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Trade Costs and the Agglomeration of Production

by

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Abstract

The object of this paper is to study the evolution of trade costs and of the agglomeration of production, as well as their relation. The Home Market Effect prescribes increasing agglomeration when trade costs decrease because it is supposed to strengthen. We study the joint variation of trade costs and agglomeration in all the sectors that we consider, and specifically in those which support the home market effect hypothesis. We employ an original approach based on the combination of different bootstrap distributions. Our analysis yields insights into the evolution of trade costs and agglomeration in Europe in the last decade.

Keywords: Trade Costs, Agglomeration of Production, Home Market Effect, Bootstrap.
JEL Codes: F10, F12, F15.

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Contents

1 Introduction

Over the last two decades trade theorists have devoted much effort to the understanding of how trade costs condition trade patterns. As Anderson & van Wincoop (2004) explain, the group of costs which actually affect trade is large and difficult to disentangle. Shipment costs play an important role, but other factors raise the cost of consuming a product in a different location. Border-related formalities, technical and non-technical barriers, tariffs and standards, trade insurance and financing are just some other members of the trade costs family. In many regards, globalization and trade costs are the two sides of the same medal. Indeed, many believe that the large increase in trade observed during the last decades has been possible thanks to the evolution of communication and transportation technologies, evolution which has turned trade costs down. A big step forward which made proclaim *the death of distance* (Cairncross 1997). Even though trade costs have truly decreased over time (Jacks 2009), distance still matters (Disdier & Head 2008) and trade costs continue to condition trade flows significantly.

Production activities are not equally spread throughout the geographic space. As a matter of fact, agglomeration patterns always emerge (Brulhart & Traeger 2005). Patterns are a constant for some real activities such as manufacture, but they are common for immaterial activities too. There are many factors which cause activities to agglomerate in specific locations or to settle as far apart as possible from others. Resource endowments, economies of scale, infrastructures availability are just some possible explanations. In this paper we focus on agglomeration from a trade theory perspective (Combes et al. 2008).

Under the new focus on trade costs, New Trade Theory models have generated predictions on how trade costs affect the agglomeration of production. Proximity to consumers is thought to influence firms' location decision according to a mechanism known as Home Market Effect (hereafter, HME) (Helpman & Krugman 1985). Accordingly, firms prefer to settle close to consumers because trade costs are proportional to distance and they influence the market price and firms' mark-up (Melitz & Ottaviano 2008). A recent theoretical paper by Behrens et al. (2009) shows that if one controls for the effect of "geographic differences" (Relative Centrality) and of "differences in productivity" (Comparative Advantage), agglomeration might truly follow the HME also in a multi-country world. In this case the HME predicts that when trade costs decrease, agglomeration increases consequently because the HME strengthens; a general empirical test of this dynamic is provided by Head & Ries (2001) for North America and by Niepmann & Felbermayr (2010) for the OECD countries.[1]

In this paper we study the evolution of trade costs and of the agglomeration of production at the sectoral level (2-digit ISIC rev.3) in the EU countries in the period 1995-2006. Our

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[1] Given the different possible causes of any observed agglomeration pattern, a relation between trade costs and agglomeration is not to take for given. To wit, if agglomeration occurs because firms settle in a region to exploit that region's factor endowment, trade costs are not likely to affect that sector's pattern of agglomeration. Trade costs might also influence agglomeration through other channels. For example, lower trade costs might decrease a firm's incentive to settle in the large market with respect to another location's comparative advantage in fiscal terms. Given that trade-costs are less binding, the firm could serve the large market from a close-by fiscal-advantageous country.

interest in the evolution of these two variables has as theoretical reference the HME theory and its prescription of an inverse relationship between the two. However, we are interested in the evolution of trade costs and agglomeration regardless of the HME hypothesis. Indeed, given deepening integration in the EU during the period under consideration (to wit, the Euro was introduced in 1999), we want to check whether and how trade costs and agglomeration have changed and if it is possible to establish a connection between the two. Afterwards, we will also consider how these two entities evolve when the HME hypothesis holds in a specific sector.

The contribution of this paper consists in our sectoral study of the evolution of trade costs and agglomeration, and of their interaction. We devise an original test of the sign of the joint variation between trade costs and agglomeration which exploits different bootstrap distributions. Their relationship is also analysed through a regression analysis which, differently from the literature, does not use production and demand shares whereby avoiding any simultaneity bias. Furthermore, our analysis provides information about the net change of trade costs and agglomeration in the period under analysis, and the test of the HME hypothesis suggests in which sectors it is likely to hold. The paper is structured as follows: in section 2, we briefly introduce the data used; in section 3, we study trade costs and agglomeration; in section 4, we test the HME hypothesis in our sample of sectors; in section 5, we draw the main conclusions. In appendix 1, we provide a detailed discussion of the data used in the analysis. Appendix 2 introduces an alternative approach to test the sign of the joint variation discussed in section 3.3.

2 Main features of the data

The empirical analysis discussed in this work uses a data set which considers twenty-one sectors of activity. These sectors are: "Mining and Quarrying" (ISIC Rev.3 10-14), "Electricity, Gas and Water Supply" (ISIC Rev.3 40-41), 18 subsectors of the manufacture aggregate (ISIC Rev.3 15-37), and "Agriculture, Hunting and Forestry" (ISIC rev 3 01-02); the full list of sectors is in Table 1. Our group of countries consists of the EU-15 countries before the May 2004 enlargement. All the data are for the 1995-2006 period, yearly figures. For analytic convenience, we will consider four subperiods defined as: period 1, 1995-1997; period 2, 1998-2000; period 3, 2001-2003; period 4, 2004-2006. In section 3.1 we account for trade costs through an indicator computed using bilateral export and national trade. Agglomeration in section 3.2 is computed using employment figures at the NUTS-2 regional level; for the agglomeration analysis "Agriculture, Hunting and Forestry" is not available (sector 21 in Table 1). To test the HME hypothesis in section 4, we use value added and *domestic absorption* figures computed as production plus import less export. All the data have the sector k, country i, year t or period p dimension; bilateral export has also the partner j dimension. More information on the data are in appendix 1.

[TABLE 1 about here]

3 Trade Costs and Agglomeration

The objective of this section is twofold. Firstly, we study the evolution of trade costs and agglomeration separately and calculate their overall net change. Afterwards, we consider (i) their joint sequential variation to asses how one evolves given the other's specific change in one direction, and check (ii) whether and at which extent variations of trade costs explain variations in the agglomeration pattern. Accordingly, in subsection 3.1 and 3.2 we consider the evolution of trade costs and agglomeration across the first (1995-97) and last period (2005-2006) to draw conclusions about their net evolution, while in sections 3.3 and 3.4 we consider their sequential evolution between all the periods available (P1, P2, P3, P4) in order to study their interaction.

3.1 Trade Costs

In our analysis we account for trade costs through an indirect measure known as trade freeness (TF) (Head & Mayer 2004), this is an indicator of bilateral trade costs computed using bilateral export and national trade. The TF quantifies trade costs through the difference between foreign and domestic trade, assuming that this difference depends only upon restrictions to foreign trade.[2] In our analysis, we use a sectoral and time specification of this indicator:

$$TF^k_{ij,t} = \sqrt[2]{\frac{x^k_{ij,t} \cdot x^k_{ji,t}}{x^k_{ii,t} \cdot x^k_{jj,t}}} \tag{1}$$

where $x^k_{ij,t}$ is country i's export of k to j in year t, and $x^k_{ii,t}$ is country i's national trade, computed as country i's total production less total export of k in year t.

Implicit to its construction is the hypothesis of symmetric trade barriers ($TF_{ij} = TF_{ji}$). The TF ranges in the 0-1 interval, where $TF = 0$ indicates prohibitive trade costs and $TF = 1$ indicates free trade; domestic trade is assumed to be free ($TF_{ii} = 1$).To wit, for $TF = 0.5$ (very high level, compare with Table 3) the product of bilateral trade (numerator) is one-forth the product of national trade (denominator). In Table 2 we report summary statistics for $TF^k_{ij,t}$ and in Figure 1 we plot the across-sectors and pairs average of $TF^k_{ij,t}$ ($TF^k_{ij,t} \Rightarrow TF_t$). From Table 2 it emerges that the bulk of TF values is below the 0.15 level ($95th$ percentile); the mean value is only 0.035 and the median value 0.009. Then, trade costs as accounted by the TF indicator are high among the EU-15 countries.[3] Figure 1 shows that the mean

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[2] The role of preferences is completely disregarded by the TF indicator. For a discussion of how the difference between imported and domestic consumption is due to the combined effect of preferences and restrictions to trade, see Anderson & van Wincoop (2003).

[3] Our values are in line with the ones reported by other authors. For a comparison, see Niepmann & Felbermayr (2010) Figure 2b and Table 9, or Head & Mayer (2004) Table 5.

trade-freeness (TF_t) has decreased from 1995 to 2001 and risen again afterwords.

