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A Panel Co-integration Analysis of Industrial and Services Sectors' Agglomeration in the European Union

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Abstract

This study empirically investigates the relevance of Traditional Trade Theory, New Trade Theory and New Economic Geography in explaining industrial and services sectors' agglomeration in the European Union. Therefore, new dynamic panel data estimation techniques will be employed. Static panel data analysis reveals that assumptions of New Trade Theory and New Economic Geography can explain industrial concentration in the EU best. Results from dynamic panel OLS show that intermediate goods' intensity and therewith New Economic Geography's assumptions are important in explaining both industrial and services sectors' agglomeration. Several non-stationarity and co-integration relationships can be detected. Further, decomposition of effects across and within sectors is provided. Scale economies are only important for across industries' variation in agglomeration, not within. For services sectors' agglomeration results show that intermediate goods intensity matters only for within and not across industries' variation in agglomeration. Further evidence for intra-sectoral trade explaining equalizing economic structures for services sectors is given.

Keywords: Panel Co-integration, Agglomeration, Industries, Services

JEL classification numbers: C22, F14, R12

I Introduction

New Economic Geography was set into place in 1991 when Paul Krugman established what is nowadays known as the workhorse model of New Economic Geography. The novelty that Krugman (1991 b) offered was to take account of the *endogeneity* inherent in the process of agglomeration. In his model manufacturing firms will want to locate closer to a larger demand in order to realize scale economies and save transport costs. Demand in turn will localize close manufacturing firms because consumers (producers) can thus buy cheaper goods (inputs).

Krugman's model has been enhanced by several scholars. Forslid and Ottaviano (2003), for example, considered skill heterogeneity of workers. The authors can show that agglomeration increases in the region where more highly skilled workers are available. This is due to highly skilled workers possessing higher purchasing power, which forms an incentive for firms to localize in this region, too. Firms making profits will become able to pay higher wages, which in turn makes workers move to this region. A circular process arises.

Martin and Ottaviano (2001) investigated the relationship between growth and agglomeration incorporating innovation processes within their model. Agglomeration fosters growth since in a region where many firms are located in, innovation becomes cheaper --through use of knowledge spillovers, for example-- and increasing innovations will lead to a higher level of growth. On the other hand, the sector having benefited from innovations will expand, other firms will move close because of increasing returns, thus leading to a higher level of agglomeration.

The empirical literature, so far, tried to disentangle reasons for agglomeration, which might lie in Marshallian type causes comprising labor availability and quality, knowledge spillovers and input-output linkages between firms. On the other hand, influences of scale economies, factor intensity or intermediate goods intensity for agglomeration have been investigated (see Amiti 1998, 1999; Brülhart 2001, Midelfart-Knarvik *et al.* 2000, for example). Another piece of research aims at directly verifying the importance of New Economic Geography (Davis and Weinstein 1999, 2003). The authors could prove the existence of what Paul Krugman (1980) termed the '*home market effect*': countries will specialize in that good which is characterized by a high domestic demand and will finally export that good. The high level of demand will make firms clustering close to each other in order to benefit from increasing returns to scale and lower transport costs.

As Redding (2010) and Brakman, Garretsen (2009) point out , more work needs to be done in Empirics, like discriminating between different agglomeration forces for evaluating the agglomeration effects explained by Krugman. In my investigation I will disentangle the driving factors of industrial and services sectors' agglomeration in the European Union making use of a panel data set from the EU KLEMS data base applying adequate panel data estimation methods. Explanatory factors will be derived from Traditional Trade Theory, New Trade Theory and the New Economic Geography. Non-stationarity issues will be addressed, panel unit roots and co-integration tests will be conducted and dynamic OLS regression for co-integrating variables will be applied. To the best of my knowledge, non-stationarity properties of regression variables have not been considered adequately in Empirics on New Economic Geography so far. They are, however, essential in order to gain valid estimation results. So, the main contribution of this paper is to address econometric issues not having been given much attention to in the New Economic Geography literature so far: non-stationarity issues calling for dynamic panel data analysis.

II Literature Review

Taking a look at studies on industrial and services' agglomeration one will find that there is fewer work being done on services. The reasons for this might be lower data quality and availability for services as well as problems related to defining services. Summarizing work on industrial agglomeration for the EU, most studies found that agglomeration increased over time. Brülhart and Torstensson (1998) show that specialization in the EU increased beginning with the 1980s. They find that increasing returns to scale industries tend to localize, and industries localizing do so primarily in central EU countries. Brülhart (2001) finds evidence for an increasing level of industrial agglomeration in the EU from 1972 to 1996. Especially labor intensive industries show the highest increase in agglomeration. Amiti (1998, 1999) found that scale economies and intermediate goods intensity (representing the importance of New Trade Theory and New Economic Geography in explaining agglomeration) significantly influenced agglomeration in the EU from 1968 to 1990.

As regards services sectors' agglomeration, Jennequin (2008) found that services sectors got concentrated in the EU although concentration is only moderate from 1986 onwards. He can show that business and financial services are the most agglomerated sectors. Midelfart-Knarvik *et al.* (2000) investigated services' concentration in the EU considering only five services sectors. They find that services sectors are highly agglomerated compared to industrial sectors. Financial services, insurance, business, communication and real estate activities are the sectors that are the most concentrated over time and also those that deagglomerated most between 1982 and 1995. Transport services are the most dispersed services over time; in turn this sector shows the highest increase in agglomeration over time. The authors see changes in demand as a reason for an increase in agglomeration.

Three other studies are worthwhile noting, which either provide information on the variation in agglomeration explained or have only very recently been published and therewith point to the relevance of investigating agglomeration issues.

