Agglomeration and Trading Activity of Firms

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Abstract
The paper looks to see if agglomeration at the firm level is driven by firms engaged in international trade and if agglomeration affects the performance of both traders and non-traders. Using a rich panel data of Hungarian manufacturing firms from 1992 to 1999, we find that localization pattern of trading firms seem replicate and/or drive the average localization of Hungarian manufacturing. We find significantly higher productivity in locations with more dense employment. At the level of the firm this advantage holds only for those engaged in foreign trade, we found no effect of agglomeration in case of non-trading manufacturers.

Keywords: agglomeration, international trade, firm heterogeneity

JEL classification: F14, R12, R30

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1 Introduction

Geography matters for firm activities. Performance of a firm is related to its location in space as it influences the transportation costs or access to markets. The proximity of other companies influences its production options and the input prices it faces. Location advantages may be fairly different for different firms. For example, firms in international trade needed to overcome the fixed costs associated to engage in trade and hence, factors reducing such costs matter a great deal. One such factor is the knowledge of carrying out international commerce transactions as such. Being in proximity to firms with such knowledge - other traders - is likely to reduce these fixed costs of commerce. In other words, concentration of firms with relevant information may affect such costs thus making traders concentrate in relative terms.

There may be several approaches to explain why agglomerated economies are more productive. On one hand there might be an intrinsical property of the region itself, which gives productivity advantage. These might involve abundance of natural resources, preferable business or legal environment, relatively easy access to international trade by proximity to borders, or even oceans, rivers etc. Such factors attract workers and firms alike - this is the case with wine industry in Bordeaux or multinational firm headquarters in Brussels. On the other hand, the fact that economic agents are relatively close to each other creates external economies that boosts productivity. Cities have better quality of employer employee match, firms find larger pool of better quality inputs, more reliable and more differentiated suppliers. Larger communities can afford indivisible public goods, such as street light or an ice-rink with a Zamboni [2], have good restaurants and theater which all increase the well-being and the productivity of the worker and firm.

As these processes occur simultaneously, it is not easy to tell apart one effect from the other. Studies estimating the effect of agglomeration or labour density on productivity, need to control for factors that otherwise attract workers and firms, but do not influence present performance of the regions.

This paper builds on recent results both in international trade and regional science. Explaining the formation of agglomerations, new trade and economic geography theories, e.g Krugman (1991), Ottaviano & Thisse (1998) have proposed that agglomerations are naturally formed of identical firms due to trade costs and scale economies or important backward and forward linkages. Both in the U.S. and across European regions agglomerated regions have were found more productive as shown by Ciccone & Hall (1996) and Ciccone (2002). Average labour productivity increases with 6-13% on average when employment density doubles.

[2] An example from Duranton & Puga (n.d.)

The agglomeration affect may be different by sectors and firm types. We show that when looking behind the forces of agglomeration, one would primarily see firms pursuing international trade activities. Trading firms preform better in agglomerated areas - in other words, manufacturing firms are more productive in agglomerated areas if they are engaged in foreign trade.

There may be two explanations. First, trading firms being ex-ante more productive select themselves to agglomerated environments along a spatial sorting process. This argument lies on the following: only high productivity makes it possible to pay higher wages in cities, harness financial possibilities, better matching supply. For instance, Okubo & Rebeyrol (2006), Baldwin & Okubo (2006) have shown, that when firms relocate the most productive ones will cluster. From Bernard & Bradford (1999) and Melitz (2003), one might look at trader as firms with productivity over a certain cut-off point of a productivity distribution will engage, self-select in foreign trade. Thus, firms self selecting themselves to trade are such high productivity firms.

Second, trading firms are more sensitive to agglomeration advantages. In case of trading activity, knowledge spillover may be of greater advantage, from a specially skilled sales staff for instance. Special services may appear assisting in the trading activity - translators, financial services, etc. In any case, it is hard to distinguish between these two stories.

Using a large panel of Hungarian manufacturing firms to empirically investigate the relationship between spatial concentration of firms and their trading activity. The paper looks to see if agglomeration at the firm level is driven by firms engaged in international trade and if agglomeration affects the performance of both traders and non-traders.

We find that localization patter of trading firms replicate and/or drive the average localization of Hungarian manufacturing. We find significantly higher productivity in locations with more dense employment. Doubling employment density implies 14-16% increase in productivity. At firm level we find no evidence that on average firms in more dense environment would be more productive, unless they are engaged in international trade. Trading firms on average are 4-6% more productive in more dense areas.

Therefore, controlling for trading activity, even as proxy for high productivity, is important when assessing the effects of agglomeration.

2 Data

We use a panel of Hungarian manufacturing firms from 1992-1999 [3] with very detailed firm level information on balance sheet and trading activity. Data also contains the location of the firm. The panel contains on average 15000 firms yearly, without size restraints of the manufacturing sectors of NACE 2-digit classification from 17 to 37. The balance sheet information allows us to estimate productivity and also to see whether the firm is engaged in exporting or importing activity, thus trading in the given year. We use two measures of productivity at a firm level, labour productivity and TFP as proposed by Olley & Pakes (1996) [4] For detailed description of the dataset see Békés et al. (2008). On the geography side, the location of the firm primarily points the headquarters, which in case of manufacturing coincides with the place of production with higher probability than in other sectors. Location identifiers allow to use three levels of geographical aggregation. These are, from larger to lower: county (megye), micro-region (kistérség) and zipcode levels [5] .

Table 1
Basic description of the 150 ND's

Variable	Mean	Std. Dev.	Min	Max
Population	67920	158431	7577	1905661
Manuf. Employment	4122	15504	40	188280
Num. of firms	116	563	3	6899
Area (ha)	62018	31029	10308	157474

Hungary consists of 20 counties, which actually correspond to the NUTS 3 level entities. Their average size is 4600 km^2 and they hold less than half million inhabitants on average. A county consists of eight micro-regions on average, which are the NUTS 4 regional levels [6] . The number of micro-regions was originally set to 150 by the Statistical Office, which was later modified to 168 and more recently to 174. This study uses the 150 system. Each contain approximately 4-10 towns and villages which corresponds to a range where firms are operating within a 30 km radius. Their average size is 620 km^2 and 70 thousand inhabitants. See Table [7] for summary statistics. The source of the geographical data on population and area is ILOMA by IE-HAS [7] .

[3] We hope to expand the dataset till 2003.

[4] Actually we modify Olley & Pakes (1996) TFP estimates using trade dummies as proposed by De Locker (2007) and Amiti & Konings (2007). Due to the lack of sufficient data sector 23 is omitted.

[5] While zipcode level is the most disaggregated information at hand we will not use them in this study for the following reasons: 1. There are many towns and cities that hold numerous zipcodes with considerable within-town variation over time. 2. There are zipcodes that correspond to two or more villages, small towns. Both hinder unique identification.

[6] Budapest is in itself a NUTS3 and NUST4 level entity at the same time.

[7] available online at http://iloma.econ.core.hu

3 Measurement of Spatial processes

Agglomeration and spatial concentration are not a universally defined spatial concepts. Therefore we use several approaches that need clarifications and reasoning.

By agglomeration we mean the spatial concentration of employment and inhabitants, and not the fringe of satellite areas to large cities. The data allows us to define three agglomeration measures, which are the following: density of total population over a given area (*density*), that of manufacturing workers ($density_m$) and sectorally differentiated worker population ($density_s$) in a given area. The first definition corresponds to the measures used by studies such as Ciccone & Hall (1996) and Ciccone (2002). The second and third definitions are more specific, both of them are calculated from the data, in a way that firms own employment is subtracted. This way $density_m$, controls for the immediate manufacturing environment of the firm, while $density_s$ considers only density of the own sector. Excluding the firm itself from the measure not only given higher variance, but also gives a 'spillover' flavour to the density measure.

By concentration, we mean spatial bunching of employment differentiated by sectors [8]. One key difference in measures of concentration with respect to those of agglomeration is that, indices of concentration do not point towards location.

Measuring spatial concentration and agglomeration, from economic geography point of view has several pitfalls [9]. There are at least three important points that one should take into account. The measurement should be relative with respect to the topographic concentration, as more dense regions are naturally excepted to hold more firms of any sector. The relative concentration is often referred to as localization. One should take into account the so-called dart-board effect, which highlights the importance of industrial organization structures e.g. that of oligopolies. One should control for the possible biases from the artificial division of space by county, and district borders. This last issue causing a problem in both measurement often referred to as MAUP [10]. To alleviate its possible bias we use the smallest meaningful area units available, the micro-regions.

