REGIONAL EXPORT PERFORMANCE: FIRST NATURE, AGGLOMERATION … AND DESTINY? THE ROLE OF INFRASTRUCTURE*

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ABSTRACT

Within large and internally dissimilar countries, regional export performance is, at first, a matter of destiny. The interplay between 'first nature' and 'second nature' tend to determine the pattern of production in each region, and hence their exporting capabilities. But… is it not just a matter of destiny. In fact, the way in which this interplay occurs and the chances for agglomeration forces to emerge ultimately depends on the extent of interaction within and across countries. This paper addresses regional export performance focusing on the role played by transport costs and infrastructure in the competitiveness and interconnection of different geographical spaces. A model-based gravity equation is derived and an empirically testable specification is applied for the case of the Argentinean regions between 2003 and 2005. We find that infrastructure enhancement or the reduction of transport costs may help for changing regional competitiveness and market accessibility. Hence, these policies could facilitate turning the destiny of less advantaged Argentinean regions.

- **JEL Classifications:** F14, H54, R12, F13, F12
- **Key Words:** Export Performance, Infrastructure, Economic Geography, Industrial Location, Regional Inequalities, Trade Liberalisation

1. INTRODUCTION

Within large and internally dissimilar countries, regional export performance is, *at first*, a matter of destiny. A highly varying geographical landscape (topography, climate, environment, etc.), big internal distances, and huge regional differences in terms of physical accessibility tend to constrain the regional production and consumption profiles inside those countries. In addition to these 'first nature' characteristics, both market and non-pecuniary interactions propitiate the spatial distribution of economic activities within their territory. As it has been put forth by Economic Theory, flows of ideas and knowledge, movement of factors, vertical linkages, trade flows and factor accumulation likely stimulate agglomeration and dispersion processes, which ultimately shape the economic landscape of the countries.

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To sum up, the interplay between 'first nature' and 'second nature' tend to determine the pattern of production and consumption in each region and, hence, their exporting capabilities. But… is it *just* a matter of destiny? In fact, the way in which this interplay occurs and the chances for agglomeration forces to emerge ultimately depend on the extent of interconnection within and across countries –namely, the spatial scope of market accessibility, migration, knowledge diffusion, etc. Indeed, which of these phenomena explains relatively more of the resulting pattern of production and trade ultimately depends on their relative strength within each particular geographical area, along with regional 'first nature' characteristics and history.[1] Therefore, regional export performance is not a matter of *irreversible* destiny, but one that can be altered or even shaped by accurately intervening at its basis.[2]

In the last twenty years, New Trade Theory (NTT) and New Economic Geography (NEG) have stressed the role played by market accessibility in determining the distribution of increasing returns to scale activities across regions. Further, recent theoretical extensions have proposed that regional export performance is driven by that basic force, which assumes a dual dimension when firms are vertically linked, namely: the real access to purchasers for products local firms sell, and the real availability of suppliers for intermediates goods those firms use.[3] Within this framework two elements appear as principal targets when attempting to shape destiny: trade costs and locally settled advantages. Broadly interpreted, the former comprises all those features that limit or even preclude trade flows –such as the level of search costs, the cost of enforcing contracts, transport costs and the level of policy trade barriers. Whilst the later corresponds to those modifiable assets that make local agents particularly efficient, and thus more competitive, for producing and exporting certain goods; for instance local transport and communication infrastructure, the stock of human capital, the techno-scientific profile of the region, its institutional framework, among others.

A clear evidence of the popularity infrastructure issues have nowadays is given by the multiplication of studies on infrastructure impacts and the proliferation of regional initiatives intended to develop infrastructure projects. We can mention, for instance, the contributions of Estache and Fay (2007) reviewing current debates on infrastructure policy, and of Mu and van de Walle (2007), Grigoriou (2007) and Iimi and Smith (2007) assessing the impacts of infrastructure improvements in Asian and African countries. As regards those initiatives, we can refer to the World Bank's and the African Development Bank's projects

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[1] History matters; processes occurred in the past may restrict others in progress.

[2] It is worth to notice that this intervention can be done in account of either efficiency or equity matters. Even if spatial concentration were economically efficient, it may be not equitable to allow the irrevocable emptiness of some territories.

