DUMMIES FOR POLICIES OR POLICIES FOR DUMMIES? A MONTECARLO-GRAVITY EXPERIMENT.

Maria Cipollina*, Luca De Benedictis**, Luca Salvatici***, Claudio Vicarelli****

Abstract

The use of the gravity model to evaluate the effect of policies in a cross-country framework is largely predominant in the international economics empirical literature. This literature usually implements importer and exporter fixed effects to account for the theoretical Multilateral Trade Resistances, since it is a computationally easier approach. Moreover, the country's adoption of specific policies can be also approximated through the use of dummy variables. This paper argues that the identification of trade policy effects using a gravity equation that includes fixed effects to control for the multilateral price terms is severely limited. Using a Monte Carlo-Gravity experiment the hypothesis we want to test is the following: the more we control for heterogeneity, the less we are able to capture the policy effect of interest, because this latter would be captured by the full set of interactions terms.

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JEL Classification: C13, C14, F10, F43

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1. Introduction

The gravity model is nowadays the main empirical strategy to evaluate bilateral trade flows and to assess the effect of specific countries’ policies in a cross-country context (Evenett and Keller, 2002; Feenstra, 2004). It can be derived from different theoretical models – from comparative advantage theory (Deardorff, 1998) to heterogeneous firms models (Chaney, 2008) – and it can be applied to largely available datasets and offers the advantage of a large community of users that in the last ten years or so have discussed at length the pros and cons of estimators, data characteristics, and common mistakes (De Benedictis and Taglioni, 2011).

Some results have become fundamental benchmarks, necessary to confront with, and some papers have become sound milestones to depart from for further explorations. The literature still offer interesting “puzzles” and challenges that stimulate and encourage further research.

The standard formulation of the gravity equation posits a positive between trade and national incomes, and a negative one between trade and distance. One of the most widely cited theoretically grounded gravity model (Anderson and van Wincoop, 2003) shows that the typical gravity equation should account for the so-called “multilateral resistance” term, since what really matter are relative (rather than absolute) bilateral trade costs. An omission of this term may lead to inconsistent estimates. However, exporter’s market openness and, even more so, importer’s CES price index are difficult to construct. The literature usually implements importer and exporter fixed effects to account for the theoretical Multilateral Trade Resistances, since it is a computationally easier approach.

The country’s adoption of specific policies is often approximated through the use of dummy variables. This paper argues that the identification of trade policy effects using a gravity equation that includes fixed effects to control for the multilateral price terms is severely limited.

The gravity equation is characterized by remarkable country, as well as product if estimated at a disaggregated level, heterogeneity, both in a static and a dynamic context, that must be controlled for to avoid a bias in the coefficient of the policy dummy variable. Empirical works that applied the full set of fixed effects (dummies for importer or exporter countries, product and time effects) in gravity equations has been able to control for as much heterogeneity as possible.

The more we control for heterogeneity, the less we are able to capture the policy effect of interest, because this latter would be captured by the full set of interactions terms. In this paper we attempt to quantify to what extent estimates of the impact of the “policy variables” (dummy variables that usually capture the policy effect of interest, like the effects on bilateral trade of signing Free Trade Agreements, or the effects of Currency Unions, etc) are impaired in the gravity equation when we control for all the cross sectional and time series heterogeneity.

Although it has been known for quite some time that gravity type models using policy dummies are misspecified and lead to improper economic inference (Màtyàs, 1997), the approximation of continuous trade policy through dummies is still quite common. In order to get a sense about the order of magnitude of the error implied by such a choice, we implement a data-generating-process, and set up a Monte Carlo simulation analysis that
allows us to assess the consequences of the fixed-effects specification on the estimation of the policy impact.

The Monte Carlo analysis has recently been growing in popularity in gravity equation experiments (Silva and Tenreyro, 2006; Martin and Pham, 2008; Bergstrand et al., 2012). Silva and Tenreyro used a data-generating-process for their Monte Carlo analysis to obtain a dataset containing no true zero values. Martin and Pham used a Monte Carlo simulation analysis to make an assessment of the properties of the different estimators as a basis for recommending a particular estimator in presence of many zeros in trade flows. Bergstrand et al. employed a Monte Carlo analysis to demonstrate that the comparative static effects on trade flows of a given trade-cost change can be very sensitive to the elasticity of substitution.