[TABLE 2 about here]

[FIGURE 1 about here]

For the purpose of our analysis, we average the yearly bilateral TF values along two dimensions: first, to obtain a unique sectoral estimate of the index ($TF_{ij,t}^k \Rightarrow TF_t^k$), second, to obtain average values for 4 subperiods of 3 years each ($TF_t^k \Rightarrow TF_p^k$). Then, we consider the TF evolution from the first to the last period: $\Delta TF^k = TF_{p4}^k - TF_{p1}^k$. $\Delta TF^k > 0$ indicates a trade costs decrease, $\Delta TF^k < 0$ viceversa. Average TF values for the whole period (1995-2006), the 4 subperiods and the time difference are in Table 3; the subperiods values are plotted in Figure 2 to display the temporal evolution. The lowest TF value (highest trade costs) is for sector 20 "Electricity, gas and water supply", the highest TF value (lowest trade costs) is for sector 13 "manufacture of office machinery and computers". It comes with no surprise that trade costs impact relatively less sector 13. Indeed, this is a high value-added sector where products are realized in large plants and shipped at low cost to several markets for sale.

[TABLE 3 about here]

[FIGURE 2 about here]

To study the evolution of trade costs as quantified by the TF indicator, we refer to the ΔTF^k values in Table 3. However, these differences could be not statistically significant (to wit, they might emerge because of measurement errors), we therefore employ a statistical procedure to check their significance. As discussed in Brulhart & Traeger (2005), bootstrap for hypothesis testing is an appropriate approach in this case.[4] We generate two distributions of the indicator through a bootstrap simulation, one for each period. Then, we calculate the difference of the paired values and generate the distribution of the differences; this is used to test the hypothesis $\Delta TF^k = 0$. The column ΔTF^k in Table 3 reports the outcome of the bootstrap-based test using asterisks.[5]

Given non-normality of the bootstrap distribution in the bulk of sectors, we resort to *Bias-corrected and Accelerated Confidence Intervals* (BCA-CI) to define rejection areas.[6] The system of hypotheses is "$H_0 : \Delta TF^k = 0$" against "$H_1 : \Delta TF^k \neq 0$". Significant trade costs variations emerge in 14 out of nineteen sectors available: sectors 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 17, 18, 19, 21 exhibit a significantly positive variation. Then, whenever TF changes

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[4] We refer the reader to Cameron & Trivedi (2005) chapter 11 for more information about the Bootstrap.

[5] We instruct 1000 replications for the bootstrap, then the distribution counts 1000 observations. We check normality through the Shapiro-Francia Test (Shapiro & Francia 1972); normality supported in sectors 3, 7,15. Sectors 13 and 20 not available for bootstrap-computation given the high number of missing values.

[6] For a discussion of the different confidence intervals for hypothesis testing available in this context, see Diciccio & Romano (1988).

significantly, this reflects a trade costs reduction. We expected a generalized TF increase because the period under analysis comprises the implementation of many EU integration policies (first of all, the Euro's introduction in 1999). Nonetheless, the analysis shows that some sectors were unaffected.

3.2 Agglomeration of Production

The distribution of production is uneven throughout the geographic space. Agglomeration emerges because of different causes and, usually, it can be explained through direct and evident arguments such as infrastructure availability, manufacture tradition, resource endowments, etc. By abstracting from specific cases, New Economic Geography models (Baldwin et al. 2005) provide a formalization of these processes and stress the role of trade costs. For the purpose of our analysis, we need to measure agglomeration through a synthetic index which quantifies how much each sector is far away from an even distribution over the geographic space.

Agglomeration can be measured in absolute or relative terms through concentration indices. An industry is concentrated in absolute terms if the bulk of its production takes place only in few locations (no other sector considered), while it is in relative terms if its geographic distribution is concentrated with respect to the average distribution of all the other sectors considered (Haaland et al. 1999).[7] Since we are interested in scale economies and trade, we compute the Theil Index for absolute concentration (ThI), its formula is:[8]

$$ThI^k = \frac{1}{R} \cdot \sum_{r=1}^{R} \left[\left(\frac{x_r^k}{\overline{x}^k} \right) \cdot \log \left(\frac{x_r^k}{\overline{x}^k} \right) \right] \tag{2}$$

where $0 \leq ThI^k \leq \log R$, x_r^k is activity x (employment, production, value-added, etc.) in sector k $(k = 1, ..., K)$ and region r $(r = 1, ..., R)$, $\overline{x}^k = \frac{1}{R} \sum_{1=r}^{R} x_r^k$ is the across- regions average and each region belongs exclusively to one country i $(i = 1, ..., M)$.

As for trade freeness, we consider the evolution of agglomeration $\Delta ThI^k = ThI_{p4}^k - ThI_{p1}^k$, where $\Delta ThI^k > 0$ indicates an increase in agglomeration. To compute the index and obtain its between/within decomposition, we use regional employment for the first twenty sectors listed in Table 1.[9] The index is calculated both for the whole time-span (12 years, from 1995 to 2006) and for 4 subperiods of 3 years each. The index values are reported in Table 4 and

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[7] The two measures coincide for a group of geographic units of identical size, but they do not if geo-units differ in size. For a discussion of absolute and relative concentration, see Cafiso (2009).

[8] The Theil Index is obtained through the formula of the Generalized Class of Entropy Indices when the sensitivity parameter $\alpha = 1$ (Brulhart & Traeger 2005). If $\alpha = 2$ one obtains the Half Square Coefficient of Variation. The more positive α is, the more sensitive the index to differences at the top of the distribution, the less it is, the more sensitive the index to differences at the bottom of the distribution.

[9] In case of relevant productivity differences across regions and sectors, the use of employment figures might bias the indicators of agglomeration. For this reason some authors prefer using value added figures (Behrens et al. 2005). We use employment because this is available at the Nuts-2 regional level for the sectors, countries and years to match with the trade data. Besides, we reckon that such differences are not particularly relevant in our analysis because we consider a homogenous set of countries. In the Eurostat Regio data set, employment figures were not available for sector 21 "Agriculture, Hunting and Forestry".

plotted in Figure 3.

[TABLE 4 about here]

[FIGURE 3 about here]

Agglomeration is lowest for sector 2 "manufacture of food products, beverages and tobacco" and highest for sector 3 "manufacture of textiles, textile products, leather and footwear". From the between/within decomposition, it emerges that concentration is mainly due to agglomeration within countries. The highest share of within contribution -minimum of between- is for "manufacture of coke, refined petroleum products and nuclear fuel" (sector 6), while the lowest -maximum of between- is for "manufacture of wood and products of wood and cork, ..." (sector 4).[10] It comes with no surprise that sector 6 has the highest share of within concentration, this sector enjoys large scale economies but it is strategic for each country. Then, production is highly concentrated within countries but not at the European level. On the contrary, given its resource-based feature, sector 4 might be concentrated in areas which fall over different countries.

As for the evolution of agglomeration between the first (1995-1997) and the last period (2004-2006), column ΔThI^k in Table 4 reports the time difference of the Theil Index. To check the statistical relevance of the variation ($H_0 : \Delta ThI^k = 0$), we employ a bootstrap-based test as the one discussed in the previous section for trade freeness. We resort to bias-corrected and accelerated confidence intervals again to define rejection areas; the test results are in Table 4.[11] A significant change occurs in 7 out of twenty sectors: sectors 1, 7, 11,12, 13, 16 exhibit a significantly negative variation (agglomeration decreases), while sector 3 exhibits a significantly positive variation. On the whole, agglomeration does not increase in the period considered, it is either stable or decreasing. This is an important result which confutes the common belief of increasing agglomeration in manufacture.[12]

3.3 The Sign of the Joint Variation

In this section we consider the sequential evolution of trade freeness and agglomeration to assess in which direction one of the two has changed given a specific variation of the other. More in details, we are interested in knowing for which sectors TF and agglomeration have changed in the same direction ($TF \uparrow$ - $ThI \uparrow$ or $TF \downarrow$ - $ThI \downarrow$) and for which in the opposite direction ($TF \downarrow$ - $ThI \uparrow$ or $TF \downarrow$ - $ThI \uparrow$). The time-differences of TF and agglomeration

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[10] When the within contribution is higher than the between, concentration depends mainly upon an uneven distribution within countries; the across-countries distribution is relatively less unequal. To wit, if a sector were spread unevenly between countries but equally among the regions of each country, concentration would depend only upon across-countries diversity.

[11] The Shapiro-Francia test (Shapiro & Francia 1972) signals a normal distribution for sectors 3, 4, 5, 6, 8, 10, 11, 14, 16, 17, 18, 19. We use again BCA-CI for coherence with the TF test. As a matter of fact, non-normality does not bias the Z-test since we get the same sectoral outcome when we refer to rejection areas based on the normal distribution. This holds both for trade freeness and agglomeration.

