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Trade Potentials in Gravity Panel Data Models

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Abstract

The paper shows how - using as an example the trade flows between eleven European countries and 31 OECD 'reporting' countries - the result of a gravity model, in terms of potential trade, changes substantially when country heterogeneity and dynamics are taken into account.

Comparing the in-sample trade potential index derived from various estimators yields three different results: (a) the average trade potential index poorly represents the distribution of yearly trade potentials; (b) the index converges towards the demarcation value corresponding to the equality between observed and predicted trade flows when country heterogeneity and dynamics are taken into account; (c) the sign of its yearly average is not the right statistic with which to determine the (in)existence of unrealized trade potentials.

Finally, the index derived from a dynamic specification with multilateral fixed-effects is better able to reflect the role played by the time-variant country-specific unobservable element associated with the possible presence of positive or negative trade potentials.

KEYWORDS: International bilateral trade, Gravity model, Trade potentials, Dynamic Panel Data, System-GMM estimator

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1 Introduction

In the past decade, empirical international trade economists have devoted much effort to explaining the bilateral volume of trade through estimation of a gravity equation (Disdier and Head, 2004). Reminiscent of Isaac Newton’s law of gravity, the trade version of the latter is a reduced form which comprises supply and demand factors (GDP or GNP and population) as well as trade resistance (geographical distance, as a proxy of transport costs and home bias) and trade preference factors (preferential trade agreements, common language and borders, common currency and common institutions).

Because of the model’s appeal as an empirical strategy, its application has gained great popularity. To quote Eichengreen and Irwin (1997), the gravity model is today “... the workhorse for empirical studies ...” in international trade. Since the early 1990s, the wide availability of the international data necessary to fill the standard specification of the model, its relative independence from (or ability to mirror) different theoretical models, and a bandwagoning effect have made the gravity model the empirical model of trade flows (Evenett and Keller, 2002; Feenstra, 2004).

A large proportion of the many studies using the gravity framework undertake the research or institutional task of predicting trade potentials.¹ These studies seek evidence of a trade enhancing effect of countries’ integration, their aim being to predict the additional bilateral trade to be expected if integration between two countries (or more than two countries) is fostered.²

As summarized by Egger (2002), two main strategies have been used to calculate trade potentials. The first derives out-of-sample trade potential estimates (Wang and Winters, 1992; Hamilton and Winters, 1992; Brulhart and Kelly, 1999): that is, the parameters for highly integrated countries are estimated by a gravity model, and then the same coefficients are applied

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¹ The UNCTAD-WTO International Trade Centre (ITC) has recently developed a gravity model called TradeSim (International Trade Center, 2003) with the main objective of estimating bilateral trade flows between Developing Countries and any of their partner countries. The purpose of the model is to support country member institutions, trade representatives and international institutions in assessing the actual trade potentials of countries with limited trade relations in the past. For example, a previous version of TradeSim has been used by UNCTAD to estimate the impact of infrastructure on trade for several African countries (UNCTAD, 1999).

² A different use of the gravity equation has been proposed by the U.S. Trade Commission (Rivera, 2003) for quantification of the trade effects of liberalization.
to project ‘natural’ trade relations between these benchmark countries and
countries starting to integrate.\(^3\) The difference between the observed and
predicted trade flows should represent the unexhausted trade potential. The
second strategy derives \textit{in-sample} trade potential estimates (Baldwin, 1994;
Nilsson, 2000; Martinez-Zarzoso and Nowak-Lehemann, 2003): that is, the
latter group of countries is directly included in the regression analysis, and the
residuals of the estimated equation should represent the difference between
potential and actual trade relations.

In spite of the strategy used, there is a widespread tendency to draw
strong conclusions from the sign of the difference between potential and ef-
fective trade flows. One frequently comes across assertions like the following
in the literature: “...[when] two countries trade currently much more than
the gravity models predicts ... there is a very successful bilateral partner-
ship .... When the two countries trade much less than in theory ... there
seems to be an untapped trade potential (International Trade Center, 2003)”.

The policy implications associated with the finding of a negative sign in
the difference between effective and potential trade (untapped trade poten-
tial) range from the need for country specific export promotion and broader
bilateral integration to the need to anticipate major distribution changes
caused by the expansion of bilateral trade flows in the near future.\(^4\) A pos-
itive sign in the difference between effective and potential trade (successful
partnership) generates different policy recommendations: trade has reached
its potential level and no social cost can be expected from future integration.
Our suggestion is that these advises should be taken with a grain of salt when
they are based on \textit{average estimates}, and if the magnitude and, especially,
the sign of the difference between effective and potential trade is not robust
when country-heterogeneity and dynamics are controlled for.

In this paper we calculate trade potentials using an \textit{in-sample} approach.