[3] The adjective 'real' indicates that both concepts, demand and supply access, acknowledge for the fact that the mass of customers/suppliers improve access (market size effect), while the number of competitors (competition or market-crowding effect) and the level of trade costs across regions (hub effect) may worsen it.

(Buys et al., 2006) and the Initiative for the Integration of the South American Regional Infrastructure (Vega Alvear, 2002; IIRSA, 2007), among others.

Within the academia, as it is reviewed in this paper, many works have already studied the interaction between, on the one hand, those modifiable assets we have mentioned and trade costs and, on the other, the levels and patterns of trade. Indeed, some empirical papers, which have measured the actual impact those features could provoke on bilateral flows, seem to have confirmed the above theoretical predictions. The present paper belongs to this strand of the literature. Specifically, it addresses regional export performance focusing on the role played by transport costs and regional infrastructure. The objective is to verify whether regional export performance can be explained through a theoretical framework where those features govern firms' location decisions. Moreover, the paper aims at contributing to understand the Argentinean regional reality by answering (at least some of) the following questions: To what extent transport costs and regional infrastructure condition regional export performance in Argentina? May infrastructure enhancement or the reduction of transport costs effectively help for changing regional competitiveness and market accessibility? Thus, could these policies turn the otherwise irreversible destiny of less developed or advantaged Argentinean regions?[4]

The remainder of the paper is organised as follows, section 2 reviews theoretical and empirical antecedents, underling possible extensions and explaining how this paper intends to contribute with this literature. The next section sets up a general theoretical model that specifically addresses the role played by transport costs and regional infrastructure, and which provides for an empirically testable specification. Section 4 gives details on data and methodological issues concerning the application of this framework to Argentina between 2003 and 2005. The structural gravity equation is estimated in the fifth section; where the main results are discussed looking to answer the above questions. Finally, section 6 presents some concluding remarks and draws some lines for future research.

2. ANTECEDENTS AND NEW ISSUES

From the theoretical perspective, traditional answers to the above concerns have come from Neoclassical Trade Theory, Location Theory and Regional Science. More recently, New Trade Theory (NTT) and New Economic Geography (NEG) have complemented those answers within a framework that introduce non-convexities and the endogeneity of the location choice. Within this strand, some authors have explicitly introduced assumptions

[4] The methodology this paper develops is comprehensive and can be applied for different national and sub-national spaces. Indeed, the application we present for the case of Argentina should be taken as an illustration of how this framework can be employed to derive useful policy suggestions.

related with either the functional form of trade costs or infrastructure issues.[5] In this respect, Martin and Rogers (1995) pioneer introducing public infrastructure in a NTT setting, where infrastructure is assumed to impose higher costs on trade and to comprise "*any facility, good, or institution provided by the state which facilitates the juncture between production and consumption*" (page 336). The authors, who examine the impact of infrastructure on industrial location when trade integration takes place, find that firms tend to locate in countries with better domestic infrastructure; in addition, they uncover high levels of international infrastructure and strong increasing returns to scale magnify industrial relocation. Also within NTT, but in a multi-country set up, Behrens et al. (2005) explicitly model a transport-cost function that acknowledges for the fact that firms choose among roads minimising transport costs. The authors conclude that improvements in transportation infrastructure, which reduce trade costs, have spatially limited impacts. Within the NEG approach, Baldwin et al. (2003, Ch. 17) present a growth model that assumes infrastructure can affect both domestic and international trade costs; they find results for relocation which are in line with those of Martin and Rogers, though exacerbated due to market size endogeneity. In the same vein, with a NEG linear model that allows for domestic inequalities and labour mobility, Behrens (2004) concludes that whereas trade combined with poor domestic infrastructure may exacerbate spatial inequalities; better local infrastructure may favour a more balanced development.