Kim (1995) applies a regression for explaining localization of industries in the US by plant size (addressing scale economies) and resource intensity (addressing Traditional Trade Theory arguments). He uses 20 industries and 5 time periods (1880, 1914, 1947, 1967 and 1987) in his sample. Kim can show that plant size explains within industry variation in agglomeration and raw material intensity is able to explain across industry variation in agglomeration.

Some very recent research focuses on co-localization of industries, clarifying the issue which industries locate next to each other. In their rigorous study Ellison *et al.* (2010) investigate co-agglomeration patterns and its causes for US manufacturing industries. The authors want to test the relative importance of natural advantages and Marshallian externalities for industrial agglomeration with a cross-section analysis for the year 1987. They find that input-output-linkages are most important out of the Marshallian externalities, but the influence of shared natural advantages appeared to be most important within their regressions. The authors point to the need of investigating Marshallian externalities for services and assume that input-output-linkages should be important in that sector.

Another study deals with non-stationarity issues within an agglomeration context. Zheng (2010) employs co-integration analysis on time series data investigating dynamic externalities for Tokyo. Zheng found out for the Tokyo metropolitan area that knowledge spillovers among firms in one industry explain total factor productivity growth in manufacturing, finance, trade and overall industry. Further, he defines network dynamic externalities which are knowledge spillovers resulting from the agglomerated area via transportation networks. There exist co-integration relationships between network dynamic externalities and total factor productivity in manufacturing, finance, wholesale and retail trade and overall industries. Knowledge spillovers resulting from the diversity of industries are important for total factor productivity in the services sector, only.

III Methodology

In the following, procedures for panel unit root and co-integration tests will be briefly discussed. In the end it should be possible to figure out the most appropriate test for investigation of either industrial or services agglomeration. Issues of size and power of tests will be addressed. Furthermore, dynamic panel OLS and fully modified OLS will be briefly explained.

Panel Unit Root tests

The analysis of non-stationarity in panel data required the development of new unit root tests coping with both the time series and cross-section dimension of the data. Testing for non-stationarity and co-integration benefits from adding the cross-section dimension to time series because the data base thus increases and the power of testing and estimation will be enhanced. The tests from Levin, Lin, Chu (2002), Im, Pesaran, Shin (2003), Choi (2001), Maddala, Wu (1999) and Breitung (2000) will be explained in the following.[1]

The different models start with considering a stationary autoregressive process of first order, that is:

$$y_{it} = \rho_i \, y_{it-1} + u_{it} \tag{1}$$

[1] A comprehensive review on panel unit root tests can be found in Baltagi and Kao (2000) or Baltagi (2009).

where $-1 < \rho_i < 1$ is the autoregressive parameter, y is the variable of interest, i is the number of cross sections, t is the number of time points and u_{it} is the error term. Now, a unit root exists when $|\rho_i| = 1$. For the following tests, however, only positive autocorrelation will be tested for, that is $\rho_i = 1$.

Levin, Lin and Chu (2002) (LLC) test the hypothesis that each individual time series contains a unit root against the alternative that each time series is stationary. The authors start with the model:

$$y_{it} = \rho_i y_{it-1} + z'_{it}\,\gamma_i + u_{it} \quad (2)$$

where z_{it} is a deterministic component and could be zero, one, the fixed effects or fixed effects plus time trend and γ_i is a vector of coefficients. Further, it is assumed that the u_{it} are $iid\ (0, \sigma_u^2)$, that is independent and identically distributed with mean 0 and variance σ_u^2, and $\rho_i = \rho$ for all i. Equation (2) can also be written as:

$$\Delta y_{it} = \delta y_{it-1} + z'_{it}\,\gamma_i + u_{it} \quad (3)$$

with $\Delta y_{it} = y_{it} - y_{it-1}$ that is taking $-y_{it-1}$ on both sides of the equation having $\delta = \rho - 1$. The hypotheses being tested for are:

$$H_0 : \ \delta = 0 \text{ versus } H_{alternative}: \delta < 0 \quad .$$

This would mean $\rho = 1$ under the null. The authors employ a three-step procedure to get their test-statistic: first, estimating separate ADF-regressions (therefore including lags of Δy into the regression) for each individual, getting orthogonalized residuals and standardizing these residuals, second, estimating the ratio of long-run to short-run standard deviations for each individual, and third, computing the panel test statistics. The adjusted test statistic is given by:

$$t_{\delta}^{*} = \frac{t_{\delta} - N\tilde{T}\hat{S}_N \hat{\sigma}_{\tilde{\varepsilon}}^{-2} STD(\hat{\delta})\mu_{m\tilde{T}}^{*}}{\sigma_{m\tilde{T}}^{*}} \quad (4)$$

where $\sigma_{m\tilde{T}}^{*}$ and $\mu_{m\tilde{T}}^{*}$ are the standard deviation and mean adjustment, N is the number of cross sections, $\tilde{T}$ is the average number of observations per individual in the panel, $\hat{S}_N$ is the estimator of the average of the ratio of long-run to short-run standard deviation[2], $\hat{\sigma}_{\tilde{\varepsilon}}^{2}$ is the estimated variance of the error term, $STD(\hat{\delta})$ is the standard error of $\hat{\delta}$ and t_{δ} is the conventional t-statistic for testing $\delta = 0$. t_{δ}^{*} is asymptotically normally distributed, $N(0,1)$.