\(^3\) Classic applications are the case of EU enlargement to Central and Eastern European
Countries (CEECs), the Mercosur and the NAFTA. See Greenaway and Milner (2002) for
a good survey of the topic.

\(^4\) For instance, in the case of the EU-CEECs literature - (Wang and Winters, 1992;
Hamilton and Winters, 1992; Baldwin, 1994; Gros and Gonciarz, 1996; Brenton and Di
Mauro, 1999; Nilsson, 2000) – the finding that the actual level of EU-CEECs trade had
reached its potential level gave rise to declarations that the expected effects of further EU
enlargement to the East would be modest, in terms of both adjustment costs and expected
relevant, natural, and potentially destructive remark that any large systematic difference between the observed and the in-sample predicted trade flows only indicates problems of misspecification in the econometric model. A large trade potential revealed by the residuals of the estimated equation is just the mirror-image of the model’s misspecification.

One could take Egger’s remark a step further by applying it to the out-of-sample strategy. In this case too, if the estimate of bilateral trade flows between the group of countries taken as benchmark is misspecified the bias is transmitted to the projection of the ‘natural’ bilateral trade flows of the targeted countries. Neither of the two strategies used to quantify trade potentials can therefore be considered immune from the eventuality of serious bias if the equation regressed is not properly specified.

In this paper we start from Egger’s remark and verify whether the magnitude and the sign of the difference between effective and potential trade is robust to various estimators used to deal with misspecification issues.

We consider the kind of misspecification related to country heterogeneity and to dynamics. We will therefore disregard the possible specification problems arising from the exclusion or inclusion of specific covariates, since the correct selection of these should be indicated by the theoretical model producing the gravity reduced form to be estimated, an issue already discussed by several other studies (Evenett and Keller, 2002; Anderson and van Wincoop, 2003; Feenstra, 2004). While the heterogeneity bias is controlled through the use of fixed-effects, the dynamic model we consider is different from the one suggested by Egger (2002): we explicitly included a lagged dependent variable in the specification (Hendry, 1995).

As regards the potentially destructive aspect of Egger’s remark, we do not take it to the extreme of asserting that the evidence itself of trade potentials is merely the consequence of a wrong specification of the econometric model: the true trade potential is null, on average. Our view is slightly different. We consider trade potential to be a unobservable element which is country-specific but not time invariant and which may affect bilateral trade flows together with covariates. It is generally hidden in the residuals and cannot be eliminated by fixed-effects. In other words, a certain degree of misspecifi-

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5 Neither in Egger (2002) do trade potentials entirely vanish, however. Although the estimates are greatly reduced in size when the first-order autocorrelation Hausman-Taylor estimator is used instead of a Random-Effects, or a Between, or a simple Hausman-Taylor estimator, they do not entirely disappear.
cation is inherent to the treatment of potentialities (i.e. market potentials). To tackle this issue, our analysis will reduce misspecification by taking account of both country-heterogeneity and dynamics, using the system-GMM estimator proposed by Arellano and Bover (1995) for the purpose.

To summarize, the very existence and the quantification of potential trade may be inflated by problems of misspecification in the regression. Careful analysis of the specification is therefore needed if proper assessment is to be made of the presence and magnitude of bilateral trade potentials.

The rest of the paper is organized as follows. After a description of the dataset and of the trade potential index, Section 2 presents the three models used in the analysis: a traditional static OLS regression (Section 2.1), a fixed-effects regression (Section 2.2) and a dynamic specification of the latter (Section 2.3). These regressions are applied to bilateral trade flows of 11 European countries in the euro-zone. Since the dynamic specification has not been frequently used in gravity panel data, space is devoted to its theoretical justification, to description of the econometric methodology, and to its appropriateness in our specific contest. Section 3 consists of a comparison and a visual description of the results. Section 4 concludes.

2 Three panel gravity estimators for European Countries exports

In this section we climb the staircase of panel data specifications of the gravity model, starting from a static linear equation, then moving to a static linear equation with fixed-effects, and finally examining a dynamic linear system with fixed-effects.

We estimated the same functional form for eleven European countries pooled together, using all three different estimators. We therefore disregarded any specification issue concerning an individual country, our emphasis being, not on misspecification due to the omission of specific covariates, but on misspecification associated with country heterogeneity and to dynamics.

The choice of the covariates is also of limited relevance. We selected the functional form used most frequently in the empirical trade literature for no particular reason apart from the fact that it is the mode in the meta-distribution ranging from the Zen functional form of Disdier and Head (2004) to the Baroque functional form of Rose and van Wincoop (2001). As far as
we are concerned, any other functional form would have served equally well.

