ups on the productivity growth of incumbent establishments of the same industry at different categories of incumbent's distance from the technological frontier

Figure 1 shows the estimated marginal effects of the regional start-up rate on incumbent productivity. The pattern is in line with Aghion et al. (2009), who find that incumbent productivity growth in industries close to the technological frontier responds more positively to technologically advanced entry. This suggests that those incumbents that operate at the technological frontier are able to react more positively to the challenge of regional start-ups than those that are farther away. It seems, then, that an incumbent's distance from the technological frontier plays a dual role in regard to its productivity-reaction to competition from new businesses. On one hand, the independent effect (Table 2) shows that establishments that are farther away from the technological frontier find it easier to improve, at least until a certain point (category 3). However, the moderating effect presented in Table 4 indicates that farther distance from the technological frontier makes incumbents less capable of reacting positively to new entry. Apparently, being at the technological frontier has negative implications as finding ways to shift the frontier ahead seems to require more effort than upgrading to the frontier. However, frontier incumbents appear to be more

alert to what is happening in the market and to pay more attention to newcomers, from which they can benefit in various ways, which benefits are reflected in higher productivity increases.

5. Conclusions

In this paper we attempted to identify the effects of new business formation on the productivity of manufacturing incumbent establishments. We found robust empirical evidence that manufacturing incumbents' productivity is positively influenced by competition from new establishments in the same industry (Hypothesis 1). In contrast, the level of regional new business formation in all other private sector industries that can be regarded as an indicator for competition on regional input markets (Hypothesis 2) had no statistically significant effect. We conclude from these results that it is more the competition on the output markets, as indicated by the level of start-ups in the same industry, than competition on input markets that links new business formation to incumbent productivity. It is noteworthy that this competition is largely limited to the region where the start-ups occur; we never found a statistically significant effect for the level of new business formation in adjacent regions. This is in accordance with our Hypothesis 3.

We confirm the result of Aghion et al (2009) that the effect of entry is more pronounced for incumbents operating close to the technological frontier. Incumbents with up-to-date machinery benefit most from competition by start-ups (Hypothesis 4). However, in contrast to the analysis of Aghion et al. (2009), who only considered entry of established multinational firms into a national market that can be assumed to be highly competitive, we analyzed new business formation in general. Moreover, while the analysis of Aghion et al. (2009) measured distance from the technological frontier at the aggregate level of industries, assuming that all incumbents within an advanced industry operate at the frontier, we used a proxy for distance from the technological frontier at the micro-level of establishments. Our data also allowed us to determine how establishment-

specific factors—such as the initial level of productivity, the volume of investment in previous years, and development of labor inputs—affect productivity change. Of particular interest in this regard is that the productivity enhancing effect of regional start-ups in the same industry can be identified independent of a productivity increase due to a reduction of labor inputs that may also be a reaction of incumbents to new regional competition. The volume of investment in the previous years was insignificant for explaining productivity change, indicating that in most cases, a productivity increase was *not* due to increased investment. This suggests that the improvement of incumbent's labor productivity due to increased competition from entry mainly result from reduced X-inefficiency and smaller product and process innovations that do not require significant amounts of capital.

Our result that regional new business formation in general, not only entry of highly competitive firms, leads to enhanced productivity of manufacturing incumbents through competition on the output market suggests that the usual understanding of creative destruction as new firms displacing incumbents needs to be complemented by a component of creative *construction* (Agarwal, Audretsch and Sarkar 2007), that is, that competition by newcomers can make incumbents significantly stronger. Future research should investigate the competitive processes between newly founded businesses and incumbents in more detail. In particular, it is still largely unknown why the effect of entries on incumbent productivity is limited to establishments in the same region, while the effect on incumbents in adjacent regions remains largely insignificant. Moreover, it would be helpful to know more about the impact of different types of entry, such as highly innovative versus purely imitative new businesses. Finally, it is important to explore the role of entry barriers, market structure, and other characteristics of the respective market, such as the stage in the industry life-cycle, on the effects of new business formation on incumbent performance.