For descriptive purposes, to show the existence of spatial concentration we use relative measures, such as the Krugman index and the Theil index. More elaborate discussion of the indices see Combes & Overman (2003) and Brülhart

[8] For better tractability we NACE 2 digit level sectors
[9] For a good summary on problems of measuring spatial concentration read e.g. Duranton & Overman (2003)
[10] Modifiable Areal Unit Problem

& Traeger (2003). For dartboard considerations we employ the EG index proposed by Ellison & Glaeser (1997).

3.1 Concentration indices

The Krugman index, measures the relative spatial concentration of industry. It is commonly used, as it does not necessarily require firm/plant level data and is easy to calculate. Intuitively, it captures the phenomenon that some regions hold more of the activity of that industry, than distribution of the general economic activity by population would imply. The index sums the absolute values of these deviations the following way, calculated over a given activity x_{ik} (i is location, k is industry), where x is any activity, say employment in our case:

$$KC_k = \sum_k \left| \frac{x_{ik}}{\sum_k x_{ik}} - \frac{\sum_i x_{ik}}{\sum_i \sum_k x_{ik}} \right| \tag{1}$$

The index is between zero and two, where higher values imply that industry is overrepresented in some locations. It takes up zero, the null hypothesis, when industry is represented as equal percentage of population at all locations. Unfortunately, there is no clear indication from what value of the index we can consider an industry concentrated. The Krugman index has some further limitations. Though we can compare industries bilaterally, the index is not comparable across spatial scales. The calculation does not take into account the how spatial units locate in the geography with respect to one-another, they are simply and randomly put on an imaginary line.

From this respect, Theil index is can be considered an improvement. The Theil index is also a relative one, assessing the spatial clustering of an industry, but it can be calculated in a way, such that harnesses the fact that smaller regions are parts of bigger ones. Brülhart & Traeger (2003) have suggested to use this index in order to distinguish within and across-country patterns of concentration. The index can be calculated the following way, for y_{kir}, of industry (k), at location (i), in region (r):

$$Theil_k = \sum_{r=1}^{R} \frac{n_r}{N} \frac{\tilde{y}_{kr}}{\tilde{y}_k} log \frac{\tilde{y}_{kr}}{\tilde{y}_k} \tag{2}$$

where $\bar{y}_{kr} = \frac{\tilde{Y}_{sr}}{n_r}$ and $\bar{y}_{kr} = \frac{\tilde{Y}_s}{N}$, furthermore $\tilde{Y}_{sr} = \sum_i \frac{y_{kir}}{\sum_k y_{kir}}$ also, $\tilde{Y}_s = \sum_r \tilde{Y}_r$.

The index increases with concentration on scale of small positive numbers, with maximum depending on the sample. In present study, region is defined at county (megye) level, while location at micro-region level. So, constructed this way, the measures concentration of industry at county level, harnessing within region concentration. The reason why we still report this index is twofold, first from Brülhart & Traeger (2003) we know it is comparable over time and second we use it as a control against the Krugman index.

To capture how the spatial distribution of an industry differs from a randomly distributed one, and control for industry stucture, we use the Ellison-Gleaser index (EG or γ onwards). While previous indices we were able to calculate with regional level data, EG requires firm level information, which with some restrictions we have. The random distribution here, does not refer to uniform distribution but to one created by dropping industries from an 'airplane' or throwing them on a 'dartboard'. In the EG model, firms sequentially relocate taking into account both the natural geography, both the possible spillovers gained from the presence of other firms. The two patterns cannot be identified separately, this joint spatial distribution is captured with:

$$\gamma_k = \frac{G_k - (1 - \sum_i x_i^2)}{(1 - \sum_i x_i^2)(1 - H_k)} \tag{3}$$

Where G is $G_k = (s_i^k - x_i)^2$, also often referred to as the raw concentration index , H is plant-level Herfindahl index, s is the share of industry in regional employment, x is that of in aggregate. Under the null-hypothesis of no localization the index takes up the value of zero. Positive measure implies localization. This is the only index, which comes with a rule-of-thumb for interpretation. Ellison and Glaeser specify γ, the index to be zero at randomly distributed locations, if the value of γ is between 0.02 and 0.05 the industry is said to be moderately localized, while above 0.05 industry is said to be localized. See later, that EG-γ, has been calculated for a number of countries, allows for international comparison also.

4 Geographical Patterns in Hungarian Manufacturing

We calculated above indices for the Hungarian manufacturing sectors. The detailed results are reported in the Appendix, while over time averages of each sector is presented Table [2] below.

The Krugman index shows that most relatively concentrated industries are Office equipment, Coke and Petroleum, Recycling. The least localized are Fabricated metals, Machinery and Rubber and Plastic. Over time the localization pattern is quite stable for most industries, however we find that with mod-

Table 2
Average Localization indices of industries

	NACE	EG	Raw	Theil	Krugman
17	Textiles	-0.01	0.02	0.24	0.72
18	Clothes	0.02	0.03	0.14	0.77
19	Leather	0.05	0.06	0.47	1.09
20	Wood	0.04	0.05	0.32	0.94
21	Paper	-0.02	0.03	0.52	0.87
22	Publishing	0.09	0.09	0.30	0.79
23	Coke, Petroleum	-16.75	0.40	3.14	1.34
24	Chemicals	0.00	0.04	0.42	0.96
25	Rubber, Plastic	0.00	0.02	0.19	0.66
26	Non-metallic minerals	0.04	0.05	0.25	1.04
27	Basic metals	0.05	0.11	0.66	1.24
28	Fabricated metals	0.01	0.01	0.09	0.54
29	Machinery	0.01	0.02	0.09	0.64
30	Office equipment	0.11	0.27	1.20	1.36
31	Electric	-0.02	0.04	0.38	0.86
32	Audio, Video	0.01	0.04	0.92	0.99
33	Medical, precision	0.04	0.06	0.57	0.88
34	Motor Vehicles	-0.03	0.09	0.42	1.02
35	Other transport	-0.02	0.05	1.01	1.09
36	Furniture	0.01	0.01	0.17	0.71
37	Recycling	0.05	0.19	1.10	1.29

eration but the concentrated sector get more concentrated, and Recycling, Furniture and Wood manufacturing sectors show decreasing localization.

The Ellison-Gleaser index shows slight moderate but increasing localization over time. The most localized sectors on average the Recycling, Office equipment and Publishing, while the least localized are Textiles, Paper and Chemicals. Using the EG rule-of-thumb, we find that industries, such as Clothes, Wood are showing decreasing, while Office Equipment, Motors and Vehicles show increasing localization. Over time we see that 8-9 out of the 21 industries are localized in some sense.

The importance of controlling for industrial structure is also well visible from Table [2]. Coke and Petroleum industry shows high relative concentration, but a low EG index[11] . The industry has on average 15 firms, which though shows a spatially concentrated industry, we also know that the industry is by economies of scale monopolistic, with the national oil company (MOL) being its prime actor.

Less extreme example is that of the Motor and Vehicles industry, which shows localization in EG sense only at the end of the period, by other indices it is considered to be concentrated over all years. Which allows to suggest that over time it has become both less oligopolistic and more localized. A more clear example is the Publishing industry, which holds 10 times more firm than the Motor industry with average 2000 firms. By the EG index the Publishing is very localized industry, indeed 60% of the firms are situated in Budapest.

[11] The figure is actually unbelievably low, so we excluded from any average calculations.

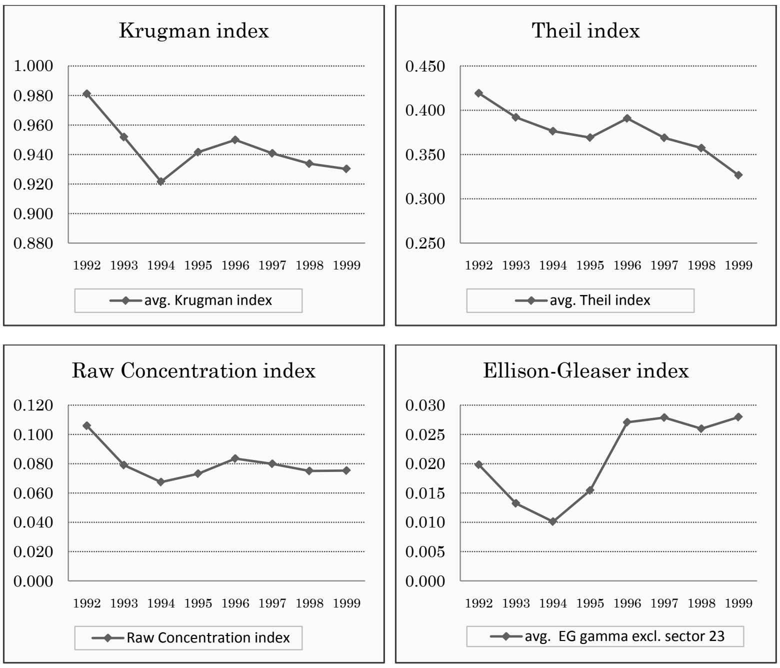
Other indices, both Krugman and Theil have Publishing on the lower end of the distribution, because average size of the firm is very small (12) and by structure it the industry seems very competitive.