Finally, although we estimated each functional form by pooling the eleven exporting countries together, we derived and visualized trade potentials for individual countries. Since this visual analysis serves purely the purpose of exemplification, we apply it only to France, Germany, Italy, Ireland, and Spain.\(^6\)

2.1 The model, the dataset and the trade potential index

Whilst early empirical studies used cross-section data to estimate a gravity model, in more recent years researchers have relied on panel data (Baldwin, 1994; Gros and Gonciarz, 1996; Brenton and Di Mauro, 1999; Egger, 2000; Nilsson, 2000). In general, both kinds of analysis are static and they refer to long run relationships.

On the basis of this traditional gravity approach, we started by estimating an equation of bilateral exports of goods and services in a static panel form. We considered eleven former European exporter countries (Austria, Belgium, Luxemburg, Finland, France, Germany, Italy, Ireland, the Netherlands, Spain, Portugal; considering Belgium and Luxemburg as a single unit) and 32 importer countries (the eleven European countries previously indicated plus 21 other countries: Argentina, Australia, Brazil, Canada, China, Czech Republic, Denmark, Korea, Hong Kong, Hungary, Japan, Mexico, Norway, Poland, Romania, Russia, Sweden, Switzerland, Turkey, United Kingdom, United States). The period considered is 1991-2000.

The estimated equation was

\[
\begin{align*}
    x_{ijt} &= y_{ijt}\beta + z_{ij}\gamma + u_{ijt} = h_{ijt}\delta + u_{ijt} \\
    \text{where} & \\
    u_{ijt} &= \alpha + \epsilon_{ijt} \\
    h_{ijt} &= [y_{ijt}, z_{ij}] \\
    \delta &= [\beta', \gamma'].
\end{align*}
\]

\(^6\) Pooling all the data together increases the efficiency of the estimates and allows consideration to be made of trade potentials in a multilateral context, at the cost, however, of focusing on average EU values rather than specific country values. Visual treatments for single country regressions are available on request or can be found in the working paper version of this article (De Benedictis and Vicarelli, 2004).
where $i \neq j = 1, 2, \ldots, 31$ are the destination countries, and $j = 1, 2, \ldots, 11$ are the exporting countries; $t = 1991, \ldots, 2000$ is the time span; $x_{ijt}$ is the natural logarithm of exports; $y_{ijt}$ is a vector of time-varying regressors, including the natural logarithm of the gross domestic product of country $i$ and of country $j$ and a trade agreement dummy taking value 1 when there is a trade agreement between the exporter and the partner country, 0 otherwise; $z_{ij}$ is a vector of time invariant regressors, including the natural logarithm of the distance in Km between the capital cities of the exporter and destination countries, and a border dummy that takes value 1 if the exporter and the partner country share a common border. $\epsilon_{ijt} \sim i.i.d.(0, \sigma_\epsilon^2)$.

Exports are in dollar terms, and current prices (source: IMF Direction of Trade statistics) are deflated by export deflators (source: Economist Intelligence Unit). GDP data are in US dollars at 1996 prices (source: Economist Intelligence Unit); distance measures are taken from Brenton-Di Mauro’s database (Brenton and Di Mauro, 1999); the trade agreement dummy is built on the basis of information obtained from the WTO Trade Policy Review.

In accordance with the gravity approach, export flows were expected to be positively influenced by: (1) the size and the demand of the home and the host market (proxied by GDP), (2) the presence of trade agreements, (3) geographical closeness (proxied by the presence of a land or sea border). On the other hand, bilateral exports flows were expected to be negatively correlated with the geographical distance of the host’s market, a proxy of trade costs, home bias and time and search costs (Disdier and Head, 2004).

We estimated this equation using a simple OLS estimator with a White heteroskedasticity correction. The estimated coefficients - contained in the first column of Table 1 - were statistically significant and the signs were the expected ones.

We used the estimated coefficient to calculate an in-sample trade potential index, $x_{ijt}^p$:

$$x_{ijt}^p = \frac{e^{x_{ijt}}}{\hat{e}_{ijt}}$$

where $x_{ijt}$ are the effective export flows from exporter country $j$ to partner country $i$, and $\hat{e}_{ijt}$ are the fitted export flows generated by the gravity equation.

We then standardized $x_{ijt}^p$ so that the index would take values between
\[-1, 1\],

\[
S x_{ijt}^p = \frac{x_{ijt}^p - 1}{x_{ijt}^p + 1}
\]

A positive index value \((0, 1]\) shows greater bilateral effective trade than predicted by the model; negative values \([-1, 0)\) show the opposite. The zero represents the demarcation value where neither positive nor negative trade potentials are shown.

The characteristics of the distribution of the bilateral potential trade calculated by estimating equation (1) are depicted for each of the five European countries in the corresponding rows \(s\) in figures 1-5. We will describe the figures and comment on the resulting \(S x_{ijt}^p\) of different specifications all together.