The authors can show via Monte Carlo simulations that generally the power of their test is higher than the power of a standard DF-test (for $N = 1$ and T varying) if a panel with moderate sizes is being taken for analysis (that is N between 10 and 250 and T between 25 and 250). Size distortions get lower with increasing N in case of including individual specific effects and time trends or none of these two elements to the regression framework. Power is lower for smaller T when including both individual specific effects and time trends into the model compared to just including individual effects or considering none of these two deterministic elements. However, this should not lead one to just consider running tests of the hypothesis without any deterministic elements because the unit root test will be inconsistent if such an element does exist in real data but is not taken account of in the estimation (see Levin, Lin, Chu (2002), p. 5). The LLC test is criticized for being valid only in case there is no cross sectional correlation present and for the formulation of hypotheses referring to identical individuals (see Levin, Lin, Chu (2002), p. 18). Drawing a conclusion, for my study making

[2] To derive this estimate, kernel-based techniques are used. They are necessary for removing time trends. In fact, a truncation lag parameter has to be determined, however, it is data dependent, that is where kernel methods come into use.

use of a rather small panel of $N = 20$ and $T = 11$ in case of industrial agglomeration and $N = 13$ and $T = 36$ in case of services sectors' agglomeration, the LLC test appears to be not too powerful. At least power increases applying the test in case of services' agglomeration.

Im, Pesaran and Shin (2003) (IPS) use a test based on averaging individual unit root test statistics. The authors use ADF-tests like the one in equation (3) including additional lags of Δy.

They test the hypothesis that each series in the panel contains a unit root against the alternative that some (so not necessarily all) of the individual series have unit roots whereas others have not, so a less restrictive testing than the LLC test did:

H_0: $\delta_i = 0$ for all i versus $H_{alternative}$: $\delta_i < 0$ for at least one i.

A standardized test statistic is:

$$t_{IPS} = \frac{\sqrt{N}(\bar{t} - N^{-1}\sum_{i=1}^{N} E(t_{T_i}))}{\sqrt{N^{-1}\sum_{i=1}^{N} Var(t_{T_i})}} \qquad (5)$$

which converges to $N(0,1)$ as T and N $\rightarrow \infty$. $E(t_{T_i})$ and $Var(t_{T_i})$ are the mean and the variance of t with T varying across groups i and $\bar{t} = \frac{1}{N}\sum_{i=1}^{N} t_{T_i}$ is the mean of individual test statistics. Running Monte Carlo simulations, Im, Pesaran, Shin can show that when there is no serial correlation then their test has higher power and smaller size distortions compared to the LLC test even for small T. However, when errors are serially correlated then T and N need to be sufficiently large, furthermore, the order of ADF-regressions becomes important. The power of the IPS test increases the higher is the order of ADF-regressions. So, for my study the IPS test seems to be more appropriate than the LLC test because of gains in power. However, as Im, Pesaran, Shin point out, one has to be careful with the interpretation of test results. A rejection of the null hypothesis does not mean that the null of unit roots is rejected for all individuals but for just some of them.

Breitung (2000) generally follows the LLC test procedure.[3] However, he uses a different transformation for Δy and y, adjusting for time trends in computing orthogonalized residuals. Therefore, no kernel methods are needed. His test is asymptotically normally distributed. Monte Carlo simulations demonstrate that his test attains a much higher power than LLC or IPS tests.

Choi and Maddala/Wu propose a Fisher test combining p-values from unit root tests for each cross section i. Formally this looks:

$$P = -2\sum_{i=1}^{N} lnp_i \quad (6)$$

p_i is the p-value from any individual unit root test for i and P is distributed as Chi-square with $2N$ degrees of freedom as $T_i \rightarrow \infty$ for all N. The hypotheses are:

H_0: $\rho_i = 1$ for all i versus $H_{alternative}$: $\rho_i < 1$ for at least one i.

Out of Choi's (2001) proposed tests, the Z-test appears to be the one that has highest power in relation to size, also outperforming the IPS test which can be seen by Monte Carlo

[3] Formal notations follow LLC, except for the differences briefly talked about here.

simulations. However, Choi's test considerably gains in power only as N increases. Formally the Z-test is:

$$Z = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} \varphi^{-1}(p_i) \tag{7}$$

$Z \rightarrow N(0,1)$ as $T_i \rightarrow \infty$ and $N \rightarrow \infty$. $\varphi(.)$ denotes the standard normal cumulative distribution function. For my study, including intercept and trend, and N being quite small, the quality of Choi's test can be seen comparable to the quality of IPS' test.

Maddala and Wu (1999) find that for high values of T and N (50-100) the Fisher-test dominates the IPS test as size distortions are smaller at comparable power. For small T and N, however, IPS and LLC seem to be preferable over Fisher-tests.

When I test for unit roots in the following, p-values for the Fisher-test will be gained by using ADF- and Phillips-Perron individual unit root tests.

Summarizing, for the setup of my study keeping track of the sizes of panels, the Breitung test appears to be the best test having a high power, followed by IPS.

Panel Co-integration tests

The Kao (1999) and Pedroni (2004) tests will be briefly explained in the following.[4] These tests are based on the Engle-Granger (1987) test. There, I(1)-variables are regressed on each

[4] See also Baltagi and Kao (2000) or Baltagi (2009) for a summary on these tests' procedures.

other, then the resulting residual is being checked for stationarity. The residual being I(0) will indicate co-integration.

Kao developed four DF- and one ADF-test for testing the null hypothesis of no co-integration. He starts with the regression:

$$w_{it} = \alpha_i + \beta x_{it} + e_{it} \tag{8}$$

where w is the dependent, x the independent variable, α is the intercept, and e the error term and w and x are assumed to be integrated of order 1, that is I(1). The estimated residuals, needed for the ADF-test statistic are:[5]

$$\hat{e}_{it} = \rho \hat{e}_{it-1} + \sum_{j=1}^{p} \varphi_j \Delta \hat{e}_{it-j} + \tau_{it} \tag{9}$$

τ_{it} is the disturbance term, and 1 to p lags of the first difference of estimated residuals $\sum_{j=1}^{p} \varphi_j \Delta \hat{e}_{it-j}$ are included in the regression. The null of no co-integration is $H_0\colon \rho = 1$.