In Graph [1] we plot the yearly averages of the indices to capture an aggregate picture. We find two interesting phenomena.

First, there in a break in all patterns around the middle of the sample. The break in the patterns can be attributed to many underlying processes. In 1995 Hungary introduced "Bokros-package", measures to stabilize budget. Also the bulk of the transition process, privatization process had occurred in the pre 1995 era. Furthermore, the restructuring and opening up of the economy was accompanied by the emerging of new leading economical regions, that alleviated the previously monopole position of the capital. That is, there is a shift from Budapest towards Györ, Székesfehérvár.

The second is that Ellison Gleaser finding shows a contrasting picture to the other three. On average, we find that relative measures show decreasing concentration, while average EG measure increases from 1995 on, which implies change from no-localization to moderate localization. This tendency in higher later period localization is only somewhat visible from the graph of raw concentration, which is the baseline of EG. This implies that industry structure may play an important role.

Fig. 1. *Localization of Manufacturing over time*



This increasing localization can be attributed mostly to the increasing localization Motor and Vehicles, Office Equipment and Recycling sectors. Although

Ellison-Gleaser index does not provide inference on the place or places of localization, we make some robustness checks by eliminating regions sequentially from the analysis. We find that, as expected, Budapest the capital plays an important role. Excluding Budapest, lessens the value average of concentratedness at the end of the period to 0.16. However, it does not change the main inference about the localization of individual industries, except for the publishing industry, which is localized in Budapest. Here the EG index drops to zero from 0.08. In another exercise we excluded further 3 counties [12] that were dynamically developing the last decades. As suspected, these regions are responsible an important part of the localization present in the Hungarian economy. Both Motor and Vehicle and Office and Equipment sectors are localized in these regions. Basic metals and Recycling sectors however, still remain localized in the economy, elsewhere.

4.1 International Comparison

Most international findings are however for 4-digit industry codes and for areas between 52 and 1142 km^2. This implies that micro-region level is the suitable to have the Hungarian case compared. Table[3] compares our finding to those available in the literature. We found that Hungarian manufacturing is moderately localized with a mean γ of 0.036. Compared with countries of matching size and openness, the value is similar to that of Belgium, however lower than than of Portugal, and much lower than that of Ireland.

Table 3
Comparison of Mean EG indices at 4-digit NACE level

County	Source	Year	Unit	km2	EG-γ
UK	Devereux et al. (2002)	1992	county	n.a.	0.033
US	E.-G. (1997)	1987	county	1142	0.051
Portugal	Barrios et al. (2003)	1998	NUTS-5	320	0.079
Ireland	Barrios et al. (2003)	1998	township/DED	120/20	0.133
Belgium	Barrios et al. (2003)	1998	communes	52	0.027
Hungary	our finding	1998	micro-region	cc. 590	0.036

4.2 Concentration of Trading Activity

The Hungarian manufacturing trade is a concentrated activity. While on average 41% of the firms are involved in foreign trade, this means 85% of the manufacturing employment. The share of trading employment is sightly increasing, virtually stable over time, while the share of trading firms drop from

[12] Györ-Sopron, Fejér, Komárom

45% to 39%. This, keeping in mind the constantly increasing number of firms, suggest more and more concentrating trading activity.

Do sectors show differences in localization in terms of trading activity? Somehow we need to do calculations of the previously used indices, for trader and non-trader firms. However we need consider at least two issues.

On one hand, firm size differs systematically across trading activity. Trading firms employ on average 80 people, while a non-trading firm 20 on average in our sample. Also the size distributions are different within the sample, the standard deviation of firm size is 10 times higher across trading firms. When calculating indices on these separate sample should not cause a problem, it is just scaling issue. We expect that trading part of the sectors are more concentrated in Herfindahl sense, which in principle only EG index controls for, other relative indices contain this bias (when comparing trader to nontrader).

On the other hand, among trading firms foreign ownership is somewhat over represented. While on average the share of foreign owned firms is 32%, while amongst traders we see 46% foreign ownership. This might cause a problem if foreign firms like each others proximity, or that of e.g. the western border. For this reason we also calculate indices omitting some western regions and the capital.

Fig. 2. *Localization of Manufacturing by Trading*

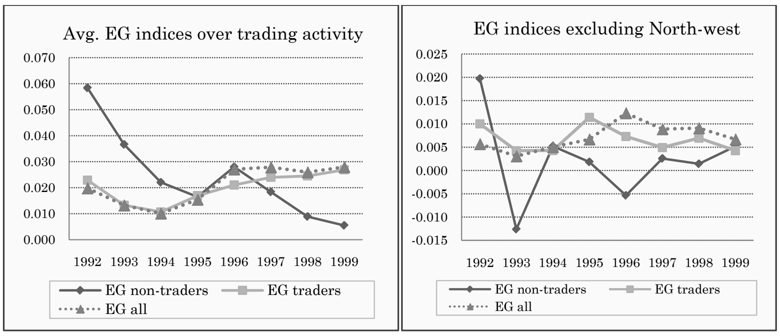


Figure [2] shows EG index per trading activity. We find that late period average moderate localization is driven by trading firms. Excluding western regions and the capital reinforces the common belief that manufacturing (and) trade is localized in the most agglomerated and fast growing regions of the country. When looking at eastern part of Hungary only we find no evidence of general localization. However, we find that localization pattern is again driven by that of trading firms. As for the whole country one can say, that trading firms play important role in the localization of the sectors.

5 Agglomeration effects at micro-region level

More densely populated areas were found to be more productive by e.g. Foster & Stehrer (2008). The agglomeration effects on productivity may be categorized the following way: 1. Proximity of other firm reduces transport cost and created increasing returns to firms with fixed costs of production. See e.g. Krugman (1991) 2. Externalities created by the density of the firms around increase productivity. These have been already laid down by Marshall (1920): input-sharing, labour-market pooling and localized technological spillovers. 3. Dense economic activity allows for greater degree of specialization. [13]

For examining the relationship between spatial density and economic activity based on the effects of increasing returns, Ciccone & Hall (1996) develop two otherwise observationally equivalent models, that draw the external effect either from local externalities or the variety of intermediates. On US county level 1988 data they test whether labour density affects productivity. Regressing labour productivity on measure of education and density instrumented by land area and historical infrastructure measures, they find that doubling labour density increases labour productivity by 6% on average. For European countries Germany, Italy, Spain, France and UK on NUTS-3 regional level data Ciccone (2002)'s repeated the exercise. He finds that doubling the density of labour results in an average increase of 5% in labour productivity.

Dekle & Eaton (1999) estimate agglomeration effects for Japan. Investigating the financial and manufacturing sectors they find that although effects significantly fade with distance, agglomeration explains 8.9 % and 5.6% labour productivity growth respectively. Gambardella et al. (2003) investigate that besides the agglomeration economies how openness affects productivity. Find that besides labour density and patents, openness matters.

More recently, Brülhart & Mathys (2007) and Foster & Stehrer (2008) estimate the effect of labour density across European regions. Brülhart & Mathys (2007) modify the Ciccone estimation in order to tackle the inherent endogeneity of the problem arising from the fact that causality between agglomeration and productivity runs both ways. [14] Estimating the long run elasticity between density and productivity on panel of 20 European countries at NUTS-2 level, they find it to be 13%. As a novelty to previous studies they also estimate localization and urbanization effects across sectors.

Foster and Stehrer extend Ciccone's model and estimate agglomeration effects

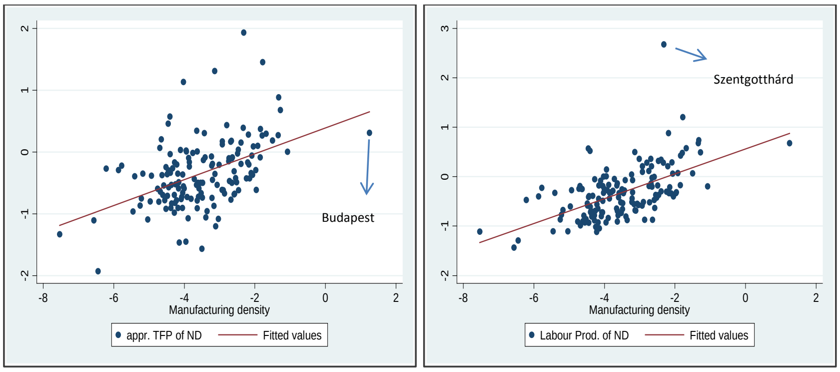
[13] For a good survey of the literature see Hanson (2000)

[14] While Ciccone uses area of the region to IV population density, harnessing the panel structure they use system-GMM estimator of Arellano & Bond (1991). This not only supposed to deal with endogeneity without the problem of instrumenting, but also with the low variation across time as well.

for 27 European countries at NUTS-2 level. They reinforce Ciccone's finding about 5 percent density elasticity of productivity. Investigating sectoral level effects, they find significant positive agglomeration effects only in manufacturing, however of a much lower figure of 1.5 percent. They also find that agglomeration effects are significantly higher in new member states. While in old states the figure is only 3 percent, in new member states it is 15%. This higher figure pertains at sectoral level if present.