### 2.2 Fixed effects

Adopting a common procedure, the first element that we added to equation (1) consisted in time invariant country-specific effects.

There are good reasons for arguing that country-specific fixed effects are relevant when export or import effects or ‘environmental’ determinants that may drive or hamper trade flows (geographical, political or historical determinants) are present. These factors are deterministically linked with a country’s specific characteristics and cannot be considered as random.\(^7\) Moreover, a fixed effect (within) estimator - including all the country-specific characteristics in a constant term – avoids misspecification problems due to omitted variables that should be included in \(z_{ij}\).\(^8\)

Indeed, consideration of bilateral fixed effects yields a version of the gravity equation that can be viewed as a reduced form of a model of trade with

\(^7\) From an econometric point of view, fixed-effects and random-effects can be selected by running a Haussman test. Several empirical analyses of bilateral trade have shown that the fixed effects methodology is preferable to random effects models (Egger, 2002). See also Baldwin (1994) and Matyas (1997, 1998) for a description of further advantages of this methodology.

\(^8\) A well known problem for studies adopting gravity equations is the measurement of geographical distance. If distance reflects comparative advantages related to geography (Melitz, 2001), it is not clear which sign can be expected, because an increase in distance may increase, not decrease, trade if differences in comparative advantage prevail. A fixed-effect estimation bypasses this problem by including distance in bilateral constant terms.
solid microfoundations. In particular, on introducing the notion of a multilateral ‘trade resistance index’, Anderson and van Wincoop (2003) have correctly pointed out that trade between a pair of countries depends on their bilateral trade barriers with all trade partners; trade will be greater for those countries with relatively low trade barriers. Following Rose and van Wincoop (2001), we approximated the multilateral ‘trade resistance index’ using country-pair fixed effects, $\alpha_{ij}$.

Taking these considerations into account, we estimated our equation using a within estimator, i.e. a data panel with fixed effects which included specific regression constants for the observations on different home and host markets, $\alpha_j$ and $\alpha_i$.

The equation was now

$$x_{ijt} = y_{ijt}\beta + u_{ijt}$$

where

$$u_{ijt} = \alpha_i + \alpha_j + \alpha_{ij} + \epsilon_{ijt}$$

where $\alpha_i$ are unobserved time invariant importer country-level effects, $\alpha_j$ are unobserved time invariant exporter country-level effects, $\alpha_{ij}$ are unobserved time invariant bilateral country-pair effects and the error term $\epsilon_{ijt}$ is independently, identically distributed over $i$ and $t$, with mean zero and variance $\sigma^2$.

All time invariant terms in equation (2) were dropped and included in $\alpha$. The estimated coefficients were again statistically significant and the signs were the expected ones (see Table 1). In this case, too, the results were used to derive the $Sx_{ijt}^p$. They are depicted in figures 1-5 in rows denominated $f$.

### 2.3 Dynamics, persistence, and fixed effect

The recent theoretical literature on international trade with heterogeneous firms (Bernard et al., 2003; Melitz, 2003; Antràs, 2003; Helpman et al., 2004) has been largely based on evidence that there is a large degree of heterogeneity in productivity and in involvement in international transactions among firms in the same sector. In particular, there is now substantial evidence that the level of productivity of exporting firms is generally higher than that of non-exporting firms. The explanation lies in a self-selection mechanism which operates through sunk costs associated with entry into foreign markets (Roberts and Tybout, 1997; Eichengreen and Irwin, 1997).
The existence of sunk costs borne by exporters to set up distribution and service networks in the partner country may generate inertia in bilateral trade flows, and countries trading with each other at time \( t \) will tend to continue doing so at time \( t + 1 \).

This sticky behavior seems all the more important in the EMU case, where trade relationships between countries are affected not only by past investments in export-oriented infrastructure, but also by the accumulation of invisible assets such as political, cultural and geographical factors characterizing the area and influencing the commercial transactions taking place within it.

It is worth noting that, notwithstanding the general importance of this ‘persistence effect’, quite a few studies based on a panel estimation of gravity equations have considered the possibility of controlling for them through a dynamic specification of the regression (Egger, 2001; De Grauwe and Skudelny, 2000; Bun and Klaassen, 2002; de Nardis and Vicarelli, 2003).