To sum up, these models assume infrastructure improvements are trade-cost reducing, and thus affect location, export performance and disparities across regions. They disregard, however, the role infrastructure may also play like an incentive (or a constraint) to the production process. For instance, Arrow and Kurz (1970) and Barro (1990) stress the substitutability of public infrastructure and private capital in the production function. The authors consider some public capital generate a flow of services which are comparable to productive services, such as transportation, water, electric power, etc.. Other studies, like Holtz-Eakin and Lovely (1996), Bougheas et al. (2000), Justman et al. (2005), Brakman et al. (2002) and Egger and Falkinger (2006), acknowledging that public infrastructure is an important aspect of competitive location policy, sustain that it directly affects firms' production costs. Trying to make a synthesis of both positions, our paper proposes a theoretical distinction among the effects of infrastructure, dividing them between those concerning firms' production functions and those directly connected with interregional trade. In addition, our model –an extension of Robert-Nicoud (2002)'s NEG setting– deals with the location of both final goods producers and intermediate input ones. Thus, it is assumed monopolistic firms are vertically linkaged and the productive factor entering fixed costs is inter-regionally mobile. Further, Herscker-Ohlin comparative advantage is allowed

[5] Previously, though the importance of infrastructure for productivity and economic growth had been widely documented, very few studies explored the link between infrastructure and trade. One of those exceptions is Bougheas et al. (1999) who, within a Dornbusch-Fischer-Samuelson (1977) Ricardian model, assume transport costs inversely depend on the level of infrastructure.

across regions and we introduce a transport-cost function à la Behrens et al. (2005). Therefore the model displays the two mechanisms for profit equalisation across regions that characterised alternative NEG models, namely: re-localisation of firms and adjustments through costs of production. That is, the distribution of production across the space is endogenously determined by two simultaneous processes: firms relocate into those regions with higher operating profits while production costs increase in more agglomerated areas.

Within the empirical arena, during the last decade many studies have addressed the role played by infrastructure and trade costs as determinants of bilateral trade. Bougheas et al. (1999), using an augmented gravity model and data from European countries, find their two alternative infrastructure variables –i.e., the stock of public capital and the length of the motorway network– have a positive impact on the volume of trade. Though novel, the empirical exercise they propose is rather disconnected from their theoretical model. Based on stylised facts, Limão and Venables (2001) propose a transport-cost specification that relies on transport and communication infrastructure inside both trade partners and transit countries together with other country characteristics. The authors regress a gravity equation for bilateral trade where transport costs take that form, finding international support for the importance of infrastructure quality as a determinant of trade flows, especially for landlocked countries. Nordås and Piermartini (2004) follow a similar approach, but extend it to acknowledge for bilateral tariff rates, multilateral resistance indices and remoteness à la Anderson-van Wincoop (2003). They find that the quality of infrastructure has a significant impact on bilateral flows, and that bilateral tariffs have a large and negative impact on them. Finally, Shepherd and Wilson (2006), following Buys et al. (2006), examine the quality of the road network across a group of neighbouring countries. This paper regresses an extended gravity equation along the lines of Anderson and van Wincoop (2003), considering as well the methodological hints raised by Baldwin and Taglioni (2006). The authors find that better roads are strongly associated with larger trade flows within the Eastern Europe and Central Asia region, and that cross-country spillovers are important. Summarising, the gravity equation is the prevailing empirical strategy for evaluating the relationship between trade flows and both infrastructure and trade costs. In addition, every study finds infrastructure (or its quality) has a significant role explaining trade performance.

Albeit its success, this empirical literature has some weak points which amendments seem to be no so far into. For instance, some studies tend to rely on ad-hoc instead of 'model-based' equations, and to use proxy variables which identification with the 'true' variable is rather imperfect. Further, as it is highlighted by Shepherd and Wilson (2006), most studies do not take into account alternative modes of transport and the interactions among them. The present paper tries to contribute with this strand of the literature introducing some amendments. First, it proposes a NEG theoretical framework where the stock of regional infrastructure is considered, and where the choice of each the transport mode, route, and exit point –namely, port, airport or border stations used to get abroad– is introduced. Second, our paper derives a structural specification which resembles the standard gravity equation; thus allowing a more accurate selection, construction and measurement of the variables, and facilitating a more proper interpretation of the results.