The ADF-test is formally given as:

$$t_{ADF} = \frac{t_\rho + \frac{\sqrt{6N}\widehat{\sigma_\tau}}{2\widehat{\sigma}_{0\tau}}}{\sqrt{\frac{\widehat{\sigma}_{0\tau}^2}{2\widehat{\sigma}_\tau^2} + \frac{3\widehat{\sigma}_\tau^2}{10\widehat{\sigma}_{0\tau}^2}}} \tag{10}$$

[5] DF-tests are not mentioned here for reasons of lucidity.

where $t_\rho = \frac{(\hat{\rho}-1)\sqrt{\sum_{i=1}^{N}(e_i' Q_i e_i)}}{s_\tau}$, $Q_i = I - X_{ip}(X_{ip}'X_{ip})^{-1}X_{ip}'$, X_{ip} is the matrix of observations on the p regressors $\Delta\hat{e}_{it-j}$, $\hat{\sigma}_\tau^2$ is the estimated variance, $\hat{\sigma}_{0\tau}^2$ is the estimated long-run variance employing a kernel estimator and $s_\tau^2 = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{\tau}_{it}^2$.

The asymptotic distribution of t_{ADF} converges to a standard normal distribution $N(0,1)$. Kao finds out that for small T (T=10) and N=15 or 20 all of the tests have quite low power (ranging from 0.017 to 0.375). In case of an increasing σ he finds that the ADF-test outperforms all his other tests. For my case, based on the sample sizes and comparing results of Kao's Monte Carlo simulations, the ADF-test seems to be most adequate and in case of an increasing variance it would be the best choice, as has been stated before.

Pedroni proposed eleven tests, allowing for heterogeneous coefficients for explanatory variables across cross-sections (in contrast to Kao, where coefficients do not differ across individuals).[6] He tests the null of no co-integration using residuals from a regression of I(1) variables like it is done by Kao (see equation (9) for example). He separates his work in two classes of test statistics. First, pooling residuals across the within dimension of the panel, the panel statistics, second, pooling across the between dimension, the group statistics. The standardized statistic is asymptotically normally distributed. Running Monte Carlo simulations Pedroni shows that for low N and low T (N=20 and T starting with 20) the group-rho, panel-v and panel-rho tests have quite lower power than the panel-t and group-t tests.

Power increases when T gets larger. With higher N the panel-v and panel-rho tests have the highest power. Considering the sizes of tests is also important. In that context, Pedroni explains that when the group-rho statistic rejects the null hypothesis, one could be confident

[6] I will not present the formal notation here for reasons of lucidity.

about then having found a co-integration relationship, since the group-rho statistic is the most conservative test in terms of empirical size.

Estimation in Panel Co-integrating Frameworks

Estimating long-run relationships of co-integrating variables the literature proposes using for example Fully Modified OLS (FMOLS) or Dynamic OLS (DOLS).[7]

Stock and Watson (1993) demonstrate via Monte-Carlo simulations that the DOLS estimator is preferable over other estimators. The authors explain that for obtaining the DOLS-estimator one has to regress the dependent variable onto the explanatory variables, leads and lags of their first differences and a constant using either OLS or GLS. This procedure is valid only for I(1)-variables with a single co-integrating vector. The authors state that adding several lags and leads into the regression framework reduces the bias of the DOLS estimator. Formally the DOLS-estimator can be obtained by running the regression:

$$w_{it} = \alpha_i + x_{it}'\beta + \sum_{j=-q}^{q} c_{ij}\, \Delta x_{it+j} + \dot{\tau}_{it} \tag{11}$$

where $\sum_{j=-q}^{q} c_{ij}\, \Delta x_{it+j}$ comprises the leads and lags of the first difference of x, and $\dot{\tau}_{it}$ is the disturbance term. $\hat{\beta}_{DOLS}$ has the same limiting distribution as the FMOLS estimator.

The FMOLS estimator is given by (see Kao and Chiang (2000), pp. 186-187):

$$\hat{\beta}_{FMOLS} = [\sum_{i=1}^{N} \sum_{t=1}^{T} (x_{it} - \overline{x}_i)(x_{it} - \overline{x}_i)']^{-1} \times [\sum_{i=1}^{N} (\sum_{t=1}^{T} (x_{it} - \overline{x}_i)\widehat{w}_{it}^{+} - T\, \hat{\Delta}_{\varepsilon u}^{+})] \tag{12}$$

[7] See also Baltagi and Kao (2000).

where $\hat{w}_{it}^{+}$ is a transformation of w_{it} in order to correct for endogeneity underlying in OLS, $\overline{x_\iota}$ is the mean over time of x_{it} and $\hat{\Delta}_{\varepsilon u}^{+}$ is the correction term for serial correlation. If assumptions of the model hold then $\sqrt{N}T(\hat{\beta}_{FMOLS} - \beta) \rightarrow N(0, 6\omega_{\epsilon}^{-1}\omega_{u,\epsilon})$, with ω as the covariance matrix.

Kao and Chiang (2000) demonstrate via Monte Carlo simulations that the DOLS estimator is superior to FMOLS and OLS in both homogenous and heterogeneous panels.

Summarizing, in the following, estimation via dynamic OLS will be taken into account for long-run relationships because it is superior to FMOLS.

IV Empirical Analysis

The empirical analysis aims at assessing the relevance of Traditional Trade Theory, New Trade Theory or the New Economic Geography in explaining industrial or services' agglomeration in the EU. Data are taken from the EU KLEMS database (2008). EU KLEMS is a data collection project funded by the European Commission and is conducted by the OECD, several research institutes and universities in the EU. The sample period taken covers the years 1970-2005 for 14 European countries, 20 industries and 22 services sectors.[8] Data on explanatory variables for Italy (that is labor compensation, capital compensation, intermediate inputs, value added, gross output as volume and as value) were missing in the EU KLEMS database. Therefore I decided to take data for explanatory variables for Italy from the OECD STAN database. Further, values given in national currency for Denmark, Sweden and the UK were converted to values in euros, using the respective exchange rates on

[8] Countries included in the sample, as well as industrial and services sectors are listed in the appendix.