### 2.3.1 A reminder on Dynamic Panel Data Analysis

One possible reason is that introducing dynamics into a panel data model raises serious econometric problems due to the inconsistency of the estimators (Baltagi, 2001). If trade is a static process, the within estimator is consistent for a finite time dimension \( T \) and an infinite number of country-pairs \( N \). But if trade is a dynamic process, the estimate of a dynamic panel like our static model (1) with the inclusion of a lagged dependent variable \( y_{it-1} \) is more complex.\(^9\) If country specific effects are not observed, they are included in the error term, as in equation (2). Insertion of the lagged dependent

\[^9\] Some authors propose that dynamics should be introduced into a static regression via an autoregressive error term. This is a slight variation of the model presented in equation (1):

\[
x_{ijt} = y_{ijt} \delta + z_{ij} \gamma + u_{ijt} = h_{ijt} \delta + u_{ijt}
\]

\[
u_{ijt} = \alpha + \rho u_{it-1} + \epsilon_{ijt} \quad \text{with } |\rho| < 1
\]

and is precisely the model estimated in Egger (2002).

Since the above model can also be written as an auto-regressive distributed-lag model:

\[x_{ijt} = \alpha (1 - \rho) + h_{ijt} \delta + h_{it-1} \delta \rho + y_{it-1} \rho + \epsilon_{ijt}\]

particular attention should be given to interpretation of the coefficients.
variable on the right hand side of the equation leads to correlation between the lagged dependent variable and the error term that (for a finite $T$ and an infinite $N$) renders the least square estimator biased and inconsistent.

If the time dimension $T$ is fixed, the transformation needed to eliminate the country-pair fixed effects cannot resolve the problem: the LS estimator will again produce biased and inconsistent results because the correlation between the transformed lagged dependent variable and the error term will not tend to zero even if the cross section dimension $N$ increases. A within estimator applied to a first order autoregressive model yields consistent estimates only when the number of time periods $T$ is large (Nickell, 1981).\footnote{10 If $T$ is large a LS estimator may be the best choice also as regards reducing the bias of estimates (Bun and Klaassen, 2002). In this respect, Kiviet (1995) shows how the bias of a LSDV estimator can be corrected in balanced panel data.}

In order to tackle this problem, Arellano and Bond (1991) refined a two steps procedure based on differencing and instrumenting, a strategy originally proposed by Anderson and Hsiao (1981). The first step of the procedure consists in differencing the equation in order to remove the fixed effects. Since the transformed error term is now contemporary correlated with $y_{it-1}$ the estimates will still be inconsistent. Hence, in the second step Anderson and Hsiao suggested that either the two period lagged difference or the two period lagged level of dependent variable could be used as instrument for $y_{it-1}$ because both are correlated with the latter term while they are uncorrelated with $\Delta \epsilon_{ijt}$; both instruments will yield a consistent estimator. Arellano and Bond (1991) took up this idea to suggest that significant efficiency gains may be obtained by using the Hansen two-step generalized method of moments (GMM) estimator. They identified how many lags of the dependent variable and of the pre-determined variables were valid instruments and how these lagged levels could be combined with first differences of the strictly exogenous variables to form a potentially very large instrument matrix.

### 2.3.2 Dynamics, time-invariance, the system GMM estimator

In the case of the gravity model, however, the proposed strategy is not without its costs. On the one hand, first-differencing the equation removes fixed effects but also the time invariant regressors $z_{it}$ in the specification. If those regressors are of interest, the resulting loss of information may be a serious inconvenience. On the other hand, the first-differenced GMM estimator per-
forms poorly in terms of precision if it is applied to short panels (along the $T$ dimension) including highly persistent time series (Blundell and Bond, 1998). Lagged levels of time series with near unit root properties are in fact weak instruments for subsequent first-differences. Since bilateral exports between industrialized countries are expected to change sluggishly, due to sunk costs, one may expect this to affect the estimates.

Arellano and Bover (1995) describe how, if the original equations in levels are added to the system of first-differenced equations, giving rise to a system-GMM estimator, additional moment conditions can be brought to bear in increasing efficiency. They show how the two key properties of first differencing - it eliminates the time-invariant individual effects while not introducing disturbances for periods earlier than period $t-1$ into the transformed error term - can be obtained using any alternative transformation (i.e. forward orthogonal deviations).\footnote{Blundell and Bond (1998) set out the assumptions necessary for this system-GMM estimator more precisely and tested it with Monte Carlo simulations. Bond (2002) is a good introduction to these estimators and their use.}

We have already stressed the importance of country heterogeneity, and we wanted to consider it explicitly in a dynamic framework as well. Using the system-GMM estimator first-difference equations and level equations are considered. Our set of bilateral time-invariant dummies thus remained in the level regression describing all the time-independent influences that affect trade between any two countries, like the cultural, social and political factors that could not be included in the ‘persistence effect’ picked up by the coefficient of the lagged dependent variable.