[12] This result is likely to depend upon the country-sample considered. Indeed, the sample consists of advanced economies with a consolidated structure of manufacture, countries from which manufacture is moved away for destinations outside the EU-15 block.

between P4-P3, P3-P2 and P2-P1 are reported in Table 5 and plotted in Figure 4 to provide descriptive-analysis evidence regarding the sign of the joint variation.[13]

[TABLE 5 about here]

[FIGURE 4 about here]

For sectors in portion I (X-axis and Y-axis positive) and III (X-axis and Y-axis negative) of Figure 4, TF and agglomeration evolve in the same direction: positive TF changes are associated with positive changes in agglomeration and vice versa. This is the case for 34 out of sixty pairs.[14] Figure 4 is useful to gain a first insight, but we need to employ a statistical procedure to test the robustness of the sign. To wit, it could be that the sign of the observed differences is determined by few non-relevant observations, while there is not a statistically-significant information about the sign of the co-movement. This is what we aim to check now through a formal statistical procedure.

We build our testing-strategy on the consideration that if trade freeness and agglomeration evolve in an opposite direction ($TF \downarrow$ - $ThI \uparrow$ or $TF \downarrow$ - $ThI \uparrow$), the product of their variation is negative, otherwise it is positive. In the columns c, f, i of Table 5, we report ΔTF^k and ΔThI^k and the sign of their product R^k for each period/sector combination. We check the sign of R^k through hypothesis-testing based on a bootstrap-generated distribution.

The bootstrap distribution (R_b^k) of R^k comes from combining the bootstrap distributions of ΔTF^k and ΔThI^k discussed in sections 3.1 and 3.2. The R_b^k observations are generated as:

$$R_b^k = \underbrace{\Delta TF_b^k}_{\alpha} \cdot \underbrace{\Delta ThI_b^k}_{\beta} \tag{3}$$

where, as defined before, $\Delta TF_b^k = TF_{b,p}^k - TF_{b,p-1}^k$ and $\Delta ThI_b^k = ThI_{b,p}^k - ThI_{b,p-1}^k$.

The R_b^k values are the product of bootstrap-generated values, $b = 1, ..., B$ where B is the total number of replications instructed for the bootstrap.[15] To test the sign of R^k using the R_b^k distribution we employ a non-parametric approach; an alternative approach for the same objective is discussed in Appedix 2. The non-parametric approach used here is based on the portion of positive cases over the total as defined by the following statistic:

$$J^k = \frac{1}{B} \cdot \sum_{i=1}^{B} \overset{+}{R_b^k} \tag{4}$$

where $\overset{+}{R_b^k} = 1$ if $R_b^k > 0$ and $\overset{+}{R_b^k} = 0$ if $R_b^k \leq 0$. $\overset{+}{R_b^k}$ is a binary variable which has a Bernullian

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[13] Values plotted in figure 4 are those in column ΔTF^k and ΔThI^k of table 4 and 5.

[14] 20 pairs -one for each sector- for the differences between P4-P3, twenty for P3-P2 and twenty for P2-P1.

[15] As for the R_b^k distribution, it is not normal even in those sectors where ΔTF_b^k and ΔThI_b^k are normally distributed. The product of two normal distributions is not a normal distribution, but it is known as *Normal Product Distribution.*

distribution, but J^k is binomially distributed. We actually run two tests based on the J^k statistic, the hypothesis system for each of the two tests is:

1. "$H_0 : J^k = 1/2$" against "$H_{1a} : J^k > 1/2$"; rejection area for $Z_1^k > z_\alpha$.
2. "$H_0 : J^k = 1/2$" against "$H_{1b} : J^k < 1/2$"; rejection area for $Z_1^k < -z_\alpha$.

z_α is the critical value of the standard-normal for a significance-level equal to α. Indeed, we use the standard-normal approximation of the Binomial distribution because B is sufficiently large. The null-hypothesis states that the portion of positive cases is not different from half: there is no clear information about the sign of the joint variation. Obviously, H_{1b} is admissible only when H_{1a} is not. The test-statistic is:

$$Z_1^k = \frac{J^k - p_0}{\sqrt{\frac{p_0(1-p_0)}{B}}}$$

where $p_0 = 1/2$ since we test "$H_0 : J^k = 1/2$". The results based on the Z_1^k test-statistic when $\alpha = 1\%$ are in Table 6.

[TABLE 6 about here]

Non-rejection of the null hypothesis is for 4 out of fifty-two tests executed. Rejection in favor of a change in the same direction (H_{1a}) is for 27 out of forty-eight sectors; rejection in favor of a change in the opposite direction (H_{1b}) is for 21 out of forty-eight sectors. Consequently, both variables seem more likely to change in the same direction, but they have often changed in the opposite direction too. As for evidence at the sectoral level, only sectors 4 and 11 keep constant their evolution throughout the time-span considered (trade freeness and agglomeration evolve in the same direction); the other sectors alternate between variations in the same and in the opposite direction.

3.4 The Relationship between Trade Costs and Agglomeration

In the previous section we have studied the evolution of trade costs and agglomeration to understand in which direction they are likely to move when both change. In this section we want to check if there is a relation between the evolution of trade costs and agglomeration. In other words, we want to know if trade costs contribute to explain agglomeration. As a first insight into the relationship between trade costs and agglomeration, we combine trade costs and agglomeration indicators by sector and period in Figure 5 to visualize their relationship through a scatter-plot.[16]

[FIGURE 5 about here]

Higher agglomeration levels are associated with higher trade freeness values, the trend line is upward sloped in all four periods. We build on the information in Figure 5 by developing

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[16] Values plotted in figure 5 are those in column TF_{all} and ThI_{all} of table 3 and 4.

formal regression analysis of ThI_p^k and ΔThI_p^k on TF_p^k and ΔTF_p^k respectively. We aim to check if there is a significant causal relation from trade costs to agglomeration. We perform both OLS-pooled and within estimations, the estimation output is in Table 7 for the values in level and in Table 8 for the differences.

[TABLE 7 about here]

[TABLE 8 about here]

From the estimation output it emerges clearly that trade costs contribute significantly to explain agglomeration both in levels and in differences. Given the output of the F-test on the relevance of longitudinal heterogeneity, the panel-within estimator is more reliable for the estimation in level. The estimate of the coefficient is around 1 for the value in levels and around 0.73 for the differences (within estimation output).[17] As expected, the regression fit decreases from levels to differences, but it remains significant anyway. Then, for a TF increase (trade costs decrease) we may reasonably expect that agglomeration increases. This finding is consistent with the results of the sectoral test for the joint variation (section 3.3). Indeed, trade-freeness and agglomeration evolve significantly in the same direction in the bulk of cases considered (27 out of forty-eight).

We mark the importance of this result derived from an analysis where it is possible to exclude any simultaneity bias. Indeed, agglomeration (the dependent variable) is generated through employment data, while trade costs (the independent variable) through bilateral-trade data. This is not the case for other studies in the literature where the relationship between trade costs and agglomeration is analysed through production and demand shares.

4 Trade Costs and Agglomeration under the HME hypothesis

As mentioned in section 1, New Trade Theory models which embed the HME predict that decreasing trade costs boost agglomeration because the HME itself is supposed to strengthen. In this section we test whether or not this dynamics takes place in sectors which support the HME hypothesis. We proceed sequentially to achieve this objective. Firstly, we discuss the home market effect in a multicountry framework as recently modelled by Behrens et al. (2009) and show that decreasing trade costs involve increasing agglomeration in their framework. Secondly, we test in which sectors the HME hypothesis holds and check whether the sign of the joint variation is positive for those sectors.

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[17] Trade costs remain significant under the 10% threshold both in levels and in differences when using robust standard-errors. Observations are 80 for the estimation in level and 60 for the one in differences.

4.1 The Home Market Effect in a multi-country world

In a multi-country framework, Behrens et al. (2009) affirm that the HME holds if and only if:

$$\frac{\lambda_1^*}{\theta_1^*} \geq \frac{\lambda_2^*}{\theta_2^*} \geq \cdots \geq \frac{\lambda_M^*}{\theta_M^*} \tag{5}$$

where λ_i is country i's production share, θ_i is country i's demand share, we consider M countries and $\theta_1 \geq \theta_2 \geq ... \geq \theta_M$. Condition 5 does not usually hold in the real world because third-country effects offset firms' large-country motivation to settle in a specific location. In particular, Behrens et al. (2009) refer to differences in relative centrality and Ricardian comparative advantage.[18] Nonetheless, they show that when it is possible "to separate the effect of relative centrality and comparative advantage on the one side, from the impact of relative demand driven by relative size and relative wages on the other side" (Behrens et al. (2009), page 263) condition 5 is likely to hold. They demonstrate this by deriving the production shares $\left(\lambda_i^{SA}\right)$ which prevail in the case of no comparative-advantage and no centrality-advantage through a linear filter to apply to the equilibrium shares (λ_i^*) of their model under specific conditions.[19] The authors explain that for the λ_i^{SA} shares equation 5 is verified and the following relation holds:

$$\lambda_i^{SA} = \frac{1 + (M-1)\,\overline{\phi}}{1-\overline{\phi}}\theta_i - \frac{\overline{\phi}}{1-\overline{\phi}} \tag{6}$$

where $\phi_{ij} = \overline{\phi}$ (equal trade freeness for any country pair) and θ_i is country i's share of world demand.