Using micro-region level data, and different productivity measurements, we show in this section, that this phenomena is valid across locations within Hungary. As Graph[3] shows average productivity of a micro-region is visibly correlated by the density of the location. The strength of this correlation varies through time and productivity definitions, labour productivity seems more sensitive to density. We also see that, Budapest is the most dense district, but has high, but not the highest productivity. The best performance is shown by moderately dense location of Szentgotthárd. The city on the Austrian border, where a production unit of General Motors is located.

Fig. 3. *Productivity plotted against density in 1997*



This unconditional correlation needs to be controlled for idiosyncracies. Following Ciccone (2002), we estimate the correlation in between density and productivity by the following equation, where the D's represent vectors of dummy variables:

$$lnProd_{it} = \alpha_1 * lnDens_{it} + \alpha_2 * D_t + \alpha_4 * D_i + u_{it} \quad (4)$$

The estimation uses to productivity measures, labour productivity as real VA per worker and TFP [15] in a micro-region as function of manufacturing worker density [16]. The location controls capture idiosyncratic variation in micro-region characteristics by county, mainly geographical location, proxim-

[15] TFP due to the small cross-section dimension is not estimated, but approximated the following way: log(output)-0.3*log(K)-0.7*log(L)

[16] sectoral differentiation of density variable makes no sense here

ity of borders. Unfortunately due to lack of data we cannot control for quality of labour force.

Notice, that basic least squares estimation of eq. (4) is inconsistent. The location dummies cannot necessarily control for all exogenous variations of productivity differences that might attract workers. Therefore an instrumental variable estimation is advisable, where the instrument is correlated with (mainly past) variations in density, but not with current productivity differences. Ciccone (2002) uses regional area, arguing that in most European cases they were set centuries ago with the agenda to equalize population across them. In case of Hungary the history of the current regional stratification is not that clear-cut, as it has gone through many modifications in the 20th century. Though, the micro-region 150 may be considered somewhat related to the 'járás' system used pre WWII, we do not know yet if that equalized population. For now, we will use area for identification, as the main goal of the section is to show, that density plays part in explaining the variation of productivity. [17]

Table 4
micro-region Level Aggregate Estimations - Labour productivity

VARIABLES	Labour productivity					
	full sample		pre 1996		post 1995	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
log ($density_m$)	0.180***	0.175***	0.131***	0.105*	0.236***	0.256***
	[12.44]	[3.697]	[6.692]	[1.759]	[12.33]	[3.512]
Constant	-0.0462	0.365*	0.309***	-0.0565	0.483***	0.304
	[-0.897]	[1.810]	[6.721]	[-0.215]	[10.51]	[1.284]
County ctrls	yes	yes	yes	yes	yes	yes
Year ctrls	yes	yes	yes	yes	yes	yes
Observations	1200	1200	600	600	600	600
R-squared	0.365	0.365	0.288	0.285	0.391	0.39

Robust t statistics in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 5
micro-region Level Aggregate Estimations - FTP

VARIABLES	TFP					
	full sample		pre 1996		post 1995	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
log ($density_m$)	0.141***	0.169***	0.0833***	0.0468	0.205***	0.311***
	[9.458]	[3.252]	[4.693]	[0.785]	[8.955]	[3.551]
Constant	-0.608***	0.485**	-0.138***	-0.403	0.347***	-0.183
	[-11.85]	[2.190]	[-3.165]	[-1.539]	[6.509]	[-0.644]
County ctrls	yes	yes	yes	yes	yes	yes
Year ctrls	yes	yes	yes	yes	yes	yes
Observations	1200	1200	600	600	600	600
R-squared	0.407	0.405	0.27	0.263	0.326	0.295

Robust t statistics in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

[17] possible IV candidates are: historical density data, above-the sea level measure

Table [4] shows parameter estimates of eq. (4)'s density variable. We find that on average doubling of the density increases labour productivity by 16-17%. The two-stage least square estimations confirm the result. As the concentration patterns in previous sections suggested, we expect manufacturing sectors on average to be more localized in, and concentrated towards the end of the sample-period. Our regressions show, that after 1995 denser regions had higher productivity premia. The difference is not surprising, as pre-1995 transition year hold less mature and less productive firms. We find that when productivity accounts for capital abundance with TFP the result is quite similar. The range of results are higher than findings of Brülhart & Mathys (2007), but in one sense, reinforce Foster & Stehrer (2008)'s estimation about higher Central European findings. For robustness, we also repeated analysis excluding Budapest micro-region as outlier, but results did not change significantly.

6 Agglomeration effects at firm level

In this section we conduct estimation at firm level. That is, we ask does density explain variations of individual firm performance? From e.g. Altomonte & Békés (2008) we know, that trading manufacturing firms differ from non-trading firms in Hungary. They are not only larger and more productive (traders are 50-60% more prod.), but also they are handle more complex production structure via using imported inputs. Inputs cover not only intermediated goods, but better matching in terms of employment and services that suppliers provide. This line of thought suggest, that controlling for trading activity of a firm, both imports and exports is necessary to assess the effect of agglomeration. Importance of import is also stressed by Halpern et al. (2005) and Amiti & Konings (2007) and Muûls & Pisu (2007).

Wide empirical evidence suggests that traders are more productive than those firms not engaging in trading activity.[18] However, question whether higher productivity precedes trading activity or follows is not yet fully resolved. Otherwise said do firms learn-by-trading or self-select to trade? Based on the theoretical work of e. g. Melitz (2003) and Bernard et al. (2003), on heterogenous firms engaging in trading activity a body of empirical research suggest that traders have to pay a fix-cost of engaging into international trade, which is only affordable for the most productive ones. Given the ex-ante advantage traders also gain from trading activity. Exporter e.g face larger competition and larger market, importers benefit from improved and wider variety of intermediate goods and learning.

[18] See e.g. Bernard & Bradford (1999)

New economic geography (NEG) and trade models, such as that e.g. of Krugman (1980) Krugman (1991) explain the unequal spatial distribution of economic activity and international trade together. The theory implies that in presence of trade cost and economies of scale manufacturing sector tends to agglomerate. In regions with better market access will have higher factor prices and factor inflow, falling trade cost induces agglomeration and the the so-called home market effect implies that production of good is agglomerated in a country where it has larger share from the overall demand.

Baldwin & Okubo (2006) claim that if firm heterogeneity and relocation possibility is introduced to NEG models then the firms that move to the larger market or more dense region will actually be the most productive ones, which might induce overestimation of agglomeration effect. This idea is also coherent with the notions that in agglomerated regions factor reward are higher e.g average wage, rents are higher which presumably only affordable for the more productive ones. This also consistent with finding of Melitz & Ottaviano (2008) that in large markets the cut-off marginal product that permits market entry is lower, so wider range of less efficient firms are eliminated.

6.1 Estimation

Simply re-estimating equation (4) at would be misleading without controlling for firm-specific heterogeneity. Controls such as dummy foreign ownership, size and age and dummy for NACE 2 digit sector seem necessary. We suspect that productivity of foreign owned firms are higher, as per better management skills easier access to imports or simply being a index for the advantages of being a subsidiary. Firms might develop productivity advantage over years, and different covariates should matter differently across sectors. E.g. more labour intensive sectors might be more sensitive to agglomerate locations.