The estimated equation took the form:

\[
x_{ijt} = y_{ijt}\beta + z_{ijt}\gamma + y_{it-1}\rho + u_{ijt} = h_{ijt}\delta + y_{it-1}\rho + u_{ijt} = \alpha_i + \alpha_j + \alpha_{ij} + \epsilon_{ijt}
\]

where geographical distance and the border-effect, both included in $z_{ijt}$, are strictly exogenous covariates, $y_{it-n}$ is endogenous, and GDP and regional agreements, included in $y_{ijt}$, are predetermined.
3 Results

Equations (1), (2) and (3) were estimated using respectively a simple OLS estimator, the within estimator, and the system-GMM discussed previously. The results in Table 1 do not greatly differ from those expected: generally all the covariates are statistically significant, signs are correct, and the fit of the regressions is usually high. Since our focus is not on parameters estimate but on the resulting trade potentials $S_{ijt}$, we do not discuss any single result but concentrate on how the $S_{ijt}$ varies with the change in the estimator used.

Figures 1-5 plot the distribution of the $S_{ijt}$ index computed on the basis of each version of the gravity equation considered (s means ‘static’ and refers to equation (1); f means ‘static with fixed effects’ and refers to equation (2); and d means ‘dynamic with fixed effects’ and refers to equation (3)). For each year in the time span we calculated the ratio between effective export flows and fitted export flows and then standardized it. The resulting $S_{ijt}$ index is the vector of those yearly values. Although the index may take values between [-1,1], for visual purposes the interval shown in figures 1-5 has been restricted to [-0.4,0.4].

Each figure depicts the $S_{ijt}$ index of each of the five European countries considered with respect to its 31 partners. Partner countries are ordered alphabetically from left to right, and shown in each panel is the distribution of the $S_{ijt}$ index obtained through the three panel gravity estimators. The characteristics of each distribution are visualized by means of boxplots. The right and left ends of each box plotted along the line drawn in correspondence to the labels indicating the different estimators are the upper and the lower quartiles of the distribution of the respective $S_{ijt}$. The horizontal

\[\text{[12] Most of the yearly values of } S_{ijt}^{p} \text{ are in fact between -0.3 and 0.3. Only in some specific cases has the decision to restrict the visual interval been costly: in Figure 1 the values of } S_{ijt}^{p} \text{ resulting from the static estimator were all above 0.4 in the case of Hong Kong, indicating that effective export flows were substantially larger than predicted by the model. In the same figure, some effective bilateral exports with Norway were largely below the level predicted by the static model, resulting in } S_{ijt}^{p} \text{ values below -0.4. Similar cases are not frequent (Austria, Belgium, Denmark, Germany, Hong Kong, the Netherlands, Norway, Russia, and the UK in Figure 2; Australia, Hong Kong, and Turkey in Figure 3; Argentina, Canada, Japan, Romania, Russia, and Switzerland in Figure 4; Australia, Belgium, China, Germany, Hong Kong, Hungary, Japan, the Netherlands, Sweden, the UK, and the US in Figure 5), and they all concern trade potentials resulting from the static estimator.}\]
Table 1: Estimates results, 11 Eurozone Countries Export Flows

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model (1) OLS</th>
<th>Model (2) Within</th>
<th>Model (3) System-GMM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagged endogenous variable</td>
<td></td>
<td></td>
<td>0.528 *** (0.151)</td>
</tr>
<tr>
<td>Importer’s GDP</td>
<td>0.814 *** (0.013)</td>
<td>1.134 *** (0.069)</td>
<td>0.572 *** (0.186)</td>
</tr>
<tr>
<td>Exporter’s GDP</td>
<td>0.960 *** (0.013)</td>
<td>1.931 *** (0.077)</td>
<td>1.207 *** (0.354)</td>
</tr>
<tr>
<td>Border Dummy</td>
<td>0.350 *** (0.063)</td>
<td>-0.502</td>
<td>(0.100)</td>
</tr>
<tr>
<td>Geographical distance</td>
<td>-0.783 *** (0.023)</td>
<td>-1.340 *** (0.28)</td>
<td></td>
</tr>
<tr>
<td>Free trade agreements</td>
<td>0.240 *** (0.044)</td>
<td>0.148 *** (0.024)</td>
<td>-0.001 (0.027)</td>
</tr>
<tr>
<td>$\alpha_i$ and $\alpha_j$</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>$\alpha_{ij}$</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>-2.150 *** (0.222)</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

| obs.                       | 3347          | 3347            | 2994                 |
| groups                     | 341           | 341             | 341                  |
| Adj. $R^2$                 | 0.782         |                 |                      |
| $R^2$ Within               |              | 0.5015          |                      |
| Sargan test                |               |                 | $Pr > \chi^2$=0.101  |
| A.B. AR(1) test            |               |                 | $Pr > z$=0.000       |
| A.B. AR(2) test            |               |                 | $Pr > z$=0.387       |