Equation 6 involves that decreasing trade costs $\left(\overline{\phi} \downarrow\right)$ strengthen the HME towards the largest country. This is made clearer through the following numerical example where in case B trade is freer than in A (trade freeness parameter from 0.40 to 0.45):

- Case A: $M = 3; \overline{\phi} = 0.40$;

  $\theta_1 = 0.45 \;\rightarrow\; \lambda_1^{SA} = 0.683 \;\rightarrow\; \lambda_1^{SA}/\theta_1 = 1.517$
  $\theta_2 = 0.30 \;\rightarrow\; \lambda_2^{SA} = 0.233 \;\rightarrow\; \lambda_2^{SA}/\theta_2 = 0.773$
  $\theta_3 = 0.25 \;\rightarrow\; \lambda_3^{SA} = 0.083 \;\rightarrow\; \lambda_3^{SA}/\theta_3 = 0.332$

- Case B: $M = 3; \overline{\phi} = 0.45$;

  $\theta_1 = 0.45 \;\rightarrow\; \lambda_1^{SA} = 0.763 \;\rightarrow\; \lambda_1^{SA}/\theta_1 = 1.695$
  $\theta_2 = 0.30 \;\rightarrow\; \lambda_2^{SA} = 0.218 \;\rightarrow\; \lambda_2^{SA}/\theta_2 = 0.726$
  $\theta_3 = 0.25 \;\rightarrow\; \lambda_3^{SA} = 0.045 \;\rightarrow\; \lambda_3^{SA}/\theta_3 = 0.180$

In Behrens et al. (2009) the HME strengthens when trade costs decrease because the less trade costs impact profit maximization, the more firms settle in the large market (by so

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[18] When demand is equally distributed across regions, locations with a relative advantage in terms of better centrality and higher productivity always attract a larger share of production.

[19] These conditions require a quite unlikely bilateral trade-costs structure which guarantees production in all M countries (interior solution of the model).

increasing agglomeration) and serve periphery through exports. On the contrary, if trade costs are prohibitive, the motivation to stay close to each portion of consumers (not only to the largest one) is stronger.[20]

4.2 Test of the HME hypothesis

We are now interested in testing the HME hypothesis sector by sector in order to check what the joint variation is when the HME hypothesis holds. We achieve this by verifying condition 5 in each sector through Behrens et al.'s (2005) approach. They develop three tests based on the same statistic $\left(Z_{ij}^k\right)$ and use Spearman's rank correlation coefficients; the tests are non-parametric and use the observed production and demand shares. Here, we apply only one of their test (the most powerful) and Spearman's coefficients.
The statistic at the base of their testing-strategy is:

$$Z_{ij}^k = \underbrace{\left(\frac{\lambda_i^k}{\theta_i} - \frac{\lambda_j^k}{\theta_j}\right)}_{A} \cdot \underbrace{(\theta_i - \theta_j)}_{B} \tag{7}$$

where k stands for the sector considered, i and j are two (a pair) of the M countries considered, λ^k stands for sectoral production share and θ for overall demand share. The total number of Z_{ij}^k equals the number of combinations of M countries taken by two. If $B > 0$,country i's demand share is larger than country j's; the HME requires A to be positive as well. $Z_{ij}^k > 0$ therefore supports the HME. If $B < 0$, country i's demand share is less than country j's; the HME requires A to be negative. The product of two negative quantities is positive, consequently $Z_{ij}^k > 0$ always supports the HME. Building on Z_{ij}^k, Behrens et al. (2005) define the Pairwise-Average Z-test, the Country-Average Z-test and the World-Average Z-test. The statistic of the Pairwise-Average Z-test, which is their most powerful in testing the HME hypothesis, is:[21]

$$S_1^k = \frac{\sum_i \sum_{j<i} \overset{+}{Z}{}_{ij}^k}{N}$$

where $\overset{+}{Z}{}_{ij}^k = 1$ if $Z_{ij}^k > 0$ and $\overset{+}{Z}{}_{ij}^k = 0$ if $Z_{ij}^k \leq 0$, $N = M(M-1)/2$ the number of combinations. The test checks whether Z_{ij}^k is positive in more than half cases through S_1^k. S_1^k is the fraction of favorable cases over the total. The system of hypotheses is "$H_0 : S_1^k = 1/2$"

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[20] It is to notice that we have considered two different shares so far: λ_i^* and λ_i^{SA}. The former are the equilibrium shares derived in Behrens et al.'s (2009) theoretical model, the latter are the accessibility-filtered shares derived from the first under specific conditions. However, in our analysis we use observed shares which come from real data, we name them λ_i; these are the real counterpart of the equilibrium shares λ_i^*. From Behrens et al. (2009) one realizes that if she uses λ_i to test the HME hypothesis, this is not likely to hold unless third-country effects are irrelevant.

[21] The strongest test of the HME is the Pairwise Z-test, the Country Average and the World Average follow. The pairwise test is the strongest because, differently from the other two, it does not sum across individual Z_{ij}^k values. Then, it cannot be the case of many small negative observations to be offset by some few positive ones.

against "$H_1 : S_1^k > 1/2$"; rejection of H_0 in favour of H_1 supports the HME hypothesis. S_1^k is binomially distributed. Since the number of pairs (available combinations) is sufficiently large, we resort to the standard-normal approximation of the binomial distribution which is:

$$Z_2^k = \frac{N \cdot S_1^k - N \cdot p + \frac{1}{2}}{\sqrt{N \cdot p \cdot (1-p)}}$$

where $N = M(M-1)/2$, $p = 1/2$ and $(1/2)$ is the continuity correction for the approximation of the discrete binomial to the continuous normal distribution. We also compute Spearman's rank-correlation coefficients between the series λ_i^k/θ_i and θ_i (Conover 1999). The coefficients are instrumental to testing the independency hypothesis between the two series; positive (and possibly significant) correlation values signal support of the HME hypothesis. The test results and Spearman's coefficients are in Table 9.[22]

[TABLE 9 about here]

Spearman's coefficients signal positive correlation (support the HME hypothesis) for fifteen out of twenty-one sectors; however, only for four sectors the correlation is statistically significant at 5 percent. The strongest correlation is for "manufacture of fabricated metal products" (sector 11). The Pairwise Z-test signals that the HME hypothesis holds in eleven out of twenty-one sectors (5% significance); strongest evidence is again for sector 11.[23] For these eleven sectors, Spearman's coefficients are always positive.

4.3 The HME and the evolution of trade costs and agglomeration

At this point we check whether and for which sectors the prescription of an inverse relationship between trade costs and agglomeration holds when the HME hypothesis is valid. If the prescription holds, we should observe a positive sign of the joint variation (alias, inverse relationship holds) in the eleven sectors which support the HME hypothesis. In Table 9, we report the number of cases when the joint variation is positive by sector; the test is available only for nine of the eleven sectors where the HME hypothesis is valid.

For sector 11, the inverse relationship emerges in three out of three cases available, for sectors 7, 8, 10, 19 in two out of three cases available, while for sectors 12, 14, 16, 18 only in one case. On the whole, the prescription of an inverse relationship is weakly supported by the data. Our analysis shows that it is far to be a robust prescription and that it needs to be checked sector by sector. This result is against the HME theory.

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[22] We report results only for the Pairwise-Average Z-test, results for the Country and World-Average tests are available upon request.

[23] The sectors which support the HME hypothesis are: sector 7 "manuf. of chemicals and chemical products", 8 "manuf. of rubber and plastic products", 10 "manuf. of basic metals", 11 "manuf. of fabricated metal products, except machinery and equipment", 12 "manuf. of machinery and equipment n.e.c", 13 "manuf. of office machinery and computers", 14 "manuf. of electrical machinery and apparatus n.e.c.", 16 "manuf. of medical, precision and optical instruments, watches and clocks", 17 "manuf. of motor vehicles, trailers and semi-trailers", 18 "manuf. of other transport equipment", 19 "manuf. of furniture; manufacturing n.e.c".

5 Conclusions

The objective of this work was to produce evidence on how trade costs and agglomeration of production interact. We developed our analysis on the prescription of an inverse relationship between trade costs and agglomeration when the Home Market Effect takes place. Even though we have used the HME case as a reference, we were interested on trade costs and agglomeration regardless of the HME validity because their relationship is relevant in any case.