January 4th 1999.[9] Next, all values for explanatory variables for all countries were deflated using the price index for gross output (1995=100).

Measurement and tendencies of Agglomeration

Measurements for agglomeration differ over the literature. Some authors employ absolute measures of agglomeration (like Aiginger and Leitner, 2002 or Aiginger and Pfaffermayr, 2004), others use relative ones (see for example Amiti, 1998, 1999 or Kim, 1995). Relative measures of agglomeration share the advantage that they allow for a comparison of an industry's importance (in terms of employment, value added, exports etc.) in a given country to the importance of a country in relation to the whole EU.

Hoover (1936) was the first to employ the Gini coefficient, a relative measure, for analyzing concentration of US manufacturing. Krugman (1991 a) made use of this measure using relative employment shares. The same procedure will be undertaken here. Therefore, data on employment, namely *numbers of persons engaged* was extracted from the EU KLEMS database. For getting a Gini coefficient, first the Balassa index needs to be computed as

$$B_{ij} = \frac{\frac{e_{ij}}{e_i}}{\frac{e_j}{E}} \tag{13}$$

Here, e_{ij} denotes an industry i's employment in a country j, e_j denotes total manufacturing employment in country j, e_i denotes total industry i's employment in the EU and E denotes total manufacturing employment in the European Union.[10] Ranking the Balassa index in descending order, constructing a Lorenz-curve by plotting the cumulative of the numerator on

[9] See ECB, exchange rate statistics.

[10] Substitute the index s for i when addressing services.

the vertical axis and the cumulative of the denominator on the horizontal axis (cumulating over countries for calculation of $gini_{it}$, that is the Gini for industrial agglomeration, or of $gini_{st}$, that is the Gini for services' agglomeration), then taking twice the area within a 45 degree line and the Lorenz-curve yields the Gini coefficient (see for example Amiti, 1998, 1999). Theses indices were calculated for both industries and services sectors. [11] The main results and tendencies for agglomeration are the following.

Among the most agglomerated industries in 2005 were the leather and footwear industry, textiles and textile products and wood and wood products. These are also the industries which experienced the highest increase in agglomeration from 1970 to 2005. Motor vehicles, trailers and semitrailers also experienced an enormous increase in agglomeration. Leather and textiles belong to the labor intensive industries as classified by the OECD. The Balassa-Index for these industries is especially high for countries like Greece, Italy, Portugal or Spain. One could argue now that labor intensive industries got agglomerated in these countries because of lower labor costs, supporting Heckscher-Ohlin theory. The following analysis shall shed light on which factors might explain agglomeration tendencies in the EU.

Concerning services' agglomeration it can be stated that water transport is highly agglomerated both in 2005 and 1970, which is not a big surprise since these services need to be located next to the river or sea and depend on actively used waterways. Research and development activities are also highly agglomerated possibly pointing to the need of high-skilled labor, other industries' or services' products or other supportive materials. Among the most dispersed services are other inland transport both in 2005 and 1970 and in particular retail trade. Retail trade, however, experienced a rather large increase in agglomeration over the time period 1970-2005. One could have argued before that the dispersion of retail trade

[11] A detailed analysis can be found in another work of mine.

was in favor of consumers' needs, but there is a tendency for clustering over time evident. Financial intermediation is still quite dispersed in 2005 although it records a high increase in agglomeration over time. It can be expected that financial services will become more and more clustered, particularly in the highly active business districts.

Trade theories, New Economic Geography and explanatory factors

The aim of this study is to find out if agglomeration can be explained by several trade theories' and the New Economics Geography's assumptions. Adequate measures for representing Heckscher-Ohlin theory, New Trade Theory and the New Economic Geography have to be developed. Authors like Amiti (1998, 1999), Brülhart (2001) or Midelfart-Knarvik *et al.* (2000) offer a guide in doing so. [12]

The following measures are applied:

$$fact_{it} = \left| \frac{w_{it}L_{it}}{VA_{it}} - \frac{\overline{w_t L_t}}{\overline{VA_t}} \right| \tag{14}$$

$$scale_{it} = \frac{\frac{w_{it}L_{it}+Cap_{it}+Int_{it}}{Q_{it}}}{Q_{it}} \tag{15}$$

$$intermediate_{it} = \frac{P_{it}Q_{it}-VA_{it}}{P_{it}Q_{it}} \tag{16}$$

Addressing Heckscher-Ohlin theory (see equation (14)) I employ a measure as is done in Amiti (1998, 1999). It indicates whether an industry produces under a higher level of labor

[12] Substitute the index s for i in case of services.

intensity than the average of industries. $w_{it}L_{it}$ denotes labor compensation of employees in industry i at time t and VA_{it} is gross value added at current basic prices at time t in industry i. A high value of *fact* indicates a high level of labor intensity, a low value will represent another factor's high intensity, for example capital's one. A higher value of *fact* should lead to a higher level of agglomeration according to Heckscher-Ohlin theory, since theory tells us that countries specialize in products that need the factor relatively intensively that the country is well endowed with.

For the measure representing scale economies over time (see equation (15)), $w_{it}L_{it}$ denotes labor compensation at time t for industry i, Cap is capital compensation, Int is intermediate inputs at current purchasers' prices and Q is gross output as a volume index (1995=100). As *scale* increases, the lower will be scale economies, because then an industry would have to bear higher unit costs per given output. New Trade Theory tells us that the higher are scale economies, the higher should be agglomeration because then firms would rather tend to cluster than serving markets from single locations. This is because firms would want to reap off benefits of scale economies through localization (see Krugman, 1998).