**Note:** Standard errors in brackets (***) significant at 1 per cent; (**) significant at 5 per cent; (*) significant at 10 per cent. *yes* means the inclusion of specific country dummies. In model (2) the constant term is an average bilateral constant term (not reported). We used all variables as instruments in model (3): for the equation in levels we used (differenced) instruments lagged by 2 periods, and for the equation in differences we used (level) instruments lagged by 2 periods. The system-GMM estimator used in the analysis is the one implemented in Stata 8 in the xtabond2 routine.
Figure 1: Visual summary of the $Sx_{ij}^p$ distributions: Italy
Figure 2: Visual summary of the $S_{ijt}$ distributions: France
Figure 3: Visual summary of the $S_{X_{ijt}}^p$ distributions: Germany

<table>
<thead>
<tr>
<th>Argentina</th>
<th>Australia</th>
<th>Austria</th>
<th>Belgium</th>
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<tr>
<td>Brasil</td>
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<td>France</td>
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<tr>
<td>Turkey</td>
<td>UnitedKingdom</td>
<td>UnitedStates</td>
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</tbody>
</table>

Standardized Trade Potentials – Germany
Figure 4: Visual summary of the $S_{x_{ijt}}$ distributions: Spain
Figure 5: Visual summary of the $Sx_{ijt}^P$ distributions: Ireland
size of the box is therefore the interquartile range and is a measure of the spread of the distribution. The red bullet is the median of the yearly values of $Sx_{ijt}$ and indicates the location of the distribution. If the interquartile range is small the distribution is closely concentrated around the mean; if the interquartile range is large the distribution is less concentrated and the yearly values of $Sx_{ijt}$ spread out far from the median. The relative distances of the right and the left quartile from the mean indicate the shape of the distribution. If one distance is much bigger than the other, the distribution is skewed. The whiskers encode the adjacent values; the adjacent value on the left - identified by the the vertical spike - is the lowest observation that is greater than or equal to the lower quartile plus 1.5 times the interquartile range; the adjacent value on the right is the higher observation that is smaller than or equal to the upper quartile minus 1.5 times the interquartile range. The observations outside the adjacent values are plotted individually (white bullets) and provide information on the presence of outliers and on the characteristics of the tails of the distribution.

The first information that can be extracted from Figures 1-5 is that the yearly values of $Sx_{ijt}$ frequently shift in sign along the time path, regardless of the estimator used. Cases where all the values in the distribution are markedly positive or negative are extremely rare.

Secondly, the distribution of the yearly values of $Sx_{ijt}$ is in general asymmetric. The degree of skewness decreases with the use of fixed-effects, but still remains substantial, which casts doubts on whether the mean is the most appropriate statistic for the location of the distribution. Since average trade potential is generally used as the indicator of a successful partnership, or instead of untapped trade potential, it would be better to use a more robust statistic, like the median. It seems, however, more convenient not to rely on measures of the location of the distribution of $Sx_{ijt}$, but rather to observe the variation of $Sx_{ijt}$ along its time dimension, as in Figures 6-10.

As regards the different estimators used, as one moves from (s) to (f), and from (f) to (d), the fit of the regression improves. This is evidenced by the change in $Sx_{ijt}$: since the $Sx_{ijt}$ index is built on the residuals of the regression, its absolute value is smaller, the lower the missfit of the regression and the standard error of the regression.

Figures 1-5 show that $Sx_{ijt}$ changes with respect to the choice of estimator. Indeed, starting from (s) and moving to models that include fixed-effects (either f or d), the index values show a clear path of ‘convergence’ toward
the demarcation value depicted by the vertical line in correspondence to the zero value: a downward ‘convergence’ if the starting value of the index (the value of $S_{x_{ijt}}$ generated by (s)) is positive, an upward ‘convergence’ if the value of $S_{x_{ijt}}$ is negative.

Furthermore, the dynamic specification of the model reduces the dispersion of potential trade index around the center of the distribution: the interquartile range of the $S_{x_{ijt}}$ index - calculated for each of the 5 European countries with respect to its 31 host markets – generally decreases as one moves from (s) to (d) for each exporter country considered, and it converges towards the demarcation value.

When country heterogeneity and dynamics are considered, there are fewer cases of systematic untapped trade potentials or successful partnerships (where the yearly values of the distribution are concentrated around the median and its sign is robust to the change in estimator).

In order to visualize the variation of $S_{x_{ijt}}$ along the time dimension, we plotted in Figures 6-10, for every partner-country, the yearly values of the $S_{x_{ijt}}$ index obtained with the three estimators. The single values are depicted by green bullets, •, red bullets, •, and black bullets, •: as in the previous figures, these refer to the estimators (s), (f), and (d) in equations (1), (2), and (3).