Our results confirm that a great part of the magnitude and significance of the policy dummies is captured by the other dummies, This is a serious shortcoming of the fully-specified fixed-effects structure, but it could be significantly reduced when a continuous variable is used to account for the adoption of trade policies.

2. “Dummies for Gravity” and “Gravity for Policies”

McCallum (1995) showed that the U.S.-Canadian border produced a magnification in intra-national trade between Canadian provinces of a factor of 22 to that between U.S. states and Canadian provinces. These results sounded implausibly large. The intuition was that these figures probably captured also the so called “border effect” i.e. any factor that might impede trade between US and Canada, such as transport costs and tariffs. In 2003 Anderson and van Wincoop published a very influential work (Anderson and van Wincoop, 2003), trying to solve the McCallum puzzle estimating a gravity equation correctly based on theory. Anderson and van Wincoop modified McCallum gravity equation, where bilateral trade flows between a couple of regions depended on the output of both regions, their bilateral distance and whether they were separated by a border, simply adding a “multilateral resistance” variable (MR thereafter). This latter term was defined as the sum of three components: (i) the bilateral trade barrier between region i and region j, (ii) i’s resistance to trade with all regions, and (iii) j’s resistance to trade with all regions. In particular, a very recent literature (Anderson and van Wincoop, 2004; Anderson and Yotov, 2011 and 2012) expresses bilateral trade flow at the sectoral level (k) between country i and j at time t (X_{ij,t}) as:

\[ X_{ij,t}^k = \frac{E_{ij,t}^k}{\gamma_i^k} \left( \frac{r_{ij,t}}{p_{ij,t}^k} \right)^{1-\sigma_k} \]  

(1)

\[ (\Pi_{i,t}^k)^{1-\sigma_k} = \sum_{j,t} \left( \frac{r_{ij,t}^k}{p_{ij,t}^k} \right)^{1-\sigma_k} \frac{E_{ij,t}^k}{\gamma_i^k} \]  

(2)

\[ (p_{ij,t}^k)^{1-\sigma_k} = \sum_{j,t} \left( \frac{r_{ij,t}^k}{p_{ij,t}^k} \right)^{1-\sigma_k} \frac{E_{ij,t}^k}{\gamma_i^k} \]  

(3)

Where \( \gamma_i^k / \gamma^k \) is the country i’s share of the world’s sales of goods class k; \( E_{ij,t}^k / \gamma^k \) is the country j’s share of the world spending on k; \( \sigma_k > 1 \) is the elasticity of substitution across
The inclusion of a MR index in empirical works has become the way to obtain a specification of gravity equation that can be interpreted as a reduced form of a model of trade with sound micro foundations. However, it raised several problems in order to find an appropriate measure of the MR index. There are three main approaches to multilateral price terms: (1) use of published data on price indexes (Bergstrand 1985, 1989, Baier and Bergstrand 2001); (2) direct estimation à la Anderson and van Wincoop (2003); (3) use of country fixed effects (Eaton and Kortum 2002, Feenstra 2002). The main weakness of the first method is that existing price indexes may not reflect true border effects accurately (Feenstra 2002). Direct estimation à la Anderson and van Wincoop (2003) requires the (non-linear) estimation of a structural equation in which multilateral resistance indexes are expressed as a function of the observable variables. The use of importer and exporter fixed effects in the estimation is widely used in the literature referred to in the previous section, since it is a computationally easier way to account for multilateral price terms in cross-country analysis. When the dependent variable is the average of bilateral import and export flows, country-pair dummies (fixed effects) has been adopted. If unidirectional flows are considered, a different option is possible instead of fixed effects, i.e the use of two different set of dummies (exporting and importing country dummies) per bilateral flows, a more general technique than fixed effects.2

Fixed effects in gravity equation estimates was not a novelty (see for instance Hummels and Levinsohn (1995). Starting from Rose and van Wincoop (2001), however, this strategy has been widely adopted in empirical literature as a way to proxy unobserved trade costs, namely the MR index. Fixed effects’ main advantage is to avoid misspecification problems that could lead to spurious regressions. In particular, fixed effects include all the possible time-invariant unobserved factors specifically affecting bilateral trade flows in each country-pair: geographical, political, cultural, institutional factors, as well unobserved price indexes. Feenstra (2002) showed that fixed effect method produces consistent estimates of average border effect across countries; indeed, it is very easy to implement. Another advantage could arise from the inclusion of bilateral distance in the fixed effects. It is true that this is an important element of the gravity equation specification; however fixed effect approach avoid the shortcomings of distance as a measure of transport and information costs.3