The strength of our analysis is twofold. Firstly, we study the joint variation of trade costs and agglomeration at the sectoral level by using an original testing approach based on bootstrap simulations. Secondly, we develop a regression analysis which avoids any likely simultaneity bias.

Our analysis suggests that the net evolution of these two entities depends specifically upon the sector considered. On the whole, trade costs seem to have decreased while agglomeration shows a non-increasing trend. As for the interaction of trade costs and agglomeration, they are more likely to move in an opposite direction but results depend on the specific sector considered in this case too. Even when the HME hypothesis holds, an inverse relationship between trade costs and agglomeration is not to take for given. Furthermore, we find evidence that trade costs contribute to explain the observed levels of agglomeration as well as its evolution. To conclude, we believe previous aggregate analyses to hide the fragility of an inverse relationship between trade costs and agglomeration, fragility which clearly emerges in our sectoral study.

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Appendix 1. Data

Throughout the paper we consider twenty-one sectors of activity classified according to ISIC rev.3/NACE 1.1, these sectors are: -a- the aggregate for "Mining and Quarrying" (NACE: C, ISIC:10-14), -b- 18 subgroups of manufacture as partition of the "Total Manufacturing" aggregate (NACE: D, ISIC: 15-37; see Table 1 for the list of all the sectors), -c- the aggregate for "Electricity, Gas and Water Supply" (NACE: E, ISIC: 40-41), and -d- the aggregate for "Agriculture, Hunting and Forestry" (NACE: A, ISIC: 01-02). The countries comprised in the analysis are those in the EU-15 group: Austria, Belgium-Luxembourg, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. Data for Belgium and Luxembourg are recorded together for the so-called Belgium-Luxembourg Economic Union (BLEU). The time range is 1995-2006, whole-period figures are the average of all the yearly observations. We use values for four sequential sub-periods defined as follows: period 1 values are the average of 1995-1997 figures, period 2 of 1998-2000, period 3 of 2001–2003 and period 4 of 2004-2006.

Trade Freeness and Agglomeration
To calculate the sectoral Theil Index we use employment figures (number of employees) at the Nuts-2 regional level; data are extracted from the Eurostat Regio data set. We start with 207 Nuts-2 regions: Austria, 9 regions; Belgium, 10 regions; Germany, 38 regions; Denmark, 5 regions (5 deleted); Spain, 19 regions (8 deleted); Finland, 5 regions (1 deleted); France, 22 regions; Greece, 13 regions (1 deleted); Ireland, 2 regions; Italy, 21 regions; Luxembourg, 1 region (1 deleted); the Netherlands, 12 regions; Portugal, 5 regions; Sweden, 8 regions; United Kingdom, 37 regions. Some regions were deleted in case of too-many missing values. Employment data for sector 21 "Agriculture, Hunting and Forestry" were not available in the Eurostat Regio data set, we therefore did not consider this sector for the agglomeration analysis.
For the trade freeness indicator we use bilateral export among the EU-15 countries which constitute our sample, plus National Trade figures computed as "total production less total export". All figures are in current US dollars. Bilateral export, total production and total export are extracted from the OECD Stan database.

Production and Demand shares for the HME
To test the HME we used sectoral-production and aggregate-demand country shares. Production shares are calculated using sectoral value-added figures, we use Domestic Absorption to account for demand. Domestic absorption is computed as "production less export plus import". Value added, national production, export and import in US dollars are extracted from the OECD Stan database.

Appendix 2. A percentiles-based Test of the Sign

The test of the sign (discussed in section 3.3) checks whether the portion of positive observations is statistically larger than half for deciding about the sign of the R^k statistic. In this context, the word *statistically* makes the difference. Indeed, if we were not looking for a statistically-significant result, one might simply check what is the percentage of positive observations over the total (B), and conclude that R^k is positive if more than 50% observations are positive. This reduces to observe the median of the distribution. The issue with this approach is that the median might be just one position away from zero. Then, a conclusion based only on the sign of the median could lead to a non-robust statement about the sign of R^k. We propose now an alternative way to decide about the sign of the R^k statistic.
In the spirit of hypothesis-testing based on Percentiles Confidence Intervals (Cameron & Trivedi (2005) section 11.2.7), one may define buffers around the median which guarantee to decide about H_0 at a certain robustness-level. We define these buffers γ as follows: when γ increases, the rejection area decreases; we get more restrictive on rejection of H_0. We opt for this definition because it guarantees that more evidence is required to opt for either sign of the statistic when larger buffers are used. We consider three standard levels: $\gamma = 1\%$, $\gamma = 5\%$ and $\gamma = 10\%$, and define respectively the rejection areas in the following Table 10.

[TABLE 10 about here]

The rationale behind the definition of the rejection areas for H_0 is that when at least $(50 + \gamma)\%$ observations are positive (negative), one can assume that R^k is positive (negative) at a robustness-level equal to $\gamma\%$. On the contrary, one concludes that the sign is not distinguishable (at a robustness-level equal to $\gamma\%$) if there is not enough evidence.[24] We run the two tests discussed in section 3.3 using $\gamma = 5\%$; the two tests are:

1. "$H_0 : J^k = 1/2$" against "$H_{1a} : J^k > 1/2$"; rejection area for $45p > 0$.
2. "$H_0 : J^k = 1/2$" against "$H_{1b} : J^k < 1/2$"; rejection area for $55p < 0$.

Results based on this approach are in Table 6. Rejection of the null-hypothesis for the same alternative is exactly for the same cases as for those selected by the Z_1^k statistic ($\alpha = 1\%$).

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[24] It is to notice that the robustness-level γ is inversely related to the significance level α used in standard hypothesis testing as applied in section 3.3. In the former, the lower is γ the more likely the rejection of H_0 is. On the contrary, in conventional hypothesis testing, the lower is α, the less likely the rejection of H_0 is.

Tables and Charts

Table 1: Sectors of Activity

Sector Number	Nace 1.1 ISIC rev 3	Sector Name
1	C, 10-14	Mining and quarrying
2	D, 15-16	manuf. of food products, beverages and tobacco
3	D, 17-19	manuf. of Textiles, textile products, leather and footwear
4	D, 20	manuf. of wood and of products of wood and cork, except furniture; manuf. of articles of straw and plaiting materials
5	D, 21-22	manuf. of pulp, paper and paper products; publishing and printing
6	D, 23	manuf. of coke, refined petroleum products and nuclear fuel
7	D, 24	manuf. of chemicals and chemical products
8	D, 25	manuf. of rubber and plastic products
9	D, 26	manuf. of other non-metallic mineral products
10	D, 27	manuf. of basic metals
11	D, 28	manuf. of fabricated metal products, except machinery and equipment
12	D, 29	manuf. of machinery and equipment n.e.c.
13	D, 30	manuf. of office machinery and computers
14	D, 31	manuf. of electrical machinery and apparatus n.e.c.
15	D, 32	manuf. of radio, television and communication equipment and apparatus
16	D, 33	manuf. of medical, precision and optical instruments, watches and clocks
17	D, 34	manuf. of motor vehicles, trailers and semi-trailers
18	D, 35	manuf. of other transport equipment
19	D, 36	manuf. of furniture; manufacturing n.e.c
20	E, 40-41	Electricity, gas and water supply
21	A, 01-02	Agriculture, hunting and forestry

Notes: · sector 21 is not available for the analysis of agglomeration.

Table 2: Trade Freeness, summary statistics.

sec	mean	min	max	p50	iqr	p5	p95
1	0.00792	1.98E-07	0.29210	0.00208	0.00642	0.00002	0.03101
2	0.01736	2.49E-04	0.50727	0.00637	0.01372	0.00054	0.06754
3	0.08167	1.58E-03	0.98252	0.03611	0.07159	0.00339	0.33165
4	0.01332	4.19E-06	0.31361	0.00456	0.00844	0.00018	0.06098
5	0.01515	3.63E-05	0.23039	0.00744	0.01339	0.00075	0.05747
6	0.02339	5.73E-07	0.91860	0.00506	0.01617	0.00002	0.07947
7	0.07671	1.30E-03	0.98201	0.03378	0.07365	0.00279	0.32332
8	0.03395	2.31E-04	0.80879	0.01522	0.03414	0.00142	0.12783
9	0.01217	5.27E-05	0.22000	0.00476	0.01177	0.00036	0.04975
10	0.07092	8.71E-05	0.97016	0.03348	0.06808	0.00185	0.29623
11	0.01105	2.50E-05	0.13189	0.00492	0.00898	0.00052	0.05111
12	0.04805	8.57E-04	0.75270	0.02416	0.04826	0.00298	0.16426
13	0.19093	2.84E-04	0.97799	0.07578	0.24522	0.00598	0.72742
14	0.05391	3.99E-04	0.92431	0.02715	0.05412	0.00232	0.19227
15	0.08233	7.30E-05	0.91629	0.02926	0.08594	0.00122	0.37948
16	0.06513	7.55E-04	0.81816	0.03994	0.06645	0.00345	0.21045
17	0.09874	5.02E-06	0.89268	0.04285	0.14493	0.00146	0.32461
18	0.04979	4.68E-05	0.68285	0.01772	0.04719	0.00126	0.22424
19	0.01955	1.53E-04	0.28260	0.00720	0.01612	0.00056	0.09172
20	0.00306	1.07E-08	0.04653	0.00042	0.00290	0.00000	0.01542
21	0.01169	3.34E-06	0.71168	0.00238	0.00791	0.00006	0.04477
Total	0.03567	1.07E-08	0.98252	0.00983	0.03014	0.00032	0.15215

Notes: · "p50" is the Median, "iqr" id the 75-25 interquantiles range, "p5" is the 5th , "p95" is the 95th .