Finally, reviewing applied studies carried out for Latin American countries, one finds they are scarce and pretty recent. For instance, Martinez-Zarzoso and Nowak-Lehmann (2003), who runs a gravity equation including infrastructure indices, finds support for the importance of the importer's infrastructure in trade between the EU and MERCOSUR. Applying a similar approach, Acosta Rojas et al. (2005) conclude that the infrastructure stock of the countries in the Andean Community of Nations (CAN) is decisive in determining their trade performance. Mesquita Moreira (2007), in a full-of-data descriptive (non-gravitational) work, discusses the relative importance of infrastructure and policy-related trade costs in South America and their potential impacts on regional disparities and growth. Finally, Benedictis et al. (2006) go beyond their predecessors and accomplish a gravitational study where sub-national regions are explicitly considered, namely the Ecuadorian provinces. The authors find that infrastructure emerges as an important determinant of provincial export performance. In this vein and relying on a complete and careful data scrutiny of the Argentinean regions, our paper studies whether transport costs and regional infrastructure are relevant determinants of export performance at the regional level.

3. THE MODEL

We build on Robert-Nicoud's (2002) refinement of Martin and Rogers' (1995) model[6], which introduces vertical linkages across firms. We extend the setting in order to acknowledge for H-O comparative advantage across regions, trade costs à la Behrens et al. (2005) and infrastructure in a double role, affecting both transport costs and production. Thus, in our model the spatial equilibrium could be due to both industry relocation –which relays on disembodied capital mobility– and adjustment of production costs across regions.

The world consists of R regions, $r=1,2,...,R$, symmetric in terms of tastes and technology; each hosting exogenously given masses of a composite resource L_r that combines labour and natural resources, financial capitalists (K_r) and infrastructure services (Z_r, or 'production infrastructure').[7] The former, $L_r > 0$, also represents the number of consumers in region r. The three types of endowments are uniformly owned and inelastically supplied by the population, all but capital is perfectly mobile across sectors and the only inter-regionally mobile factor (though disembodied) is K_r.[8] There are two productive sectors: the tradable

[6] The published version of Robert-Nicoud's work is in *Spatial Economic Analysis*, 2006.

[7] Public-infrastructure services account for energy –i.e. gas and electricity– telecommunications, provincial roads, national airports, among others. That is, they represent those items that directly influence production costs, profits and thus incentives to locate (or delocate) in different regions.

[8] In other words, capital-services are perfectly mobile; while financial capitalists reside and expend money in their region of origin though offer their factor services in any region.

sector *M* which is assumed to provide one good as a continuum of horizontally differentiated *N* varieties –being n_r the sub-set produced in region *r*– and a non-tradable sector *W* that produces an homogeneous good.[9] The first sector, which is the focus in NEG models, stands for broadly defined manufacturing activities.

3.A. Preferences and Consumption Demand

The preferences of a typical resident of region *r*, defined over the two goods *M* and *W*, are represented by the following utility function, where $C_\mu \equiv \mu^{-\mu}(1-\mu)^{\mu-1}$ and M_r and W_r are consumption of the manufactured and non-tradable good, respectively.

$$U_r = C_\mu M_r{}^{\mu} W_r{}^{1-\mu} \qquad (1)$$

Consumption of *M* can be expressed as:

$$M_r = \left[\sum_{s \in R} \int_{i \in n_s} q_{sr}^{Mfin}(i)^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}} \qquad (2)$$

where $q_{sr}^{Mfin}(i)$ is the quantity of manufactured variety $i\in[0,n_s]$ produced in region *s* and consumed in *r*, $\mu\in]0,1[$ is the weight of good *M* in the utility, and $\sigma\in]1,\infty]$ is the elasticity of substitution between any two varieties. Since the sector of interest in this work is *M*, we continue our exposition focusing on it, confining the treatment of sector *W* to the Appendix.

The representative consumer in each region maximises its two-tier utility function. First, she/he decides the amounts of goods *M* and *W* that he/she will optimally consume[10]; and after that, determines her/his demands for each variety. As usual in the D-S setting (Dixit and Stiglitz, 1977), optimal direct demands are:

$$q_{sr}^{Mfin}(i) = \frac{p_{sr}^{M}(i)^{-\sigma}}{P_r^{1-\sigma}} \mu Y_r \quad (3)$$

where $p_{sr}^{M}(i)$ is the price of variety *i* produced in region *s* and consumed in region *r*, and P_r is the price index in region *r*.[11] Thus, the quantity demanded for any variety produced in *s* by the representative consumer of region *r* depends: positively on the price index in his/her region and on her/his income, and negatively on the price of this variety in *r*.