New Economic Geography (see equation (16)) is modeled as is done by Amiti (1998, 1999). $P_{it}Q_{it}$ is gross output at current basic prices in industry i at time t and VA is gross value added at current basic prices. The higher is intermediate goods intensity, the higher can linkages between upstream and downstream firms expected to be and the higher should be agglomeration (see Amiti, 1999). This is exactly one of the core messages of New Economic Geography (see for example Krugman and Venables, 1995). With lowering transport costs upstream firms may want to locate closer to downstream firms because they can save transport costs that way. On the other hand downstream firms will want to locate closer to upstream firms because they can thus receive cheaper inputs for their production.

Explaining Industrial Agglomeration

In the following, panel data analysis will be conducted in order to disentangle the influential factors for industrial agglomeration. First, static panel analysis' results will be presented. I will estimate the following model:

$$lngini_{it} = \alpha_i + \beta_1 * lnfact_{it} + \beta_2 * lnscale_{it} + \beta_3 * lninterm_{it} + u_{it} \qquad (17)$$

that is $lngini_{it}$ is regressed on the logarithms of factor intensity, scale economies and intermediate goods intensity, u_{it} is the disturbance term. Ordinary least squares (OLS), fixed-effects (FE), random-effects (RE) and between (BE) estimation results are shown in the following table.

TABLE 1

Static panel data analysis for industrial agglomeration

Variable	*OLS*	*FE*	*RE*	*BE*
lnfact	-0.0528	-0.0046	-0.0048	-0.0825
	(-0.62)	(-0.52)	(-0.54)	(-0.67)
lnscale	-0.3187	0.0476	0.0305	-0.3426
	(-3.28)	(1.33)	(0.90)	(-2.91)
lninterm	1.6128	1.5942	1.5101	1.7617
	(2.73)	(3.34)	(3.39)	(2.50)
const	-2.0915	-0.9316	-1.0126	-2.1911
	(-7.06)	(-3.43)	(-3.52)	(-5.57)
N	220	220	220	220
R^2	0.4178	0.2513		0.4507
R^2 overall		0.0732	0.0954	0.4149
R^2 between		0.0705	0.0929	0.4507
R^2 within		0.2513	0.2497	0.1122

Source: Own calculations based on EU KLEMS data (2008) and OECD STAN data.
Note: t-stats in brackets are calculated with robust standard errors, for OLS clustered, for BE bootstrapped.

As can be seen, OLS points to New Trade Theory and New Economic Geography being important for explaining industrial agglomeration in the EU. However, scale economies' influence basically explains across industry variation in agglomeration. FE- and RE-estimators display that New Trade Theory's assumptions are not important in explaining industrial agglomeration. Heckscher-Ohlin theory appears not to be important, anyway. A Hausman test pointed to the difference in FE and RE coefficients not being systematic, thus preferring FE over RE estimation.

Overall, I can confirm results by Amiti (1999). Additionally, we learn that scale economies are able to explain across industry variation in agglomeration only and not within an industry over time. This contrasts Kim (1995) who found scale economies to be important for within industry variation in agglomeration. His result, however, might be due to the fact that scale economies have been made more and more use of over time by firms in former times (his sample for the US ends at the year 1987), whereas in recent times (my sample for the EU ranges from 1995 to 2005) there is less variation in scale economies over time existing, instead scale economies vary across industries.

In order to cope with non-stationarity issues, panel unit root tests will be conducted and if applicable, in a next step co-integration relationships will be tested for. Results are given in tables 2 and 3.

TABLE 2

Panel unit root tests for industrial agglomeration

test	*statistic*			
	variables			
	lngini	*lnfact*	*lnscale*	*lninterm*
Levin, Lin Chu	-5.9837***	-6.5455***	-1.8635**	-7.6495***
Breitung	2.3966	-0.8451	4.1649	-1.2074
Im, Pesaran, Shin	-0.0901	-0.9669	1.4707	-1.3883*
ADF-Fisher-Chi-square	45.6754	54.9315*	28.6555	58.6944**
PP-Fisher-Chi-square	75.8498***	44.7039	34.414	70.9994***

Source: Own calculations based on EU KLEMS data (2008) and OECD STAN data.
Note: *** significant at 1% level, ** significant at 5% level, * significant at 10% level. Including individual effects and individual linear trends. Automatic selection of maximum lags. Automatic selection of lags based on SIC. Newey-West bandwidth selection using Bartlett kernel. Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution.

TABLE 3

Panel co-integration tests for industrial agglomeration

test	*Panel v*	*Panel rho*	*Panel PP*	*Panel ADF*
	statistic			
Pedroni residual cointegration	-1.8213	4.6396	-0.9548	-0.6772
	weighted statistic			
Pedroni residual cointegration	-1.8624	4.1436	-3.4945***	-2.6289***

test	*Group rho*	*Group PP*	*Group ADF*
	statistic		
Pedroni residual cointegration	5.6672	-8.3065***	-3.9636***

test	*ADF*
	statistic
Kao residual cointegration	-2.565***

Source: Own calculations based on EU KLEMS data (2008) and OECD STAN data.
Note: *** significant at 1% level, ** significant at 5% level, * significant at 10% level. Null hypothesis: no cointegration. Pedroni: Deterministic intercept and trend included, Kao: no deterministic trend. Pedroni: Automatic lag selection using SIC with a max lag of 0, Kao: automatic 2 lags by SIC with a max lag of 2. Newey-West bandwidth selection with Bartlett kernel.

Results show that the null of panel unit roots is rejected for all of the four variables using the Levin, Lin, Chu test. Only the Breitung test suggests that every variable is non-stationary. Overall, *lngini*, *lnfact* and *lnscale* might be considered non-stationary, it is not so clear if *lninterm* is non-stationary. As has been explained in chapter 5.3.1 Breitung's test results are most important here, indicating non-stationarity of variables.