To capture whether firms in denser areas are on average more productive, we estimate the following equation:

$$\begin{aligned} ln(Prod_{it}) = {} & \alpha + \beta_1 lndensity_{it} + \beta_2 trader_{it} + \beta_3 trader_{it} \times lndensity_{it} \\ & \beta_4 ln(empl_{it}) + \beta_5 for_{it} + \beta_6 age_{it} + \beta_7 socfirm_{it} + \\ & \beta_8 BP_{it} \times lndensity_{it} + \beta_9 for_{it} \times lndensity_{it} + \Gamma + \epsilon_i \end{aligned} \tag{5}$$

In the equation *lndensity* we substitute each of the 3 density definitions laid down in Data section at a time. Further variables read the following way: $Trader$ is a dummy equal to 1 if firm engages in foreign trade for at least 0.5% of its sales, *empl* is the number of employees at the firm, for is a dummy equal to 1 if the firm is dominantly foreign owned, *age* is the i-th year the firm spends in the sample, $Socfirm$ is a dummy equal to 1 if firm was in our sample in 1992. BP is a dummy for Budapest location. Cross terms control for possible co-movement of foreign ownership and trader status with agglomeration. Capital gamma is a vector of dummy controls for year, sector and micro-region effects.

First we estimate [5] as simple pooled OLS on the panel of firms. At firm we use the augmented Olley-Pakes productivity measure, as it is estimated by industry and makes cross firms comparison possible. Also, the Amiti-Konings modification allows to control for productivity gains by the real exchange rate change of the imported intermediates. Results for all three density measures are shown in Table[11] As control we also employ firm level labour productivity in Table[12]

From the population density regression we learn, that in micro-regions where the population density higher, firms are likely to be more productive. However this correlation is very sensitive to firm specific characteristics, and the Budapest dummy. Although Budapest located firms are more productive then others, its density value is so high that it can be considered an outlier. [19]

When we include controls in steps as thought experiment. We find that only sectoral level density explains productivity variation significantly, once BP is controlled for. Though, we cannot identify general correlation, cross correlations convey important messages. We find that foreign and trading firms tend to be more productive in denser areas. At this point of the discussion however we cannot tell apart, whether foreign and trading firms actually benefit from denser environment, we just detect a composition "effect". When running regressions separately on traders and non-traders, we also find the foreign owned traders to be more productive in denser environment, however the average effect on traders shows only at the sectoral density level. Also we find that smaller firms seem to benefit more from density.

The ceteris paribus exercise would tell us, if a trading firm, other things held constant was replaced to a micro-region with double the density, its productivity would likely to be higher by 4-6%. The figure is similar to what Ciccone estimated for Europe at aggregate, regional level, and seems to be the most consistent and highest of the interaction terms. The corresponding foreign figure is roughly 2-3%. One might say that location, denser environment matters for the trading firm in terms of productivity, while we could not find detectable correlation in case of non-trading firms.

The correlation in case of sectoral density definition is the strongest. Note, that

[19] The interaction term of density and Budapest in itself is not interpretable, it merely serve the purpose to take BP as an outlier. Also, the density measure of Budapest is known to be biased seriously upwards. Some large manufacturing firms, that have country-wide employment have BP headquarters. Unfortunately we cannot target this bias, yet.

this definition tries to capture specialization, or sectoral localization. While it might go together with agglomeration of the whole manufacturing sector, or that of the whole population, but not necessarily. As we excluded, own employment from density measures, we might say, that traders seem to be more productive near to peers from the same sector. Doubling the density in this case goes together with ceteris. par. 6-7%. higher productivity in case of traders.

When we include the size of the firm (log-employment) interacted with our density variables we find that, small sized firm tend to be more productive in agglomerated locations. This is something we would expect, as in larger markets small firms can do specialized production, find better supply chains. When running equation separately for traders and non-traders, we find an even sharper result. This productivity advantage of small firms in agglomeration is only present for trading firms, while in case of non-trading firm agglomeration plays the opposite role.

When we are not cautious to exclude Budapest, the interaction term do not change in significance of value. However, in the case when density is calculated using the general population, the coefficient of *lndensity* remains significant with an unrealistically large figure.

The aforementioned patterns are robust over productivity definitions. Labour productivity show same fidelity, however if we use Levinsohn-Petrin estimates, density term become about a third less.

6.2 Causal effects at a firm level

When we investigated effect at aggregate level, we used the area of the district as instrument, to disentangle the causality from agglomeration to productivity, from the productivity to agglomeration one. We noted that areal coding in case of Hungary might not be old enough to provide a strong instrument, firm level estimation gives rise to other concerns. First, in case of sectoral defined density, although it can be used, but it will not vary by sector, thus we loose a dimension. The second concern is that, density interaction with Budapest term cannot be included because the structural equation will not be identified.

With these restrictions we display our results in Table [13] and [14]. In case of population and manufacturing density we still do not find significant results. In case of sectoral density, however our results very much differ when we examine sectoral agglomeration. While the presence of other manufacturing employment of the same sector in the proximity seems to increase TFP it has a negative effect on labor productivity. This suggests a congestion effect for labour but not for capital at sectoral level for the non-trading firms.

The interaction term between trading activity and density is significant and consistent across all specifications, implying 5-6% increase of productivity for traders in more dense environment. This holds even in the last columns of [14], for sectoral density, implying that traders always benefit from density.

7 Conclusion

This paper aimed at linking participation in international trade to agglomeration effect on firms. Taking one country and focusing on the sub-national level of counties and micro-regions, we investigated the relationship between foreign trade and spatial distribution of economic activity. We found that density is related to productivity. The knowledge to trade was found to matter at the sectoral level rather then a broader level: sectoral regional density (i.e. the concentration of firms in the same industry) is indeed positively correlated with TFP and importantly, this correlation is higher for trading firms. We find that localization patter of trading firms replicate and/or drive the average localization of Hungarian manufacturing. We suggest controlling for trading activity, even as proxy for high productivity, is important when assessing the effects of agglomeration.

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8 Appendix of Tables

Table 6
Basic Geographical Description

County	Area (km^2)	Population (mean)	Num.Districts
Budapest	525	1865321	1
Baranya	4430	406600	8
Bács-kiskun	8445	540004	10
Békés	5631	398598	6
Borsod-Abaúj-Zemplén	7247	741667	11
Csongrád	4263	426202	7
Fejér	4359	424703	7
Györ-Moson-Sopron	4208	432209	6
Hajdú-Bihar	6211	547807	7
Heves	3637	326300	6
Komárom-Esztergom	2265	313982	7
Nógrád	2544	220236	6
Pest	6393	1021686	14
Somogy	6036	335456	9
Szabolcs-Szatmár-Bereg	5937	574007	10
Jász-Nagykun-Szolnok	5582	416675	6
Tolna	3701	247895	5
Vas	3336	269367	9
Veszprém	4493	371070	9
Zala	3784	298131	6
	4651	508896	7.5