The main problem is related to the fact that fixed effects only control for time invariant factors; omitted variable probably varies over time, and this seems very likely in the case of prices or, more in general, in the case of trade costs. This shortcoming has been clear since the beginning of this decade. Several authors proposed solutions to control for time-varying

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1 The assumption $\sigma > 1$ implies that consumers in country $i$ have a preference to consume the largest possible number of varieties.
2 Among others, Ritschl and Wolf (2003) and Estevadeordal et al. (2003) used this approach.
3 Geographic distance is usually proxied by kilometers between capital cities of exporting and importing countries. This measure implicitly assumes that transport costs do not vary depending on transport mode, i.e. overland and overseas transport costs are equal. Indeed, the straight-line distance assumes only one economic center per country, but in fact a large country may have several economic centers.
unobserved trade costs into gravity equations. Baltagi et al. (2003) suggested a full interaction effects design to analyze bilateral trade flows. Besides bilateral characteristics of importer and exporter countries captured by fixed effects, these authors showed that it is important to control for all interaction effects in gravity models, including time effects. Comparing this “full model” (including all main and interaction effects) with other restricted version of this specification (imposing one or more of these interactions to be zero), authors found that any of the interaction effects is significant at conventional levels: time-variant exporter and importer specific effects like cycles, cultural, institutional or political change matter. The omission of any of these effects can lead to biased estimates and misleading inference.

2.1 “Gravity for Policies”

The gravity model is such an empirical success that it naturally constitute the first choice alternative for policy evaluation. What is the effect on bilateral trade flows of the adoption of a trade preferential agreement or a common currency are important and frequently asked question with relevant policy implications, and policy makers are particularly interested in plausible quantitative effect of trade impediments or trade promoting initiatives. Most applications of the gravity model search for evidence of actual or potential effects by adding various variables. The trade cost factor is a function of bilateral distances and trade policy variables, such as tariff and non-tariff barriers, preferential margins and trade agreements. The trade cost variable becomes:

\[ T^*_{ij,t} = t_{ij} \times \tau_{ij,t} \]  

(4)

with

\[ t_{ij} = \text{dist}_{ij} \times \text{border}_{ij} \times \text{lang}_{ij} \times \text{colony}_{ij} \times \tau_{ij,t} \]  

(5)

and \( \tau_{ij,t} \) representing the trade policy variable.

With particular regard to preferential trade policies (PTAs), a recent literature argues the importance of measuring the intensity of the preference margins since they vary widely across products and exporters, and various definitions and attempts to provide quantitative measures are available (Cipollina and Salvatici, 2011). The use of explicit measure of the intensity of the policies raises may questions about how should the extent of a trade policy be computed.

In general, trade policies are introduced as a dummy variable, that assumes the value “1” if the trade is between two countries belonging to a trade agreement and “0” otherwise. The use of a dummy to capture the impact of preferential policies on trade is not adequate because: (i) it also captures all other factors that are specific to the country-pair and contemporaneous to the PTAs; (ii) it does not discriminate among different instruments adopted for preferential trade policy; (iii) it does not discern the level of trade preferences (Cardamone, 2011). Moreover, since country-time dummies tend to absorb too much of the variation in the data, the heterogeneous policy effects cannot be well identified. In a fixed-effects country-time dummies gravity specification the policy dummy is particularly inadequate also because of the presence of high collinearity with the country-time dummies (Hornok, 2012).

In this work, using a Monte Carlo simulation analysis, we want to assess the power of country-time dummies in the fixed-effects gravity specification to absorb the variation in
the variable representing the policy effect of interest, considering both the case of a policy dummy and a sensitivity analysis to various definition for an explicit measure of trade policies.