Let express the price index as:

$$P_r = \left[\sum_{s \in R} \int_{i \in n_s} p_{sr}^{M}(i)^{1-\sigma} di \right]^{\frac{1}{1-\sigma}} \qquad (4)$$

Finally, the indirect utility function of region *r*'s representative consumers can be written as:

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[9] This sector can be thought as delivering commercial services and local goods.

[10] Optimal quantities are: $p_r^W W_r = (1-\mu)Y_r$ and $P_r M_r = \mu Y_r$. P_r is the CES price index in *r* for the tradable good.

[11] Since the model rules out savings, regional income is totally expended in final consumption, that is: $Y_r = E_r^{Mfin} + E_r^{W}$, where $E_r^{Mfin} = \mu Y_r$ denotes expenditure in the manufacturing good and $E_r^{W} = (1-\mu)Y_r$ stands for expenditure in the homogeneous good.

$$V_r = \frac{Y_r}{P_r^{\ \mu} p_r^{\ 1-\mu}} \qquad (5)$$

3.B. TECHNOLOGY AND INTERMEDIATE DEMAND

It is assumed that every variety of good *M* is produced with the same technology in every region, under IRS and monopolistic competition with free entry. The production of $m(i)$ units of variety *i* requires a fixed amount *F* of capital-services and a variable amount $\beta x(i)$ of a Cobb-Douglas composite input. This variable input combines labour and natural resources (l_r) with composite price ω_r and share α, infrastructure services (z_r) with price v_r and input share γ, and a composite of intermediate varieties (M_r^{int}) with price P_r and input share ρ[12]; and it is assumed $\alpha+\gamma+\rho=1$. Thus, the implicit cost function of a firm producing variety *i* in region *r* is given by:

$$TC_r^M(i) = \pi_r F + \beta m_r(i) \omega_r^{\ \alpha} v_r^{\ \gamma} P_r^{\ \rho} \qquad (6)$$

where π_r is both rental rate of capital in region *r* and firm's operating profit under free entry.[13] From now on, let $\Psi_r \equiv \omega_r^{\ \alpha} v_r^{\ \gamma} P_r^{\ \rho}$ denotes the price of the Cobb-Douglas composite input. Note that due to the form fixed costs assume, $N = \frac{K}{F}$ and $n_r = \frac{k^r}{F}$, with *K* denoting world capital endowment and k^r standing for the amount of capital-services employed in region *r*.[14] Since the optimisation programme of firms is formally equivalent to that of consumers within DS setting, a typical firm in region *r* demands the following amount of intermediates:

$$q_{sr}^{M\,int}(i) = \frac{p_{sr}^M(i)^{-\sigma}}{P_r^{\ 1-\sigma}} \rho\beta\Psi_r m_r(i) \qquad (7)$$

Thus, the n_r firms located in region *r* require $n_r q_{sr}^{M\,int}(i)$ units of each variety. Further, making a parallel with consumer's optimal demands (3), the expenditure those n_r firms devote to purchase intermediate inputs can be denoted by $E_r^{M\,int} = n_r \rho\beta\Psi_r m_r(i)$.[15] Finally, the quantities of other factors of production that a typical firm in region *r* requires can be expressed as follows:

$$l_r^M(i) = \frac{\alpha}{\omega_r} \beta\Psi_r m_r(i) \qquad (8) \qquad \text{and} \qquad z_r^M(i) = \frac{\gamma}{v_r} \beta\Psi_r m_r(i) \qquad (9)$$

3.C. COSTS OF TRADE

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[12] This intermediate composite has exactly the same form as the one consumed by individuals. Indeed, $M_r^{int} = \left[\sum_{s \in R} \int_{i \in n_s} q_{sr}^{M\,int}(i)^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}}$, where the elasticity of substitution between varieties is the same for consumption and production.