Table 7
Micro-region characteristics

MR	avg. Pop.	avg. manuf. empl.	avg. N. of firms	area (ha)	MR	avg. Pop.	avg. manuf. empl.	avg. N. of firms	area (ha)
Ajka	60584	5651	72	74344	Mezökovácsháza	48823	471	11	93355
Aszód	36011	1035	41	30907	Mezökövesd	47021	1086	30	77048
Baja	78086	3466	107	118996	Miskolc	277565	14984	378	101757
Baktalórántháza	23302	429	10	31800	Mohácsi	54322	2452	67	87944
Balassagyarmat	43322	1717	45	53188	Monor	36650	303	28	23573
Balatonalmádi	24719	3441	40	28649	Mosonmagyaróvár	71521	7333	128	93070
Balatonfüred	21769	142	22	31847	Mátészalka	66579	1826	30	62474
Balmazújváros	30549	645	11	73122	Mór	28165	4184	34	29456
Barcs	26846	790	28	69647	Mórahalom	16839	40	6	41172
Berettyóújfalu	66177	1811	41	137231	Nagyatád	28823	545	21	64707
Bicske	34701	440	24	61872	Nagykanizsa	83951	3562	71	89254
Bonyhád	30873	2781	37	37756	Nagykálló	32027	693	21	37741
Budapest	1905661	188280	6899	52516	Nagykáta	72674	1198	43	77945
Budaörs	110334	5073	340	20791	Nyirbátor	44369	577	24	69595
Bácsalmás	18426	424	8	38109	Nyiregyháza	214818	9329	309	143814
Bátonyterenye	27803	1308	32	27839	Orosháza	66040	3810	72	84858
Békéscsaba	167954	8326	185	141581	Oroszlány	28683	1382	21	19936
Cegléd	116920	3291	123	123403	Paks	48957	2072	44	75687
Celldömölk	27297	3064	29	47420	Piliscsaba	75344	3550	222	37991
Csenger	14176	573	9	24658	Polgár	14678	91	8	38387
Csepreg	11407	318	14	19683	Pápa	64053	3776	73	100140
Csongrád	25403	1557	20	33924	Pásztó	34134	597	34	55165
Csorna	36514	1266	26	63276	Pécsi	206231	10890	397	94848
Csurgó	19200	663	12	49619	Pécsváradi	11214	173	13	20014
Dabas	39645	1152	63	49870	Pétervására	22949	375	13	42626
Debrecen	290521	16847	383	153196	Püspökladány	52653	890	28	95352
Dombóvár	35222	1325	41	50947	Ráckeve	107418	3754	260	62846
Dorog	39919	1727	52	23270	Rétság	25078	1057	30	43502
Dunakeszi	57091	2989	124	10308	Salgótarján	70035	6871	95	46980
Dunaújváros	109920	11741	127	75067	Sarkad	26739	238	6	54661
Edelény	35780	645	20	73935	Sellye	13424	142	5	41056
Eger	96729	6551	150	74104	Siklósi	35855	613	27	62410
Encs	35031	557	9	79612	Siófok	47056	637	46	62783
Enying	24674	81	5	48090	Sopron	90744	6743	153	85737
Esztergom	54478	7748	129	30486	Szarvas	42455	2688	42	73982
Fehérgyarmat	38858	711	15	69641	Szeged	206262	10392	355	87598
Fonyód	28097	1006	36	42887	Szeghalom	48271	958	20	114670
Füzesabony	37093	848	22	66939	Szekszárd	89506	4149	114	103027
Gyál	89955	2392	126	43284	Szentendre	63226	2819	204	34262
Györ	170880	19304	336	72735	Szentes	46490	1618	36	81388
Gyöngyös	76900	1012	18	73344	Szentgotthárd	15363	2163	26	23344
Gárdony	32318	417	28	37890	Szerencs	63546	724	42	83676
Gödöllö	103616	7494	186	44961	Szigetvári	28263	722	20	66887
Hajdúböszörmény	59222	3677	64	73106	Szikszó	19802	47	3	31165
Hajdúszoboszló	33295	730	33	50674	Szob	12384	429	16	31486
Hatvan	56403	2697	91	36955	Szolnok	122525	9847	204	87752
Heves	36992	1552	47	69779	Szombathely	115111	13386	210	64636
Hódmezövásárhely	61060	5060	111	70782	Szécsény	20380	1492	23	27741
Jánoshalma	17896	622	14	39914	Székesfehérvár	163377	17441	313	118133
Jászberény	88411	6757	96	116146	Sárbogárd	30148	1042	8	65368
Kalocsa	56803	1725	63	102903	Sárospatak	28370	1018	31	47760
Kaposvár	123577	4553	126	157474	Sárvár	37563	3676	28	59029
Kapuvár	25833	1756	28	38271	Sásdi	16177	449	22	38387
Karcag	77238	3801	90	138360	Sátoraljaújhely	44391	3288	32	71158
Kazincbarcika	66189	5047	44	50375	Sümeg	16524	510	15	30640
Kecskemét	163329	9347	339	148318	Tab	17201	1650	14	47962
Keszthely	46359	2196	40	50456	Tamási	43323	1966	40	102613
Kisbér	21270	650	28	51075	Tapolca	38107	829	34	54021
Kiskunfélegyháza	52416	3716	63	81072	Tata	38881	1610	94	30678
Kiskunhalas	46876	1398	58	82635	Tatabánya	88972	3905	174	33166
Kiskunmajsa	16932	892	21	39192	Tiszafüred	41934	799	17	84661
Kiskörös	58125	1548	69	113033	Tiszavasvári	28534	2786	11	38167
Kistelek	19498	75	10	41020	Tiszaújváros	46750	6196	54	53274
Kisvárda	69564	1267	23	52835	Tét	30572	758	18	55778
Komló	42590	1766	60	31462	Törökszentmiklós	47022	1093	34	60332
Komárom	41181	1448	58	37898	Vasvár	15938	593	10	37414
Kunszentmiklós	30676	873	24	80281	Veszprém	86130	7820	181	65670
Kunszentmárton	40238	855	23	70923	Vác	71056	5074	126	47720
Köszeg	17812	2358	19	18505	Várpalota	37459	3869	34	27045
Körmend	22502	950	17	33091	Vásárosnamény	37626	699	17	62940
Lengyeltóti	12193	141	8	27095	Zalaegerszeg	105617	8273	166	99270
Lenti	24386	1242	33	66311	Zalaszentgrót	18967	1077	26	32712
Letenye	19602	358	16	40409	Zirc	26455	410	18	48904
Makó	51303	1648	33	70385	Ózd	76815	3418	60	54957
Marcali	32942	1453	27	81409	Öriszentpéter	7577	670	11	30523

Table 8
Krugman Indices of Manufacturing Sectors

	NACE 2	1992	1993	1994	1995	1996	1997	1998	1999	avg.	change*
17	Textiles	0.74	0.74	0.72	0.78	0.70	0.71	0.70	0.69	0.72	-0.03
18	Clothes	0.76	0.78	0.76	0.76	0.80	0.77	0.75	0.74	0.77	-0.01
19	Leather	1.09	1.05	1.01	1.12	1.11	1.12	1.12	1.13	1.09	0.07
20	Wood	1.03	1.02	1.00	0.99	0.93	0.86	0.86	0.82	0.94	-0.17
21	Paper	0.91	0.86	0.86	0.86	0.86	0.87	0.87	0.89	0.87	0.00
22	Publishing	0.82	0.74	0.75	0.81	0.82	0.80	0.80	0.78	0.79	0.02
23	Coke, Petroleum	1.27	1.28	1.28	1.33	1.36	1.38	1.40	1.41	1.34	0.12
24	Chemicals	0.90	0.93	0.95	0.98	0.99	0.98	0.99	1.00	0.96	0.06
25	Rubber, Plastic	0.72	0.65	0.65	0.67	0.65	0.65	0.63	0.66	0.66	-0.03
26	Non-metallic minerals	0.97	1.04	1.04	1.06	1.06	1.05	1.06	1.04	1.04	0.03
27	Basic metals	1.37	1.17	1.20	1.27	1.16	1.29	1.26	1.24	1.24	0.02
28	Fabricated metals	0.70	0.59	0.53	0.52	0.50	0.50	0.50	0.49	0.54	-0.11
29	Machinery	0.67	0.67	0.70	0.63	0.63	0.61	0.61	0.61	0.64	-0.07
30	Office equipment	1.16	1.39	1.25	1.25	1.38	1.47	1.47	1.52	1.36	0.22
31	Electric	0.95	0.93	0.90	0.87	0.83	0.79	0.80	0.80	0.86	-0.13
32	Audio, Video	1.00	1.05	1.00	1.02	1.00	0.99	0.95	0.92	0.99	-0.07
33	Medical, precision	0.91	0.91	0.87	0.92	0.91	0.89	0.85	0.79	0.88	-0.05
34	Motor Vehicles	0.98	0.97	0.98	1.01	1.06	1.03	1.04	1.11	1.02	0.08
35	Other transport	1.14	1.09	1.07	1.07	1.10	1.07	1.07	1.07	1.09	-0.03
36	Furniture	0.81	0.77	0.76	0.73	0.69	0.67	0.64	0.62	0.71	-0.14
37	Recycling	1.69	1.34	1.08	1.11	1.40	1.27	1.22	1.21	1.29	-0.14
	Average	0.98	0.95	0.92	0.94	0.95	0.94	0.93	0.93		

*change is calculated as the difference between the avg. values of the first and last 3 years.

Table 9
Theil Indices of Manufacturing Sectors

	NACE 2	1992	1993	1994	1995	1996	1997	1998	1999	avg.	change*
17	Textiles	0.38	0.24	0.25	0.27	0.33	0.19	0.14	0.14	0.24	-0.13
18	Clothes	0.13	0.14	0.14	0.15	0.16	0.15	0.13	0.15	0.14	0.01
19	Leather	0.39	0.38	0.43	0.44	0.52	0.55	0.52	0.50	0.47	0.13
20	Wood	0.32	0.33	0.30	0.33	0.32	0.32	0.30	0.31	0.32	-0.01
21	Paper	0.65	0.59	0.55	0.45	0.51	0.47	0.48	0.44	0.52	-0.13
22	Publishing	0.56	0.35	0.32	0.29	0.26	0.22	0.20	0.23	0.30	-0.19
23	Coke, Petroleum	3.93	2.95	2.84	3.11	3.16	3.11	3.08	2.96	3.14	-0.19
24	Chemicals	0.37	0.39	0.42	0.44	0.43	0.43	0.43	0.42	0.42	0.04
25	Rubber, Plastic	0.30	0.24	0.21	0.20	0.16	0.14	0.12	0.11	0.19	-0.13
26	Non-metallic minerals	0.32	0.27	0.28	0.25	0.26	0.21	0.20	0.19	0.25	-0.09
27	Basic metals	0.63	0.67	0.60	0.61	0.67	0.75	0.74	0.64	0.66	0.08
28	Fabricated metals	0.09	0.11	0.11	0.11	0.11	0.08	0.06	0.07	0.09	-0.03
29	Machinery	0.14	0.13	0.10	0.08	0.04	0.04	0.11	0.09	0.09	-0.05
30	Office equipment	1.44	1.24	1.10	1.16	1.15	1.22	1.13	1.14	1.20	-0.10
31	Electric	0.54	0.46	0.41	0.36	0.36	0.30	0.31	0.31	0.38	-0.16
32	Audio, Video	0.89	0.98	0.87	0.88	0.96	0.99	0.94	0.82	0.92	0.00
33	Medical, precision	0.73	0.66	0.65	0.66	0.72	0.59	0.53	0.04	0.57	-0.29
34	Motor Vehicles	0.83	0.36	0.39	0.35	0.38	0.35	0.35	0.34	0.42	-0.18
35	Other transport	0.97	1.34	1.26	1.20	0.99	0.82	0.74	0.76	1.01	-0.42
36	Furniture	0.10	0.20	0.21	0.20	0.20	0.17	0.15	0.13	0.17	-0.02
37	Recycling	0.99	1.08	0.95	0.66	1.28	1.27	1.30	1.29	1.10	0.28
	avg	0.42	0.39	0.38	0.37	0.39	0.37	0.36	0.33		