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Appendix

Table A1. Descriptive statistics

		Mean	Median	Minimum	Maximum	Standard Deviation
1	Incumbent's productivity change $_{t=0}$	0.014	0.158	-5.126	4.239	0.493
2	Regional start-up rate in same manufacturing industry $_{t-1}$	-8.944	-8.739	-13.549	-7.226	0.888
3	Start-up rate in same manufacturing industry in adjacent regions $_{t-1}$	-7.338	-7.165	-11.557	-5.243	0.898
4	Regional start-up rate in all other private sector industries $_{t-1}$	-3.710	-3.720	-4.666	-2.570	0.363
5	Regional start-up rate in all other private sector industries in adjacent regions $_{t-1}$	-0.259	-0.155	-3.134	1.728	0.732
6	Distance from the technological frontier $_{t-1}$	2.228	2	1	5	0.791
7	Size $_{t-1}$	4.505	4.62	0.000	11.012	1.956
8	Human capital $_{t-1}$	-1.998	-1.871	-6.627	2.399	1.060
9	Export intensity $_{t-1}$	3.223	3.401	0	4.605	1.024
10	Initial productivity level $_{t-1}$	10.895	10.931	4.390	14.520	0.735
11	Change in investments $_{t-1}$	-0.027	0	-17.872	17.526	2.793
12	Change in number of employees $_{t=0}$	-0.006	0	-4.348	4.942	0.204
13	Population density $_{t-1}$	5.673	5.634	4.277	7.126	0.625
14	Sales change $_{t=0}$	0.012	0.0400	-1.515	0.752	0.192

Notes: All variables, except the measure for distance from the technological frontier, are included with their logarithmic values.

Table A2. Correlations between variables

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Incumbent's productivity change $_{t=0}$	1													
2	Regional start-up rate in same manufacturing industry $_{t-1}$	-0.026	1												
3	Start-up rate in same manufacturing industry in adjacent regions $_{t-1}$	-0.025	0.814	1											
4	Regional start-up rate in all other private sector industries $_{t-1}$	0.014	0.133	0.026	1										
5	Regional start-up rate in all other private sector industries in adjacent regions $_{t-1}$	-0.022	0.758	0.968	-0.011	1									
6	Distance from the technological frontier $_{t-1}$	0.006	0.028	0.038	0.081	0.030	1								
7	Size $_{t-1}$	0.012	-0.045	-0.025	-0.026	-0.019	-0.146	1							
8	Human capital $_{t-1}$	0.017	0.016	0.008	0.022	0.046	-0.050	-0.054	1						
9	Export intensity $_{t-1}$	-0.015	-0.096	-0.100	-0.029	-0.096	-0.023	0.473	0.062	1					
10	Initial productivity level $_{t-1}$	-0.251	-0.072	-0.042	0.042	-0.048	-0.113	0.275	0.087	0.232	1				
11	Change in investments $_{t-1}$	-0.013	0.026	0.033	0.001	0.029	-0.003	-0.031	0.044	-0.049	-0.006	1			
12	Change in number of employees $_{t=0}$	-0.099	0.018	0.008	-0.023	-0.001	-0.081	-0.108	0.100	-0.014	0.082	0.061	1		
13	Population density $_{t-1}$	-0.003	0.060	0.130	0.079	0.165	0.037	0.043	0.108	0.035	0.128	0.015	-0.010	1	
14	Sales change $_{t=0}$	0.043	-0.066	-0.070	0.021	-0.077	0.010	0.000	0.105	0.015	0.025	0.018	0.038	0.022	1

Table A3. The effect of regional start-ups at the manufacturing-industry level on productivity change of manufacturing incumbents—Estimation with further lagged main explanatory variable

		Model I	Model II	Model III	Model IV
Lagged regional start-up rate in same manufacturing industry $_{t-4}$		0.116**	0.149***	0.117**	0.139**
		(0.0460)	(0.0548)	(0.0447)	(0.0529)
Start-up rate in same manufacturing industry in adjacent regions $_{t-4}$		–	–	-0.00515	0.0508
				(0.0366)	(0.0430)
Distance from the technological frontier $_{t-1}$	1	reference			
	2	0.0434	0.0497	0.0433	0.05
		(0.0292)	(0.0305)	(0.0292)	(0.0305)
	3	0.0927***	0.103***	0.0926***	0.104***
		(0.0326)	(0.0348)	(0.0325)	(0.0348)
	4	-0.0407	-0.0873	-0.0409	-0.0861
		(0.0607)	(0.0773)	(0.0606)	(0.0773)
	5	-0.221***	-0.240***	-0.221***	-0.238***
		(0.0542)	(0.0714)	(0.0541)	(0.0716)
Size $_{t-1}$		-0.0727	-0.119	-0.0727	-0.12
		(0.0557)	(0.0780)	(0.0557)	(0.0773)
Human capital $_{t-1}$		0.0376**	0.0431**	0.0376**	0.0428**
		(0.0186)	(0.0183)	(0.0186)	(0.0183)
Export intensity $_{t-1}$		0.000262	0.0053	0.000129	0.00612
		(0.0176)	(0.0203)	(0.0176)	(0.0204)
Initial productivity level $_{t-1}$		-0.835***	-0.869***	-0.835***	-0.870***
		(0.0513)	(0.0566)	(0.0512)	(0.0564)
Population density $_{t-1}$		-0.813	-1.017	-0.821	-0.953
		(1.1150)	(1.1350)	(1.1090)	(1.1110)
Sales change $_{t=0}$		-0.002	-0.00786	-0.00195	-0.00816
		(0.0277)	(0.0309)	(0.0277)	(0.0310)
Change in investments $_{t-1}$		–	-0.00434	–	-0.00462
			(0.0042)		(0.0042)
Change in number of employees $_{t=0}$		–	-0.238**	–	-0.237**
			(0.1180)		(0.1170)
Number of observations		3,954	3,434	3,954	3,434
R-squared adjusted		0.27	0.277	0.27	0.277
Variance inflation factor		1.09	1.09	1.48	1.41
F test		65.5	27.44	67.95	27.61
Log likelihood		-1092.9	-893.9	-1092.9	-893.3