Figure 1: Trade Freeness.

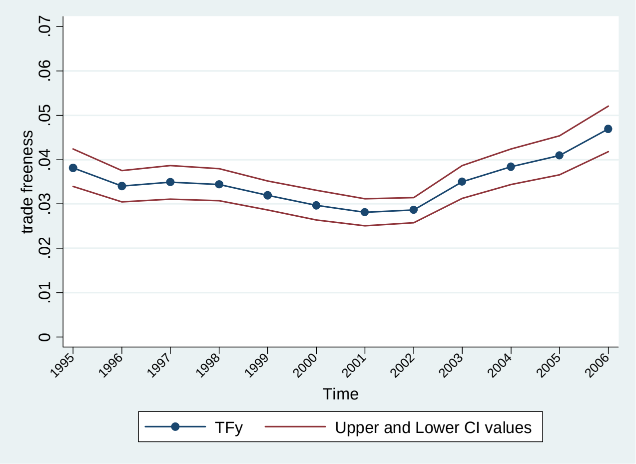

Table 3: Trade Freeness by sector.

	a	b	c	d	e	f
sec	TF^k_{all}	TF^k_{p4}	TF^k_{p3}	TF^k_{p2}	TF^k_{p1}	$\Delta TF^k_{p4.p1}$
1	0.0078	0.0094	0.0045	0.0055	0.0088	0.0006†
2	0.0169	0.0205	0.0144	0.0138	0.0146	0.0059*
3	0.0965	0.1234	0.0855	0.0572	0.0773	0.0461*
4	0.0131	0.0151	0.0111	0.0120	0.0126	0.0025*
5	0.0150	0.0175	0.0137	0.0129	0.0140	0.0035*
6	0.0228	0.0304	0.0216	0.0175	0.0179	0.0125*
7	0.0923	0.1206	0.0634	0.0532	0.0798	0.0408*
8	0.0483	0.0383	0.0262	0.0245	0.0458	-0.0075†
9	0.0120	0.0137	0.0101	0.0105	0.0120	0.0017*
10	0.0884	0.0904	0.0561	0.0795	0.0483	0.0421*
11	0.0110	0.0126	0.0096	0.0098	0.0111	0.0015*
12	0.0483	0.0651	0.0435	0.0387	0.0396	0.0254*
13	0.2301	0.1981	0.1574	0.2553	0.2448	-0.0467 na
14	0.0911	0.0627	0.0675	0.0618	0.0824	-0.0198†
15	0.1050	0.0775	0.0863	0.1195	0.0814	-0.0038†
16	0.0662	0.0797	0.0550	0.0546	0.0685	0.0113†
17	0.1022	0.1322	0.0989	0.0808	0.0669	0.0653*
18	0.0491	0.0598	0.0495	0.0477	0.0325	0.0273*
19	0.0213	0.0288	0.0204	0.0179	0.0192	0.0096*
20	0.0016	0.0038	0.0014	0.0011	0.0013	0.0025 na
21	0.0109	0.0136	0.0088	0.0080	0.0090	0.0046*

Notes: · Bootstrap-based test:"†" signals no rejection of "Ho: dfTF=0" against "H1:dfThIk $\neq$0" at 5%, "*" signals rejection, "na" stands for test-output not available. · column *a* reports the whole-period average of TF, column *b* the value for period 4, column *f* the difference value between P4 and P1.

Figure 2: Trade Freeness by sector and period.

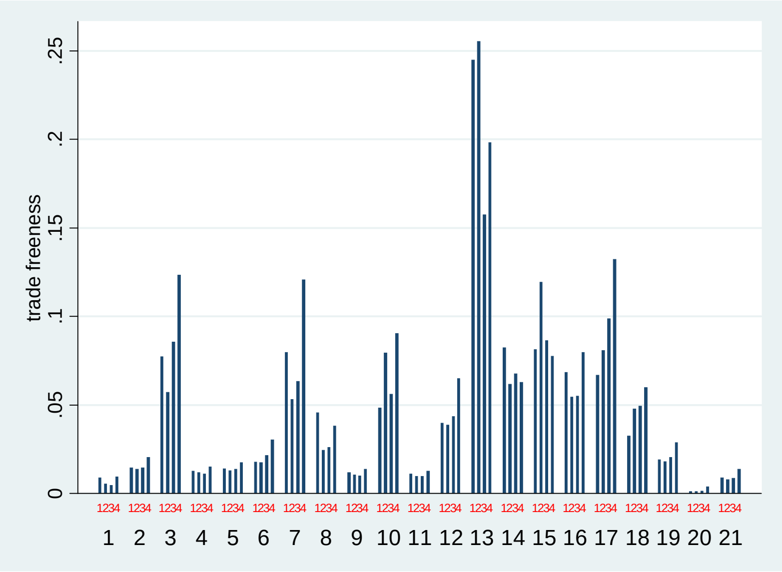

Table 4: Theil Index by sector.

	a	b	c	d	e	f
sec	ThI_{all}	ThI_{p4}	ThI_{p3}	ThI_{p2}	ThI_{p1}	$\Delta ThI_{p4.p1}$
1	0.735	0.644	0.652	0.756	0.837	-0.193*
2	0.320	0.315	0.313	0.326	0.327	-0.011†
3	1.084	1.153	1.087	1.042	1.036	0.117*
4	0.436	0.433	0.425	0.434	0.452	-0.019†
5	0.480	0.466	0.473	0.487	0.489	-0.023†
6	0.934	1.003	0.906	0.916	0.911	0.092†
7	0.702	0.688	0.683	0.699	0.736	-0.048*
8	0.506	0.500	0.496	0.503	0.524	-0.024†
9	0.477	0.500	0.491	0.459	0.458	0.042†
10	0.707	0.702	0.688	0.704	0.727	-0.025†
11	0.546	0.534	0.530	0.546	0.574	-0.040*
12	0.622	0.612	0.616	0.618	0.642	-0.030*
13	1.065	0.911	0.921	1.094	1.135	-0.224*
14	0.612	0.612	0.594	0.608	0.629	-0.017†
15	0.720	0.782	0.706	0.694	0.693	0.089†
16	0.646	0.622	0.629	0.647	0.687	-0.065*
17	0.787	0.763	0.848	0.773	0.758	0.006†
18	0.640	0.638	0.642	0.633	0.648	-0.009†
19	0.557	0.566	0.527	0.558	0.576	-0.010†
20	0.453	0.462	0.444	0.438	0.464	-0.002†
21	na	na	na	na	na	na

Notes: · Bootstrap-based test:"†" signals no rejection of "Ho: dfThIk = 0" against"H1:dfTIk $\neq$0"at 5%,"*" signals rejection. · column *a* reports the whole-period value of the index, column *b* the value for period 4, column *f* the difference value between P4 and P1.

Figure 3: Theil Index by sector and period.