3. The Monte Carlo Simulation

3.1 The econometric specification of the gravity model

In line with an increasingly popular research that attempts to assess the various determinants of bilateral trade at sectoral level, this work is based on highly disaggregated data. Working at a highly disaggregated level implies the presence of many zero trade flows that create obvious problems in the log-linear form of the gravitational equation. Zero flows, as a matter of fact, do not reflect unobservable trade values but they are the result of economic decision making based on the potential profitability of engaging in bilateral trade at all. The Heckman two-step procedure transforms a selection bias problem into an omitted variable problem which can be solved by including an additional variable, the inverse Mills ratio, between the regressors. However, the Heckman procedure still implements a log-normal model based on the questionable assumption that the error terms all have the same variance for all pairs of origins and destinations (homoskedasticity). The Poisson pseudo-maximum-likelihood (PPML) estimator of Santos-Silva and Tenreyro (2007) is commonly used to address the issues of heteroskedasticity and zeroes in bilateral trade flows. Using the PPML technique, the econometric specification of the gravity equation (1) becomes:

\[ X_{ij,t}^{k} = \exp\left[ \beta_1 \ln E_{ij,t}^{k} + \beta_2 \ln Y_{ij,t}^{k} + \beta_3 \ln \ln Y_{ij,t}^{k} + (1 - \alpha_k) \gamma \ln t_{ij,t}^{k} + \ln \tau_{ij,t}^{k} - \ln \Pi_{ij,t}^{k} + \varepsilon_{ij,t}^{k} \right] \]

(6)

with fixed effects the equation to be estimated is:

\[ X_{ij,t}^{k} = \exp\left[ (1 - \alpha_k) \gamma \ln t_{ij,t}^{k} + (1 - \alpha_k) \ln t_{ij,t}^{k} + \eta_{ij,t}^{k} + \theta_{ij,t}^{k} + \varepsilon_{ij,t}^{k} \right] \]

(7)

Where \( \eta_{ij,t}^{k} + \theta_{ij,t}^{k} = \ln \left[ \frac{y_{ij,t}^{k}}{y_{ij,t}^{k}} \left( \frac{p_{ij,t}^{k}}{\Pi_{ij,t}^{k}} \right)^{\alpha_k-1} \right] \).

The choice of estimator turns out to be irrelevant in practice in our data.

Monte Carlo simulations refer to simulating finite data from a hypothesized model. We need a specific assumption on the econometric specification of the model to construct the dependent variable with a distribution characterized by the presence of a number of zeros, randomly set, consistent with the 50-60 percent of zero values frequently observed in analyses of trade flows with disaggregated data.

With a ceteris paribus condition, in term of estimator, we want to assess the effect on the estimated coefficient of the policy dummy when we introduce fixed-effects to control for the multilateral price terms, and compare such effect to that obtained in model with an explicit variable for the trade policy. Our Monte Carlo simulations are used to examine the sensitivity of the estimated impact of trade policy on trade on the specification of multilateral price terms and the definition/measure of the policy.

3.2 The data-generating-process process

We use a dataset of 3 importers of 50 products from 100 exporters over the period 1996-2006. Dataset is building on information provided by the Cepii dataset.
(http://www.cepii.fr/) on GDP and distances between countries and dummies for contiguity, common language, and former colonial links.

We implement a data-generating-process to construct the following variables: $x_{ij,t}^k, t_{ij,t}, p_{ij,t}^k, \Pi_{ij,t}, \epsilon_{ij,t}$. All coefficients are set to “1” for simplicity. The elasticity of substitution, $\sigma_k$, is fixed to 8, a value within the range of the estimates provided in the literature (Anderson van Wincoop, 2004). Our focus is on the preferential trade policies, and we compute the intensity of the preference margins rather than relying on simple dummies. The preference margin is calculated as the difference between the MFN tariff and the actual duty paid by each exporter.

Trade preferences reduce trade costs as a consequence of tariff reduction. Then, the trade cost is a function of the preference factor: higher preferences decrease trade cost and, thus, reduce the negative trade impact of the bilateral tariffs.

Our data generating process is specified as follows:

$$
(x_{ij,t}^k)^0 = \exp(\beta_1 \ln e_{ij,t}^k + \beta_2 \ln (x_{ij,t}^k) + \text{border} + \text{lang} + \text{colony} + (\sigma_k - 1) \ln(1 + \text{pref}_{ij,t}^k)
+ (\sigma_k - 1) \ln \Pi_{ij,t})
+ \epsilon_{ij,t}
$$

where $x_{ij,t}^k = (x_{ij,t}^k)^0$ if $(x_{ij,t}^k)^0 \geq 0$; $x_{ij,t}^k = 0$ if $(x_{ij,t}^k)^0 < 0$ (8)

Zero trade flows cover around the 50% of the total sample, so that we have positive trade in 58,545 observations.