[13] The free entry-exit assumption precludes pure profits in sector *M*; then, operating profits just cover capital reward.

[14] Thus, $K \equiv \sum_r K_r = \sum_r k^r$.

[15] Note that intermediate expenditure in region *r* is defined as: $E_r^{M\,int} \equiv n_r \sum_{s \in R} \int_{i \in n_s} p_{sr}^M(i) q_{sr}^{M\,int}(i) di$.

As usual in NEG models, we assume trade of each *M* variety is subject to Samuelson's iceberg costs. This means that for one unity of differentiated good produced in region *r* to reach region *s*, $\tau_{sr}\in[1+\varepsilon,\infty[$ units must be shipped. Nonetheless, differently from many NEG settings, we enhance the structure of trade costs following Behrens et al. (2005). Indeed, our setting intends to address the issue many authors have already raised about the importance of accurately modelling and measuring the ample spectrum of frictions that hamper trade, such as physical trade barriers, policy measures and cultural differences across regions that limit trade flows.[16] Therefore, we assume the costs of trade from region *r* to region *s* are a multiplicative combination of broadly defined policy barriers to trade (t_{rs}), transport costs (δ_{rs}), and other cultural and spatial *k* determinants of trade (λ_{rs}^{k}) such as contiguity, common language, etc.. That is:

$$\tau_{rs} = e^{t_{rs}} \delta_{rs}{}^{\phi} e^{\sum_k \varphi_k \lambda_{rs}^k} \qquad (10)$$

with: t_{rr}=0, $\lambda_{rr}^{k}=0$, and t_{rs} that can differ from t_{sr}. Thus, τ_{sr} may differ from τ_{rs}, while $\tau_{rr}=\delta_{rr}$.[17] Though this functional form of trade costs is somewhat arbitrary, our intention is to link those transaction costs to the most relevant observable cost proxies.[18] This will allow to more accurately infer about the unobservable trade costs, which may differ for within-region transactions and across-region transactions.

With respect to transport costs, we model them in a simple but illustrative way that tries to introduce the effect physical infrastructure triggers on transportation ('transport infrastructure').[19] Following Combes and Lafourcade (2005), it can be précised that the cost of shipping commodities across space depends on the network of roads, railways and waterways available, the taxation system in force, the ease of access to ports, airports and border crossings, and the prevailing market structure in the transport industry, among other related issues. Hence, and adopting Behrens et al. (2005)'s arithmetic, we assume all regions contain one node of a transportation network –denoted by *s* if located in region *s*– which is connected to other nodes around the world by a set of edges $\mathcal{E}$; and we denote by $(r,s)\in\mathcal{E}$ the edge linking nodes *r* and *s*. We called path $\mathcal{P}$ to a sub-set of edges needed to be 'hiked' in order to joint two particular nodes; and we imagine there is place for both types of paths: single-edge ones between neighbour nodes, and multiple-edge paths linking any other pair of nodes. As it ca be inferred, more than one potential path connecting two particular nodes might exist; $\mathcal{P}\in\mathcal{P}_{rs}$ where $\mathcal{P}_{rs}$ denotes the set of paths connecting *r* and *s*. Let stand c_{oq}>1 for

[16] The list of authors includes: Hummels (2001), Helliwell and Verdier (2001), Eaton and Kortum (2002), Anderson and van Wincoop (2004), Combes and Lafourcade (2005), Combes, et al. (2006), Carrère (2006), among others.

[17] We could further assume that δ and t can vary across varieties. Nonetheless, we prefer to simplify our framework, leaving this issue for a future extension where *S* manufacturing sectors were modelled, M_1, …, M_S.

[18] As it is stated by Anderson and van Wincoop (2004), gravity literature usually uses this kind of ad-hoc assumptions regarding the form of the trade cost function, the list of variables, and regularity conditions. In our paper we decide to use a multiplicative set up, instead of Hummels (2001)'s additive specification.