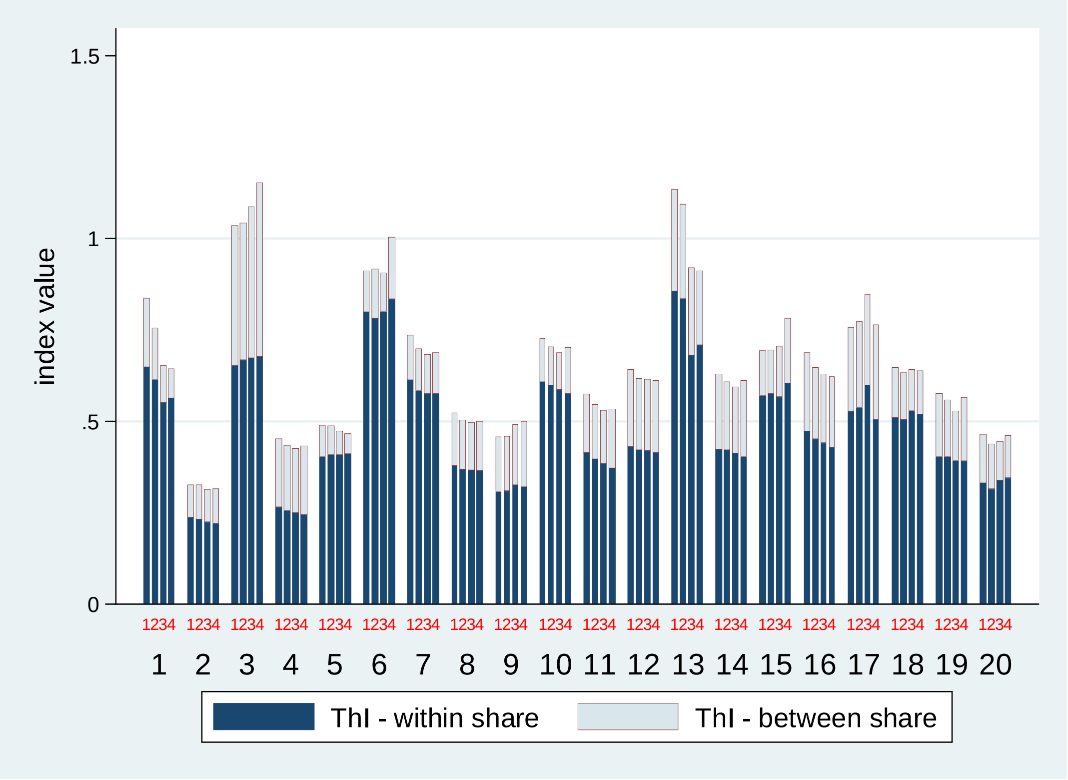

Table 5: TF and ThI differences by sector and period.

	a	b	c	d	e	f	g	h	i
sec	$\Delta TF^k_{p2.p1}$	$\Delta ThI^k_{p2.p1}$	$R^k_{p2.p1}$	$\Delta TF^k_{p3.p2}$	$\Delta ThI^k_{p3.p2}$	$R^k_{p3.p2}$	$\Delta TF^k_{p4.p3}$	$\Delta ThI^k_{p4.p3}$	$R^k_{p4.p3}$
1	-0.003	-0.081	+	- 0.001	- 0.103	+	0.005	- 0.008	-
2	-0.001	-0.001	+	0.001	- 0.013	-	0.006	0.002	+
3	-0.020	0.006	-	0.028	0.046	+	0.038	0.066	+
4	-0.001	-0.018	+	-0.001	-0.009	+	0.004	0.008	+
5	-0.001	-0.002	+	0.001	-0.014	-	0.004	- 0.007	-
6	0.000	0.005	-	0.004	-0.010	-	0.009	0.097	+
7	-0.027	-0.037	+	0.010	-0.016	-	0.057	0.005	+
8	-0.021	-0.021	+	0.002	-0.007	-	0.012	0.004	+
9	-0.001	0.001	-	0.000	0.032	-	0.004	0.010	+
10	0.031	-0.023	-	-0.023	-0.017	+	0.034	0.014	+
11	-0.001	-0.027	+	0.000	-0.016	+	0.003	0.004	+
12	-0.001	-0.024	+	0.005	-0.002	-	0.022	- 0.003	-
13	0.011	-0.041	-	-0.098	-0.173	+	0.041	- 0.010	-
14	-0.021	-0.021	+	0.006	-0.014	-	- 0.005	0.018	-
15	0.038	0.002	+	-0.033	0.012	-	- 0.009	0.076	-
16	-0.014	-0.040	+	0.000	-0.019	-	0.025	- 0.007	-
17	0.014	0.016	+	0.018	0.074	+	0.033	- 0.084	-
18	0.015	-0.015	-	0.002	0.009	+	0.010	- 0.003	-
19	-0.001	-0.018	+	0.002	-0.031	-	0.008	0.039	+
20	0.000	-0.026	+	0.000	0.006	+	0.002	0.017	+
21	-0.001	na	na	0.001	na	na	0.005	na	na

Notes: · "dfTFpX.pY" is the trade-freeness difference value between period X and period Y, "dfThIpX.pY" is the Theil Index difference value between period X and period Y, "RpX.pY" is the product of the trade-freeness difference times the Theil Index difference.

Figure 4: Trade Freeness and Theil Index by period.

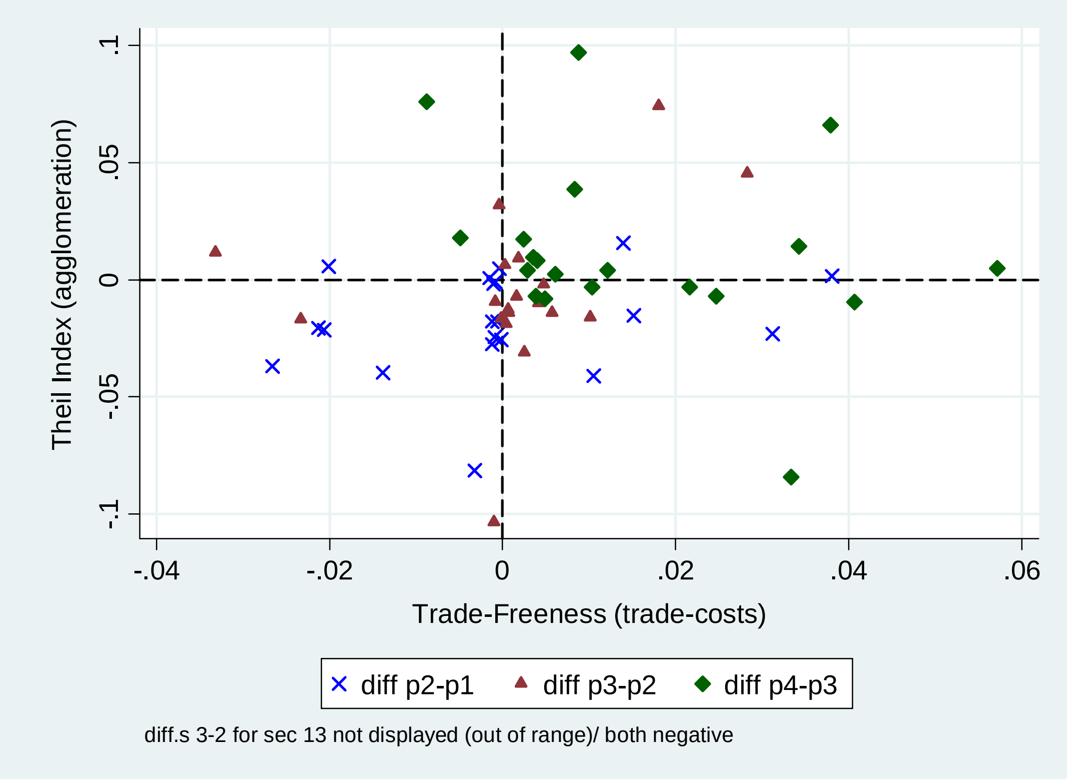

Table 6: Test of the sign of the joint variation.