*change is calculated as the difference between the avg. values of the first and last 3 years.

Table 10. *Ellison-Gleaser Indices of Manufacturing Sectors*

	NACE 2	1992	1993	1994	1995	1996	1997	1998	1999	avg.	change*
17	Textiles	-0.005	-0.003	-0.009	-0.008	-0.006	-0.003	-0.003	-0.005	-0.005	0.002
18	Clothes	0.027	0.029	0.024	0.022	0.023	0.018	0.018	0.014	0.022	-0.010
19	Leather	0.061	0.054	0.051	0.051	0.043	0.050	0.047	0.046	0.050	-0.008
20	Wood	0.064	0.060	0.055	0.042	0.034	0.027	0.026	0.022	0.041	-0.035
21	Paper	-0.043	-0.026	-0.024	-0.023	-0.019	-0.013	-0.011	-0.005	-0.021	0.021
22	Publishing	0.095	0.066	0.072	0.099	0.107	0.100	0.096	0.085	0.090	0.016
23	Coke, Petroleum	.	.	.	.	.	.	.	.	.	
24	Chemicals	-0.019	-0.016	-0.013	-0.006	-0.001	0.005	0.008	0.011	-0.004	0.024
25	Rubber, Plastic	-0.043	0.002	0.004	0.010	0.005	0.004	0.004	0.005	-0.001	0.017
26	Non-metal. minerals	0.038	0.039	0.039	0.041	0.040	0.036	0.040	0.036	0.039	-0.002
27	Basic metals	0.098	0.030	0.039	0.056	0.034	0.059	0.051	0.043	0.051	-0.004
28	Fabricated metals	0.014	0.007	0.005	0.004	0.003	0.005	0.006	0.005	0.006	-0.003
29	Machinery	0.010	0.008	0.015	0.008	0.008	0.007	0.006	0.008	0.009	-0.004
30	Office equipment	0.043	0.063	0.041	0.079	0.131	0.151	0.146	0.198	0.106	0.116
31	Electric	-0.038	-0.025	-0.026	-0.026	-0.021	-0.020	-0.014	-0.016	-0.023	0.013
32	Audio, Video	-0.004	0.020	0.022	0.016	0.015	0.010	0.004	-0.002	0.010	-0.009
33	Medical, precision	0.047	0.052	0.041	0.041	0.040	0.041	0.036	0.024	0.040	-0.013
34	Motor Vehicles	-0.146	-0.086	-0.045	-0.032	0.001	0.016	0.026	0.055	-0.026	0.124
35	Other transport	-0.017	-0.031	-0.031	-0.032	-0.029	-0.024	-0.017	-0.006	-0.024	0.011
36	Furniture	0.013	0.010	0.010	0.006	0.003	0.002	0.000	-0.001	0.005	-0.011
37	Recycling	0.202	0.011	-0.068	-0.040	0.132	0.087	0.053	0.043	0.053	0.013
		0.0198	0.0132	0.0101	0.0154	0.0271	0.0279	0.0260	0.0280		

*change is calculated as the difference between the avg. values of the first and last 3 years.

Table 11. *Firm level OLS regressions - Olley-Pakes*

	Population density			Manufacturing density			Sectoral density		
VARIABLES	TFP (OP)	TFP (OP)	TFP (OP)	TFP (OP)	TFP (OP)	TFP (OP)	TFP (OP)	TFP (OP)	TFP (OP)
ln (empl.)	0.201***	0.144***	0.157***	0.201***	0.144***	0.137***	0.200***	0.143***	0.132***
	[73.58]	[50.56]	[44.10]	[73.33]	[50.34]	[41.06]	[73.19]	[50.37]	[22.59]
ln (density)	0.634***	0.375**	-0.172	0.0523***	-0.00836	-0.00511	0.0450***	0.0073	0.0095
	[3.629]	[2.197]	[-0.655]	[2.666]	[-0.427]	[-0.235]	[9.834]	[1.469]	[1.601]
trader		0.456***	0.440***		0.568***	0.574***		0.650***	0.664***
		[49.39]	[45.84]		[65.22]	[65.49]		[42.67]	[41.55]
ln (dens.) X trader		0.0443***	0.0537***		0.0364***	0.0425***		0.0419***	0.0464***
		[10.95]	[12.47]		[11.23]	[12.30]		[9.942]	[10.24]
foreign ow.	0.222***	0.0765***	0.0711***	0.222***	0.130***	0.132***	0.221***	0.203***	0.209***
	[27.44]	[7.867]	[7.225]	[27.45]	[13.53]	[13.66]	[27.35]	[11.79]	[11.90]
age	0.0896***	0.0804***	0.0800***	0.0895***	0.0802***	0.0799***	0.0895***	0.0803***	0.0801***
	[36.21]	[33.25]	[33.06]	[36.19]	[33.18]	[33.04]	[36.19]	[33.20]	[33.13]
soc. firm	-0.0543***	-0.0284***	-0.0261***	-0.0547***	-0.0285***	-0.0268***	-0.0545***	-0.0285***	-0.0278***
	[-6.345]	[-3.402]	[-3.124]	[-6.397]	[-3.419]	[-3.210]	[-6.366]	[-3.418]	[-3.328]
ln (dens.) X BP			1.023***			0.303***			0.0379***
			[3.107]			[2.959]			[3.170]
ln (dens.) X For.		0.0210***	0.0244***		0.0181***	0.0197***		0.0314***	0.0335***
		[4.635]	[5.281]		[5.029]	[5.343]		[6.592]	[6.822]
ln (dens.) X ln (emp.)			-0.00897***			-0.00574***			-0.00361**
			[-5.766]			[-4.517]			[-2.234]
Dummy: location	yes	yes	yes	yes	yes	yes	yes	yes	yes
Dummy: sector	yes	yes	yes	yes	yes	yes	yes	yes	yes
Dummy: year	yes	yes	yes	yes	yes	yes	yes	yes	yes
Constant	-3.174***	-2.413***	-4.088***	-0.690***	-0.971***	-1.054***	-0.459	-0.714	-0.648
	[-5.068]	[-3.947]	[-5.303]	[-4.044]	[-5.779]	[-5.972]	[]	[-0.000351]	[]
Observations	99641	99641	99641	99638	99638	99638	99541	99541	99541
R-squared	0.206	0.245	0.246	0.206	0.245	0.245	0.207	0.246	0.246

Robust t statistics in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 12. *Firm level OLS regressions - Labour Productivity*