[19] This is the second effect of infrastructure in our model. First, we referred to those effects concerning firms' production functions; here, we introduce those affecting interregional trade.

the 'iceberg coefficient' of edge (o,q), which measures transport costs that arise due to the existence of physical trade barriers –such as geographic accidents (mountains, lakes, etc.), distance, etc.– between nodes o and q. Since transport costs of connecting any two particular nodes may add up to different totals, let assume arbitrage by profit-maximising firms ensures transportation always occurs along the lowest cost path. Moreover, since alternative modes of transport may exist –which indeed interact and have interfaces among them– let further assume that arbitrage ensures transportation is always done using the cheapest mode. Formally, the transport cost between nodes r and s is the overall iceberg cost calculated for the cheapest mode of transport along the minimum cost path:

$$\delta_{rs} \equiv \min_{P \in P_{rs}} \prod_{(o,q) \in P} c_{oq} \quad \text{with} \quad \prod_{(o,q) \in P} c_{oq} \equiv c_{rp_1} c_{p_1 p_2} \dots c_{p_n s} \qquad (11)$$

where $\delta_{rs}=\delta_{sr}$. We additionally allow for internal distance and other physical trade barriers within any region, so $\delta_{rr} \geq 1$.[20]

3.D. Optimal Scale of Production at the Firm Level

As it is well-known, within DS setting it is optimal for firms to apply a fixed mark-up over its marginal cost, being purchasers who pay all the costs of trade.[21] Thus equilibrium consumer prices are:

$$p_{rs}^{M}(i) = \frac{\sigma}{\sigma - 1} \tau_{rs} \beta \Psi_r \qquad (12)$$

Introducing these prices into CES price index formula (4), we get:

$$P_r = \frac{\sigma}{\sigma - 1} \beta \left[\sum_{s \in R} n_s \tau_{sr}^{1-\sigma} \Psi_s^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \qquad (13)$$

Each firm's production will equalise the sum of intermediate and final demand –both, local and external– of the variety it produces, plus the volume 'melted' in transit, $m_r(i) = \sum_{s \in R} m_{rs}(i) = \sum_{s \in R} \tau_{rs} \left[n_s q_{rs}^{M\,int}(i) + q_{rs}^{Mfin}(i) \right]$. Due to the free entry-exit assumption, this optimal scale of production must ensure zero pure profits; consequently, operating profits can be expressed as a function of the optimal scale $m_r^*(i)$ as $\pi_r = \frac{\beta \Psi_r}{(\sigma - 1)F} m_r^*(i)$.[22] Replacing that scale of production into this last expression, we just re-express the equilibrium operating profits of any firm in region r as:[23]

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[20] Intuition on this transport cost function is given in section 4.

[21] As it can be noticed, σ is the perceived elasticity of demand; therefore condition $\sigma>1$ is in fact imposed as a regularity condition.

[22] Using final and intermediate demands (3) and (7), together with equations (12) and (13), the optimal scale of production can be expressed as: $m_r^*(i) = \frac{\sigma - 1}{\sigma \beta} \Psi_r^{-\sigma} \sum_{s \in R} \left[\frac{\tau_{rs}^{1-\sigma} \left(E_s^{Mfin} + E_s^{M\,int} \right)}{\sum_{q \in R} n_q \tau_{qs}^{1-\sigma} \Psi_q^{1-\sigma}} \right]$, with E_s^{Mfin} and $E_s^{M\,int}$ denoting final and intermediate expenditure in region s, respectively.

[23] The optimal scale of production can hence be re-expressed as $m_r^*(i) = \frac{(\sigma - 1)}{\sigma \beta} \Psi_r^{-\sigma} RMP_r$

$$\pi_r = \frac{\Psi_r^{1-\sigma}}{\sigma F} RMP_r \qquad (14) \qquad \text{with } RMP_r \equiv \sum_{s\in R} RMP_{rs} = \sum_{s\in R}\left[\frac{\tau_{rs}^{1-\sigma}\left(E_s^{Mfin}+E_s^{M\,int}\right)}{\sum_{q\in R} n_q \tau_{qs}^{1-\sigma}\Psi_q^{1-\sigma}}\right] \qquad (15)$$

Thus, profitability of any region essentially depends on two elements: the prevailing cost of production of and its *RPM*, which can be interpreted as a generalised measure of accessibility from that region towards all the existent markets, included its own.