	HME	diff(P4-P3)				diff(P3-P2)				diff(P2-P1)			
sec		R	Jk	Zk1	PC method	R	Jk	Zk1	PC method	R	Jk	Zk1	PC method
1		-	0.367	Rej. Ho | H1b	Rej. Ho | H1b	+	0.873	Rej. Ho | H1a	Rej. Ho | H1a	+	1	Rej. Ho | H1a	Rej. Ho | H1a
2		+	0.737	Rej. Ho | H1a	Rej. Ho | H1a	-	0.072	Rej. Ho | H1b	Rej. Ho | H1b	+	0.585	Rej. Ho | H1a	Rej. Ho | H1a
3		+	0.985	Rej. Ho | H1a	Rej. Ho | H1a	+	0.994	Rej. Ho | H1a	Rej. Ho | H1a	-	0.299	Rej. Ho | H1b	Rej. Ho | H1b
4		+	0.837	Rej. Ho | H1a	Rej. Ho | H1a	+	0.766	Rej. Ho | H1a	Rej. Ho | H1a	+	0.854	Rej. Ho | H1a	Rej. Ho | H1a
5		-	0.161	Rej. Ho | H1b	Rej. Ho | H1b	-	0.063	Rej. Ho | H1b	Rej. Ho | H1b	+	0.610	Rej. Ho | H1a	Rej. Ho | H1a
6		+	0.991	Rej. Ho | H1a	Rej. Ho | H1a	-	0.422	Rej. Ho | H1b	Rej. Ho | H1b	-	0.489	NOT Rej. Ho	NOT Rej. Ho
7	yes	+	0.626	Rej. Ho | H1a	Rej. Ho | H1a	-	0.111	Rej. Ho | H1b	Rej. Ho | H1b	+	0.997	Rej. Ho | H1a	Rej. Ho | H1a
8	yes	+	0.723	Rej. Ho | H1a	Rej. Ho | H1a	-	0.214	Rej. Ho | H1b	Rej. Ho | H1b	+	1	Rej. Ho | H1a	Rej. Ho | H1a
9		+	0.957	Rej. Ho | H1a	Rej. Ho | H1a	-	0.099	Rej. Ho | H1b	Rej. Ho | H1b	-	0.535	NOT Rej. Ho	NOT Rej. Ho
10	yes	+	0.84	Rej. Ho | H1a	Rej. Ho | H1a	+	0.808	Rej. Ho | H1a	Rej. Ho | H1a	-	0.064	Rej. Ho | H1b	Rej. Ho | H1b
11	yes	+	0.668	Rej. Ho | H1a	Rej. Ho | H1a	+	0.902	Rej. Ho | H1a	Rej. Ho | H1a	+	0.992	Rej. Ho | H1a	Rej. Ho | H1a
12	yes	-	0.303	Rej. Ho | H1b	Rej. Ho | H1b	-	0.392	Rej. Ho | H1b	Rej. Ho | H1b	+	0.859	Rej. Ho | H1a	Rej. Ho | H1a
13	yes	-	na	na	na	+	na	na	na	-	na	na	na
14	yes	-	0.395	Rej. Ho | H1b	Rej. Ho | H1b	-	0.365	Rej. Ho | H1b	Rej. Ho | H1b	+	0.912	Rej. Ho | H1a	Rej. Ho | H1a
15		-	0.383	Rej. Ho | H1b	Rej. Ho | H1b	-	0.341	Rej. Ho | H1b	Rej. Ho | H1b	+	0.518	NOT Rej. Ho	NOT Rej. Ho
16	yes	-	0.173	Rej. Ho | H1b	Rej. Ho | H1b	-	0.501	NOT Rej. Ho	NOT Rej. Ho	+	0.996	Rej. Ho | H1a	Rej. Ho | H1a
17	yes	-	0.028	Rej. Ho | H1b	Rej. Ho | H1b	+	na	na	na	+	na	na	na
18	yes	-	0.411	Rej. Ho | H1b	Rej. Ho | H1b	+	0.576	Rej. Ho | H1a	Rej. Ho | H1a	-	0.124	Rej. Ho | H1b	Rej. Ho | H1b
19	yes	+	1	Rej. Ho | H1a	Rej. Ho | H1a	-	0.013	Rej. Ho | H1b	Rej. Ho | H1b	+	0.842	Rej. Ho | H1a	Rej. Ho | H1a
20		+	na	na	na	+	na	na	na	+	na	na	na
21		na	na	na	na	na	na	na	na	na	na	na	na
		Ho: 0/18; H1a: 10/18; H1b: 8/18.				Ho: 1/17; H1a: 6/17; H1b: 10/17.				Ho: 3/17; H1a: 11/17; H1b: 3/17.			

Notes:· columns "Zk1" report the outcome of the non-parametric test, columns "PC-method" report the outcome of the test based on the 45-55 interquantiles range (Appendix 2).

· columns "R" report the sign of Rp=dfTFp*dfThIp, columns "Jk" the portion of positive observations over the total. · "Ho:Jk=1/2","H1a:Jk>1/2","H1b:Jk<1/2".

Table 7: Regression Analysis with values in level.

ThI_p^k	OLS-pooled		OLS-within	
TF_p^k	2.55	(0.33)***	1.00	(0.29)***
constant	0.52	(0.02)***	0.60	(0.02)***
obs.	80		80	
R-squared	0.44		0.43	
No. groups			20	
$allu_i = 0, PvFtest$			0.00	

Notes: ·*** p < 0.10,** p < 0.05, *** p < 0.01. · conventional st. errors in parenthesis.

Table 8: Regression Analysis with values in differences.

ΔThI_p^k	OLS-pooled		OLS-within	
ΔTF_p^k	0.83	(0.22)***	0.73	(0.21)***
constant	-0.01	(0.00)**	-0.01	(0.00)**
obs.	60		60	
R-squared	0.20		0.23	
No. groups			20	
$allu_i = 0, PvFtest$			0.075	

Notes: ·*** p < 0.10,** p < 0.05, *** p < 0.01. · conventional st. errors in parenthesis.

Figure 5: Trade Freeness and Theil Index levels by period.

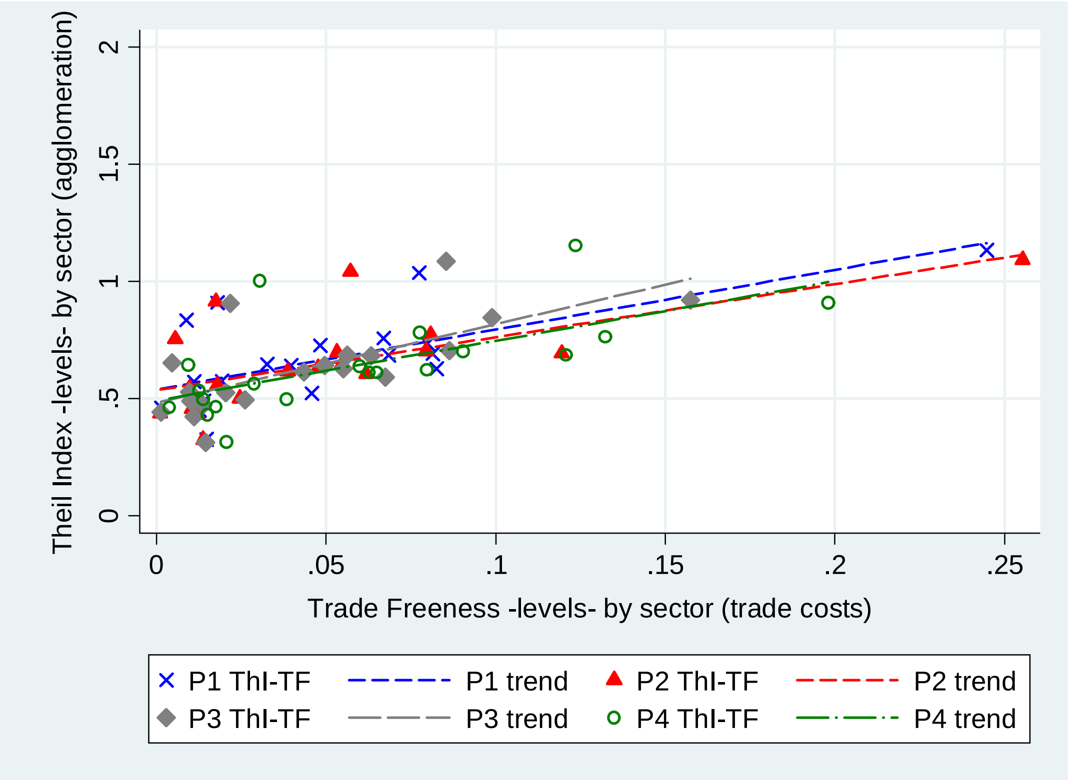

Table 9: Test of the HME hypothesis.

sec	PW-Zt	SM-rh	No.CV+	sec	PW-Zt	SM-rh	No.CV+
1	0.50	-0.03	2/3	11	0.87**	0.83**	3/3
2	0.35	-0.42	2/3	12	0.78**	0.71**	1/3
3	0.45	-0.14	2/3	13	0.67**	0.41	na
4	0.57	0.18	3/3	14	0.60*	0.25	1/3
5	0.53	0.05	1/3	15	0.55	0.08	1/3
6	0.33	-0.38	1/3	16	0.66**	0.38	1/3
7	0.62*	0.26	2/3	17	0.76**	0.70**	na
8	0.73**	0.63*	2/3	18	0.69**	0.53	1/3
9	0.37	-0.33	1/3	19	0.62*	0.35	2/3
10	0.69**	0.45	2/3	20	0.56	0.15	na
				21	0.36	-0.37	na
mean	0.58						

Notes: •"PW-Zt" reports the statistic of the Pairwise-Av. Z-test, "SM-rh" reports Spearman's coefficients. •* p < 0.05, ** p < 0.01 • "No.CV+" reports the number of positive joint variations.

Table 10: Rejection Areas

$H_0 : J_k = 1/2$	$\gamma = 1\%$		$\gamma = 5\%$		$\gamma = 10\%$
alternatives ↓	rejection area ↓	>	rejection area ↓	>	rejection area ↓
$H_{1a} : J_k > 1/2$	$p49 > 0$		$p45 > 0$		$p40 > 0$
$H_{1b} : J_k < 1/2$	$p51 < 0$		$p55 < 0$		$p60 < 0$
$H_1 : J_k \neq 1/2$	$p49.5 > 0 \mid p50.5 < 0$		$p47.5 > 0 \mid p52.5 < 0$		$p45 > 0 \mid p55 < 0$

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