As concerns co-integration, seven out of eleven tests by Pedroni do not reject the null of no co-integration. The group-rho statistic does not support co-integration. The Kao test rejects the null of no co-integration. So, evidence is less clear on whether there is co-integration among regression variables or not. As a result, the following estimation output by dynamic panel OLS can be interpreted only with caution:

$$lngini_{it} = -0.9564 - 0.0059 * lnfact_{it} + 0.0405 * lnscale_{it} + 1.6129 * lninterm_{it} \quad (18)$$

where *lninterm* and the constant are significant at the 5% level, N=217, R^2 overall= 0.087, R^2 between= 0.081, R^2 within= 0.265. Lags and leads of order 1 of first differences of co-integrated explanatory variables were included.

Taking into account the variables' dynamics does not seem to alter the basic result that New Economic Geography’s assumptions bear a lot of significant power in explaining industrial agglomeration in the European Union. A 1 % increase in intermediate goods' intensity increases industrial agglomeration by 1.61 %.

Explaining Services Sectors' Agglomeration

The same procedure is undertaken for services sectors’ agglomeration. Static panel data analysis will be presented first. The following equation will be estimated:

$$lngini_{st} = \alpha_s + \beta_1 lnfact_{st} + \beta_2 lnscale_{st} + \beta_3 lninterm_{st} + u_{st} \quad (19)$$

where $lngini_{it}$ is regressed on the logarithms of factor intensity, scale economies and intermediate goods intensity and u_{it} is the error term. Regression results are given in the following table:

TABLE 4

Static panel data analysis for services' agglomeration

Variable	*OLS*	*FE*	*RE*	*BE*
lnfact	0.1084	-0.0014	0.0017	0.1404
	(1.23)	(-0.08)	(0.09)	(0.99)
lnscale	0.2335	0.2396	0.2344	0.2857
	(2.13)	(3.01)	(3.00)	(1.24)
lninterm	-0.0904	0.5466	0.5069	-0.0916
	(-0.25)	(2.40)	(2.37)	(-0.13)
const	-1.8216	-1.4550	-1.4929	-1.6805
	(-3.14)	(-5.07)	(-5.24)	(-1.69)
N	468	468	468	468
R^2	0.2506	0.2667		0.3138
R^2 overall		0.0011	0.0025	0.2503
R^2 between		0.0019	0.0006	0.3138
R^2 within		0.2667	0.2662	0.1042

Source: Own calculations based on EU KLEMS data (2008).
Note: t-stats in brackets are calculated with robust standard errors, for OLS clustered, for BE bootstrapped.

OLS points to only a little significance of explanatory variables. New Trade Theory is important, however, the estimate does not show the expected sign. FE- and RE-estimators point to New Economic Geography being important in explaining agglomeration. Intermediate goods' intensity, however, is less important than in the case of industrial agglomeration. Heckscher-Ohlin theory is not important anyway. BE-estimates are not significant at all. A Hausman test pointed to preferring FE- over RE-estimates. Summarizing, intermediate goods intensity is only important for explaining within services' sectors variation in agglomeration and not across sectors. The positive sign for scale economies might indicate that intra-sectoral trade influences agglomeration tendencies for services. The reasoning behind is that in case of a heterogenous good increasing liberalization will make consumers getting access to a greater variety of products, intra-sectoral trade increases, economic structures across countries equalize.

TABLE 5

Panel unit root tests for services' agglomeration

test	*statistic*			
	variables			
	lngini	*lnfact*	*lnscale*	*lninterm*
Levin, Lin Chu	-2.7084***	-1.4575*	1.3016	1.3052
Breitung	1.14	-0.8115	1.7232	0.8567
Im, Pesaran, Shin	-1.6922**	-1.7413**	2.96	2.0622
ADF-Fisher-Chi-square	35.2456	43.7653**	15.9805	15.7504
PP-Fisher-Chi-square	28.2727	37.2823*	21.7274	15.8946

Source: Own calculations based on EU KLEMS data (2008).
Note: *** significant at 1% level, ** significant at 5% level, * significant at 10% level. Including individual effects and individual linear trends. Automatic selection of maximum lags. Automatic selection of lags based on SIC. Newey-West bandwidth selection using Bartlett kernel. Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution.

TABLE 6

Panel co-integration tests for services' agglomeration

test	*Panel v*	*Panel rho*	*Panel PP*	*Panel ADF*
	statistic			
Pedroni residual cointegration	-1.7726	3.2757	2.486	1.672
	weighted statistic			
Pedroni residual cointegration	-1.4444	2.5092	1.2285	0.4089

test	*Group rho*	*Group PP*	*Group ADF*	
	statistic			
Pedroni residual cointegration	3.5458	1.9721	0.9417	

test	*ADF*			
	statistic			
Kao residual cointegration	-3.6072***			

Source: Own calculations based on EU KLEMS data (2008).
Note: *** significant at 1% level, ** significant at 5% level, * significant at 10% level. Null hypothesis: no cointegration. Pedroni: Deterministic intercept and trend included, Kao: no deterministic trend. Pedroni: Automatic lag selection using SIC with a max lag of 7, Kao: automatic 1 lag by SIC with a max lag of 9. Newey-West bandwidth selection with Bartlett kernel.

Taking a look at unit root tests (see table 5), the Breitung test is the only test pointing to all of the four variables being non-stationary. As has been seen before, this test's results are most indicative for non-stationarity here. The logs of scale and interm are non-stationary most clearly, non-stationarity of *lngini* and *lnfact* is not so clear, however.