4. Discussion of Results

The first column 1 in Table 1 shows results of our benchmark regression, that is the case with perfect information: as expected, the estimated coefficients coincide with the ones assumed in the data-generating process. In Column 2, we assume that some heterogeneity cannot be observed by the analyst (i.e., $e_{ij,t}, Y_{ij,t}^k, \Pi_{ij,t}$) that does not take into account the main insight from the (rightly) famous Anderson and vanWincoop (2003) model, namely the necessity to take into account the “multilateral resistance term” ($p_{ij,t}^k$ and $\Pi_{ij,t}^k$). The estimated coefficient of the preference margin becomes around 12, implying a large overestimation of the policy impact. On the contrary, the impact of distance is drastically underestimated (and this is quite surprising in the light of the debate about the “distance puzzle”); whereas the the existence of a common language becomes a barrier to trade.

In the literature, the common and easier way to account for the multilateral price terms is to use a complete structure of fixed effects. Column 3 shows that the fixed effects are a good proxy for MRTs since the coefficient of the variable of interest is not statistically different from our initial hypothesis of $\sigma$ equal to 8. In this case, we cannot estimate the impact of other variables, such as distance or language, since they are collinear with (some of) the fixed effects.
Table 1: Results with preference margin

<table>
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<tr>
<th>Dependent variable $X_{i,j,t}$</th>
<th>TRUE</th>
<th>Without MRT</th>
<th>With FE</th>
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</thead>
<tbody>
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<td>ln_Ykt</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>ln_Yikt</td>
<td>1.00*** (0.00)</td>
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<td>ln_Ejkt</td>
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<td></td>
</tr>
<tr>
<td>ln_dist</td>
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<td>-0.03*** (0.00)</td>
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<tr>
<td>Language</td>
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<td>-1.88*** (0.00)</td>
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<tr>
<td>ln_pref</td>
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<td>11.61*** (0.00)</td>
<td>6.94*** (0.00)</td>
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<td></td>
</tr>
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<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Country Pair – Product FE</td>
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<td>No</td>
<td>Yes</td>
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<tr>
<td>Observations</td>
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<td>116050</td>
<td>114587</td>
</tr>
</tbody>
</table>

Poisson Estimator. Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

To proxy for PTAs, most papers use a dummy variable which is equal to one if a preference exists between countries. However, as highlighted by Cardamone (2007, 2009), the use of a dummy to capture the impact of PTAs on trade is not adequate because: (i) it also captures all other factors that are specific to the country-pair and contemporaneous to the PTAs; (ii) it does not discriminate among different instruments adopted for preferential trade policy; (iii) it does not discern the level of trade preferences.

The results of the studies using dummies seems to be higher, in absolute term, than those obtained by studies using some explicit measures of margins (Cipollina and Pietrovito, 2011). However, the two analyses are not comparable: the estimated coefficient of dummy refers to total effect, while the estimated effect size of the preference margin is an elasticity.

In order to shed some lights on the capability of the dummy variable to proxy the effect of policy, we estimate eq. 8 using the policy dummy instead of the preference margin.

Results in column 1 in Table 2 confirm that the policy impact coefficient associated with the dummy is much larger. Interestingly, the error implied by the omission of the MRT is much larger when the policy is modeled through dummies (Column 2). Finally, Column 3 results show that the fixed effect reduce the error, but also take way a significant amount of the policy effect.
Table 2: Results with Policy Dummy

<table>
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<th>Without MRT</th>
<th>With FE</th>
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<td>Country Pair – Product FE</td>
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<td>Yes</td>
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<tr>
<td>Observations</td>
<td>116050</td>
<td>116050</td>
<td>114587</td>
</tr>
</tbody>
</table>

Poisson Estimator. Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5. Conclusions

This paper argues that the identification of trade policy effects using a gravity equation that includes fixed effects to control for the multilateral price terms is severely limited. Using a Monte Carlo-Gravity experiment the hypothesis we want to test is the following: the more we control for heterogeneity, the less we are able to capture the policy effect of interest, because this latter would be captured by the full set of interactions terms. This impact is much more evident when the policy is proxied by a dummy variable.

References

Anderson and Yotov (2012), “Gold standard Gravity”, NBER WP17835