Notes: All independent variables, except the measure for distance from the technological frontier, are included with their logarithmic values. Fixed effects panel regressions. Robust standard errors clustered at the level of planning regions in parentheses. *** Statistically significant at the 1 percent level; ** statistically significant at the 5 percent level; * statistically significant at the 10 percent level. Year dummies in all models are jointly significant at the 1 percent level.

Table A4. The effect of regional start-ups at the manufacturing-industry level in adjacent regions on productivity change of manufacturing incumbents

		Model I	Model II	Model III	Model IV
Start-up rate in same manufacturing industry in adjacent regions $_{t-1}$		0.0129 (0.0393)	0.0708 (0.0466)	–	–
Lagged start-up rate in same manufacturing industry in adjacent regions $_{t-1}$		–	–	-0.00149 (0.0268)	-0.00442 (0.0326)
Distance from the technological frontier $_{t-1}$	1	reference			
	2	0.0448 (0.0292)	0.0513* (0.0305)	0.0446 (0.0293)	0.0509 (0.0306)
	3	0.0933*** (0.0327)	0.103*** (0.0347)	0.0931*** (0.0327)	0.102*** (0.0347)
	4	-0.0403 (0.0603)	-0.0882 (0.0767)	-0.0408 (0.0604)	-0.0903 (0.0766)
	5	-0.225*** (0.0540)	-0.245*** (0.0722)	-0.225*** (0.0542)	-0.248*** (0.0722)
Size $_{t-1}$		-0.0719 (0.0562)	-0.117 (0.0780)	-0.0718 (0.0563)	-0.115 (0.0790)
Human capital $_{t-1}$		0.0361* (0.0185)	0.0401** (0.0183)	0.0362* (0.0185)	0.0403** (0.0185)
Export intensity $_{t-1}$		0.00154 (0.0175)	0.00753 (0.0203)	0.00121 (0.0174)	0.00651 (0.0202)
Initial productivity level $_{t-1}$		-0.833*** (0.0512)	-0.866*** (0.0561)	-0.832*** (0.0513)	-0.864*** (0.0566)
Population density $_{t-1}$		-0.955 (1.1040)	-1.093 (1.1080)	-0.98 (1.1170)	-1.211 (1.1480)
Sales change $_{t=0}$		0.000066 (0.0277)	-0.00685 (0.0309)	0.00018 (0.0276)	-0.00641 (0.0310)
Change in investments $_{t-1}$		–	-0.00472 (0.0042)	–	-0.00432 (0.0042)
Change in the number of employees $_{t=0}$		–	-0.231* (0.1170)	–	-0.231* (0.1180)
Number of observations		3,954	3,434	3,954	3,434
R-squared adjusted		0.272	0.28	0.272	0.279
Variance inflation factor		1.10	1.09	1.10	1.09
F-test		62.74	27.39	54.99	25.3
Log likelihood		-1096.2	-896.9	-1096.3	-898.2

Notes: All independent variables, except the measure for distance from the technological frontier, are included with their logarithmic values. Fixed effects panel regressions. Robust standard errors clustered at the level of planning regions in parentheses. *** Statistically significant at the 1 percent level; ** statistically significant at the 5 percent level; * statistically significant at the 10 percent level. Year dummies in all models are jointly significant at the 1 percent level.