Conducting co-integration analysis (see table 6) shows that none of the Pedroni tests would suggest co-integration, whereas only the Kao test does. So, in the case of services sectors' agglomeration only with great caution on interpretation can a co-integration estimation be conducted. Running dynamic panel OLS delivered the following results:

$$lngini_{st} = -1.4324 + 0.014 * lnfact_{st} + 0.2394 * lnscale_{st} + 0.5308 * lninterm_{st} \quad (20)$$

with *lnscale*, *lninterm* and the constant being significant at the 5 % level, N=465, R^2 overall= 0.005, R^2 between= 0.000, R^2 within= 0.3. Lags and leads of order 1 of first differences of co-integrated explanatory variables were included.

Consequently, intermediate goods intensity and therewith New Economic Goegraphy's assumptions seem to be important in explaining services' agglomeration. The influence, however, is not as strong as has been the case for industrial agglomeration. Here, a 1 % change in intermediate goods' intensity increases services' agglomeration by 0.53 %. The coefficient for scale economies bears a positive sign indicating intra-sectoral trade to explain deagglomeration tendencies in services.

Sensitivity Analysis

To check for robustness of results the following analysis was conducted. In addition to the Gini coefficient, I calculated the Krugman (1991 a) index of concentration for measuring agglomeration. This index has been further elaborated by Midelfart-Knarvik *et al.* (2000) and is denoted as:

$$K_{it} = \sum_{c=1}^{C} \left| \frac{e_{ic,t}}{e_{i,t}} - \frac{1}{I-1} \sum_{i=1}^{I-1} \left(\frac{e_{ic,t}}{e_{i,t}} \right) \right| \qquad (21)$$

It measures the deviation of employment in industry i in country c as a share of employment of industry i in the EU from the mean of these employment shares for the other $(I-1)$ industries.[13] The same trends for agglomeration for both industries and services as in case of

[13] Formalizing this measure for services, the index s has to be substituted for i.

taking the Gini coefficient apply. Regression results taking the Krugman index can be found in the following table.

TABLE 7

Sensitivity analysis

	agglomeration	
	FE	*FE*
Dependent Variable	*Krugman-I industries*	*Krugman-I services*
lnfact	0.0012	0.0277
lnscale	0.0941*	0.2418**
lninterm	2.2022**	0.5081
const	-0.1152	-0.9723**
N	220	468
R^2 within	0.288	0.242
R^2 between	0.046	0.021
R^2 overall	0.05	0.041

Source: Own calculations based on EU KLEMS data (2008) and OECD STAN data.
Note: ** denotes significance at a 5 percent level, * denotes significance at a 10 percent level. Standard errors are robust.

As can be seen, robustness checks employing FE estimation give evidence for the high explanatory power of New Economic Geography for industrial agglomeration. For services' agglomeration, New Economic Geography does not seem to have any explanatory power. The coefficient for scale economies does not bear the expected sign. The positive sign might indicate intra-sectoral trade to be able to explain deagglomeration in the services sector.

V Conclusions

The aim of this study is to test for the relevance of Traditional Trade Theory, New Trade Theory and the New Economic Geography in explaining industrial and services sectors' agglomeration in the EU employing panel co-integration analysis. The analysis revealed non-stationarity of variables and co-integration relationships between agglomeration and further explanatory variables (although some of the relationships are not very strong). Taking account of co-integrating relationships between variables applying panel dynamic OLS regression I can show the importance of New Economic Geography for explaining both industrial and services sectors' agglomeration in the EU. However, intermediate goods' intensity is less important for services' agglomeration than is the case for industrial agglomeration.

Further, it could be shown that New Economic Geography's assumptions are best in explaining both within and across industry variation in industrial agglomeration. New Trade Theory is only able to explain across industry variation in industrial agglomeration. As concerns services sectors' agglomeration New Economic Geography is only important for within services sectors' variation. That means intermediate goods intensity matters for agglomeration of a given sector over time but not in explaining between services sectors' variation. This result, however, appears not to be robust. Regression results point to the fact that intra-sectoral trade can explain agglomeration tendencies in the services sector: through increasing liberalization and returns to scale sectors would become more deagglomerated.

Policy implications arise in the form that intermediate goods' intensity has been proven to be an important factor in influencing agglomeration of both industrial and services' localization. Making access to inputs or outputs between firms either more easy or more difficult, politics could to some extent manage agglomeration and specialization tendencies in the EU. This might be achieved through means of taxation or changing the infrastructure.

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Appendix

Industries included in analysis:

1.Food, beverages, tobacco; 2.Textiles, textile products; 3.Leather, footwear; 4.Wood, wood products; 5.Pulp, paper, paper products; 6.Printing, publishing; 7.Basic metals; 8.Fabricated metals; 9.Non-metallic mineral products; 10.Coke, refined petroleum, nuclear fuel; 11.Rubber, plastics, plastics products; 12.Machinery equipment; 13.Motor vehicles, trailers, semitrailers; 14.Other transport equipment; 15.Manufacturing nec. recycling; 16.Chemical industry; 17.Office, accounting, computing machines; 18.Electrical machinery apparatus; 19.Radio, TV, communication equipment; 20.Medical, precision, optical instruments

Services sectors included in analysis:

1.Sale, maintenance and repair of motor vehicles and motorcycles, retail sale of fuel; 2.Wholesale trade and commission trade, except of motor vehicles and motorcycles; 3.Retail trade, except of motor vehicles and motorcycles; repair of household goods; 4.Hotels and restaurants; 5.Other inland transport; 6.Other water transport; 7.Other air transport; 8.Other supporting and auxiliary transport activities, activities of travel agencies; 9.Post and telecommunications; 10.Financial intermediation, except insurance and pension funding; 11.Insurance and pension funding, except compulsory social security; 12.Activities related to financial intermediation; 13.Real estate activities; 14.Renting of machinery and equipment; 15.Computer and related activities; 16.Research and development; 17.Other business activities; 18.Public admin and defense, compulsory social security; 19.Education; 20.Health and social work; 21.Other community, social and personal services; 22.Private households with employed persons

Countries included in analysis:

Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, UK

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