Figures 6 - 10 convey various items of significant information. The first, which was also evident in Figures 1 - 5, is that the static estimator (s) inflates the value of $S_{x_{ijt}}$, systematically overestimating or underestimating trade potentials and their persistence over time: green bullets are generally below or above the demarcation value, indicating iterated untapped trade potentials or stable trade partnerships.

The second piece of information is that fixed-effects estimators (f and d) yield similar results in terms of $S_{x_{ijt}}$. The difference between the two is evident only in cases of very dynamic countries, such as the transition economies (the Czech Republic, Hungary, and Poland) or newly industrialized countries (China and Korea), or rapidly evolving bilateral trade relationships, such that between the EU and the UK. In all these cases also the within estimator (f) inflates the value of $S_{x_{ijt}}$. 13

13 The difference between the values of $S_{x_{ijt}}$ associated with model (2) and (3) in Table 1, depends on $\hat{x}_{ijt}$. The absence of the lagged dependent variable in equation (2) reduces the estimated value of $x_{ijt}$ obtained from the regression on pooled data, magnifying the effect of changes in $x_{ijt}$ in more dynamic countries.
Figure 6: Dynamics of the yearly $S_{\text{ytt}}$: Italy
Figure 7: Dynamics of the yearly $S_{ijt}^P$: France
Figure 8: Dynamics of the yearly $Sx_{jt}$: Germany
Figure 9: Dynamics of the yearly $S_{ijt}^P$: Spain
Figure 10: Dynamics of the yearly $S_{ijt}^P$: Ireland
The most notable result obtained using the system-GMM estimator is the absence of any systematic difference between realized and predicted exports for the EU15 European countries in recent years. The values of $Sx_{ijt}$, in fact, are very close to the demarcation value. The only noticeable general exception is the UK. In all the five cases examined the UK moved progressively from a negative to a positive value of the Index, indicating that bilateral export flows are becoming greater than predicted by the model. The other case is Ireland, where as can be seen in Figure 10, untapped potentials emerged at the end of the 1990s with Denmark, France, Germany, the Netherlands, Norway, and Portugal, while the opposite happened with the UK.

The other information concerns the bilateral flows of new members of the EU. There is no systematic evidence of persistent unexplored trade potentials. Some interesting episodes are Romania in the case of Italy, and Hungary for Germany. In the former, potential trade was absorbed during the final years of the 1990s; in the latter $Sx_{ijt}$, it did not substantially shift from the demarcation value.

In the remaining cases, there are only few episodes where the evolution of $Sx_{ijt}$ indicates the emergence or the exhaustion of untapped trade potentials: this is the case of Argentina and China for Italy; Brazil and Poland for France; China and the US for Germany; Argentina and China for Spain; Argentina, Canada, Hungary and Russia for Ireland.

In general, episodes characterized by yearly values of $Sx_{ijt}$ systematically below zero are relatively few in number, a finding which contradicts the many exaggerated reports on trade potentials. However, these cases cannot be treated as merely irrelevant: rather, they call for a theoretical explanation which defines the meaning itself of trade potential. Promising lines of future research are those which consider trade potentials as specific elements of market potentials in a spatial framework.

4 Conclusions

The paper has shown that the result of a gravity model in terms of a potential trade index changes when country fixed-effects and dynamics are considered.

There are two main findings from the analysis. First, when a gravity equation is estimated by means of a dynamic estimator instead of a static one,
generally better results are obtained in terms of standard error of regression: the fitted values are closer to the historical values. The dynamic specification of the model reduces the dispersion around $Sx_{ijt}^\psi$: the interquartile range of the index decreases from (s) to (d), converging towards the demarcation value.

Secondly, reducing misspecification via a specification that considers both country-heterogeneity and dynamics has evidenced that: (a) the average trade potential index poorly represents the distribution of yearly trade potentials; (b) the $Sx_{ijt}^\psi$ Index converges towards the demarcation value corresponding to the equality between observed and predicted trade flows; (c) the sign of the index, or even measures of location or of dispersion of the distribution of its yearly values, are not the right statistics with which to determine the (in)existence of unrealized trade potentials. Trade potentials are dynamic, they change over time, they emerge, evolve and disappear, or they give rise to successful bilateral trade relations which remain stable with the passage of time. Cases in which trade potentials between two countries emerge or are rapidly exhausted are more clearly identifiable only if $Sx_{ijt}^\psi$ is observed along its time dimension.

In any case, it would be imprudent to draw any implications in terms of trade policy if the evidence of systematic untapped trade potential or successful partnership is not observed over time.

Finally, the $Sx_{ijt}^\psi$ derived from a dynamic specification with fixed-effects gives the analyst more reliable evidence that the systematic difference between actual and fitted bilateral trade is not just the result of the poor specification of the model, but is also the result of the time-variant country-specific unobservable element hidden in the residuals and which gives rise to positive or negative trade potentials.
References