	Population density			Manufacturing density			Sectoral density		
VARIABLES	Lab. Prod.	Lab. Prod.	Lab. Prod.	Lab. Prod.	Lab. Prod.	Lab. Prod.	Lab. Prod.	Lab. Prod.	Lab. Prod.
ln (empl.)	-0.0153***	-0.0781***	-0.0639***	-0.0145***	-0.0780***	-0.0863***	-0.0161***	-0.0788***	-0.0993***
	[-5.742]	[-28.34]	[-18.63]	[-5.411]	[-28.13]	[-26.64]	[-6.069]	[-28.61]	[-17.59]
ln (density)	0.566***	0.304*	-0.374	0.0607***	0.000123	0.0038	0.0473***	0.0118**	0.0203***
	[3.316]	[1.832]	[-1.474]	[3.163]	[0.00649]	[0.181]	[10.77]	[2.453]	[3.546]
trader		0.524***	0.507***		0.625***	0.633***		0.692***	0.714***
		[58.72]	[54.61]		[72.96]	[73.17]		[46.33]	[45.65]
ln (dens.) X trader		0.0401***	0.0505***		0.0327***	0.0394***		0.0351***	0.0425***
		[10.14]	[11.96]		[10.30]	[11.63]		[8.589]	[9.691]
foreign ow.	0.250***	0.0864***	0.0807***	0.250***	0.145***	0.147***	0.249***	0.212***	0.223***
	[31.44]	[9.208]	[8.505]	[31.45]	[15.40]	[15.53]	[31.38]	[12.68]	[13.08]
age	0.0903***	0.0803***	0.0798***	0.0902***	0.0802***	0.0798***	0.0902***	0.0803***	0.0801***
	[37.04]	[33.96]	[33.73]	[37.04]	[33.90]	[33.74]	[37.03]	[33.92]	[33.83]
soc. firm	-0.0689***	-0.0402***	-0.0376***	-0.0693***	-0.0403***	-0.0383***	-0.0693***	-0.0405***	-0.0394***
	[-8.197]	[-4.942]	[-4.617]	[-8.242]	[-4.947]	[-4.707]	[-8.242]	[-4.972]	[-4.840]
ln (dens.) X BP			1.253***			0.336***			0.0205*
			[3.908]			[3.485]			[1.833]
ln (dens.) X For.		0.0228***	0.0264***		0.0198***	0.0216***		0.0298***	0.0336***
		[5.188]	[5.872]		[5.655]	[5.989]		[6.519]	[7.133]
ln (dens.) X ln (emp.)			-0.00991***			-0.00637***			-0.00657***
			[-6.556]			[-5.152]			[-4.273]
Dummy: location	yes	yes	yes	yes	yes	yes	yes	yes	yes
Dummy: sector	yes	yes	yes	yes	yes	yes	yes	yes	yes
Dummy: year	yes	yes	yes	yes	yes	yes	yes	yes	yes
Constant	0.879***	0.375	0.745	0.884***	0.517**	0.398*	0.503***	0.591***	0.623***
	[3.283]	[1.436]	[1.623]	[3.973]	[2.380]	[1.759]	[2.748]	[3.185]	[3.357]
Observations	101387	101387	101387	101384	101384	101384	101228	101228	101228
R-squared	0.155	0.208	0.209	0.155	0.208	0.209	0.157	0.209	0.209

Robust t statistics in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 13. *Firm level 2SLS regressions - Olley-Pakes*

	Population density			Manufacturing density			Sectoral density		
VARIABLES	TFP (OP)	TFP (OP)	TFP (OP)	TFP (OP)	TFP (OP)	TFP (OP)	TFP (OP)	TFP (OP)	TFP (OP)
ln (density)	0.0463***	0.0112**	0.00641	0.0943**	-0.00598	0.0944***	0.256***	0.172***	0.136***
	[19.44]	[2.064]	[0.777]	[2.153]	[-0.361]	[10.03]	[7.918]	[16.63]	[15.46]
ln (density) X trader		0.0642***	0.0609***		0.0567***	0.0535**		0.0593***	0.0511***
		[4.056]	[3.697]		[6.114]	[2.189]		[5.129]	[6.520]
ln (density) X foreign		0.0740***	0.0723***		0.0651***	0.0632***		0.0585***	0.0546***
		[4.139]	[4.043]		[6.617]	[3.927]		[6.802]	[4.899]
ln (density) X size			0.00299			0.00299			0.00625
			[0.791]			[0.437]			[1.524]
trader		0.425***	0.430***		0.591***	0.587***		0.694***	0.671***
		[15.36]	[14.99]		[44.89]	[21.13]		[19.58]	[27.12]
ln (emp.) - size	0.201***	0.145***	0.141***	0.202***	0.146***	0.151***	0.195***	0.141***	0.161***
	[72.27]	[51.10]	[22.76]	[71.93]	[48.60]	[16.73]	[53.21]	[47.71]	[11.78]
foreign ow.	0.222***	-0.00519	-0.00245	0.222***	0.186***	0.184***	0.215***	0.281***	0.270***
	[24.97]	[-0.163]	[-0.0770]	[27.49]	[12.87]	[9.359]	[13.89]	[9.789]	[7.788]
age	0.0895***	0.0804***	0.0806***	0.0896***	0.0803***	0.0807***	0.0899***	0.0807***	0.0808***
	[35.40]	[32.61]	[32.65]	[36.04]	[33.25]	[32.25]	[12.38]	[21.22]	[20.10]
socfirm	-0.0548***	-0.0294***	-0.0300***	-0.0547***	-0.0294***	-0.0298***	-0.0508***	-0.0266***	-0.0278**
	[-6.365]	[-3.512]	[-3.571]	[-6.388]	[-3.514]	[-3.126]	[-4.987]	[-2.736]	[-2.552]
Dummy: location	yes	yes	yes	yes	yes	yes	yes	yes	yes
Dummy: sector	yes	yes	yes	yes	yes	yes	yes	yes	yes
Dummy: year	yes	yes	yes	yes	yes	yes	yes	yes	yes
Constant	-0.780***	-1.171***	-0.899***	-0.286*	-0.748***	-0.524***	0	0	0
	[-6.765]	[-10.03]	[-7.604]	[-1.907]	[-5.633]	[-3.647]	[]	[]	[]
Observations	99641	99641	99641	99638	99638	99638	99541	99541	99541
R-squared	0.206	0.243	0.243	0.206	0.243	0.242	0.19	0.233	0.236

Robust t statistics in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 14. *Firm level 2SLS regressions - Labour Productivity*

	Population density			Manufacturing density			Sectoral density		
VARIABLES	Lab. Prod.	Lab. Prod.	Lab. Prod.	Lab. Prod.	Lab. Prod.	Lab. Prod.	Lab. Prod.	Lab. Prod.	Lab. Prod.
ln (density)	0.0378***	0.00284	0.00153	0.149***	0.0918	-0.0151	-0.103***	-0.115***	-0.0828**
	[16.14]	[0.534]	[0.192]	[2.847]	[1.636]	[-1.609]	[-3.164]	[-3.595]	[-2.380]
ln (density) X trader		0.0666***	0.0657***		0.0591***	0.0581*		0.0470***	0.0498***
		[4.334]	[4.107]		[7.580]	[1.926]		[5.546]	[6.589]
ln (density) X foreign		0.0751***	0.0746***		0.0660***	0.0658***		0.0578***	0.0586***
		[4.246]	[4.209]		[7.420]	[3.158]		[6.318]	[4.590]
ln (density) X size			0.000819			0.000689			-0.00107
			[0.223]			[0.0832]			[-0.212]
trader		0.483***	0.484***		0.656***	0.655***		0.732***	0.739***
		[18.01]	[17.41]		[54.49]	[20.18]		[19.86]	[30.63]
ln (emp.) - size	-0.0152***	-0.0766***	-0.0778***	-0.0136***	-0.0752***	-0.0755***	-0.0128***	-0.0762***	-0.0800***
	[-5.577]	[-27.82]	[-12.88]	[-4.902]	[-26.04]	[-7.153]	[-4.271]	[-18.27]	[-4.874]
foreign ow.	0.249***	0.00592	0.00666	0.250***	0.200***	0.199***	0.254***	0.299***	0.301***
	[28.61]	[0.189]	[0.212]	[31.53]	[14.76]	[8.248]	[25.04]	[9.327]	[7.549]
age	0.0902***	0.0804***	0.0804***	0.0904***	0.0804***	0.0803***	0.0897***	0.0798***	0.0799***
	[36.10]	[33.30]	[33.17]	[36.88]	[33.77]	[33.76]	[35.71]	[12.88]	[33.77]
socfirm	-0.0693***	-0.0414***	-0.0416***	-0.0692***	-0.0413***	-0.0416***	-0.0716***	-0.0425***	-0.0421***
	[-8.195]	[-5.072]	[-5.077]	[-8.232]	[-5.050]	[-5.002]	[-5.297]	[-4.665]	[-5.096]
Dummy: location	yes	yes	yes	yes	yes	yes	yes	yes	yes
Dummy: sector	yes	yes	yes	yes	yes	yes	yes	yes	yes
Dummy: year	yes	yes	yes	yes	yes	yes	yes	yes	yes
Constant	0.282*	-0.884***	0.0856	0.620***	0.332	0.107	0	0	0
	[1.652]	[-9.032]	[0.523]	[2.843]	[1.536]	[0.554]	[]	[]	[]
Observations	101387	101387	101387	101384	101384	101384	101228	101228	101228
R-squared	0.155	0.206	0.206	0.155	0.205	0.206	0.147	0.203	0.206

Robust t statistics in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$