Indeed, expression (15) denotes the Real Market Potential of region *r*, which resembles the idea of Harris (1954).[24] This measure weighs up the positive effect of accessing any market *s* from region *r* –in the numerator, that positively depends on manufacturing expenditure in market *s*, and negatively on the costs of trade– and the negative effect of competition coming from firms located in every region, which is greater the smaller are trade costs, the larger is the number of firms and the smaller are production costs in that region.

3.E. Equilibrium in Regional Factor-Markets

As it is standard in the NEG literature, every factor of production is assumed to be fully employed. For the case of the immobile factors, regional supply must equal the sum of input demands that stem from both the competitive sector *W* and the monopolistic firms located in the region.[25] Applying expressions (8) and (9) together with sector *W*'s input demands –see the Appendix– and using regional income equation $Y_r = L_r\omega_r + Z_r v_r + K_r\pi$,we can express equilibrium factor prices as follows:[26,27]

$$\omega_r = \frac{\alpha}{\alpha+\gamma}\frac{(\mu Y_r - K_r\pi)}{L_r} + \eta\frac{(1-\mu)Y_r}{L_r}$$
$$v_r = \frac{\gamma}{\alpha+\gamma}\frac{(\mu Y_r - K_r\pi)}{Z_r} + (1-\eta)\frac{(1-\mu)Y_r}{Z_r} \qquad (16)$$

3.F. Regional Trade Balances and Global Market Clearing

Expressions (13) to (16) define *R*x4 equations in the five regional unknowns –namely ω_r, v_r, P_r, n_r and π_r– that characterise the model's equilibrium.[28,29] In order to pin down all

[24] RMP_r represents the sum of region *r*'s Real Market Potential in every region.

[25] Therefore, $L_r = n_r l_r^M + l_r^W$ and $Z_r = n_r z_r^M + z_r^W$.

[26] Note that capital services, unlike other factor services, receive a non-regionally specific return. The model assumes capital services' reward always equals world's weighted-average operating profits, $\pi \equiv \sum_{s\in R}\frac{n_s}{N}\pi_s$.

[27] Expressions (16) can also be written using expenditure notation: $\omega_r = \frac{\alpha}{\alpha+\gamma}\frac{\left(E_r^{Mfin} - K_r\pi\right)}{L_r} + \eta\frac{E_r^W}{L_r}$ and $v_r = \frac{\gamma}{\alpha+\gamma}\frac{\left(E_r^{Mfin} - K_r\pi\right)}{Z_r} + (1-\eta)\frac{E_r^W}{Z_r}$. Therefore, intermediate expenditure is $E_r^{M\,int} = \frac{\rho}{\alpha+\gamma}\left(E_r^{Mfin} - K_r\pi\right)$.

[28] More precisely, these equations together with those corresponding to the competitive sector *W*, define a set of *R*x6 equations in the seven regional unknowns, ω_r, v_r, P_r^M, π_r, n_r, p_r^W and W_r.

variables, R additional trade balances are introduced, which states that the value of sales from region r to all other regions including itself (exports plus domestic sales) –or, what is the same, the total value of production in region r– must equal the value of purchases that agents in region r make (imports and domestic consumption), i.e., $n_r \sum_{s\in R} p_{rs} \left[n_s q_{rs}^{M\,int}(i) + q_{rs}^{Mfin}(i) \right] = \sum_{s\in R} p_{sr} n_s \left[n_r q_{sr}^{M\,int}(i) + q_{sr}^{Mfin}(i) \right]$. If we first re-express (3) and (7) in terms of final and intermediate expenditure in sector M, replace them into our trade-balance expression, then plug (12) and (13), and operate, we get:

$$n_r \Psi_r^{1-\sigma} RMP_r = \sum_{s\in R} n_s \Psi_s^{1-\sigma} RMP_{sr} \qquad (17)$$

Therefore, the total value of production in region r –the right hand-side of (17), denoted as G_r– directly depends on the number of firms located there and the RMP that benefits them, and it is inversely related with regional costs of production. To close the model, note that the value of world output in sector M must equal the value of world expenditure in sector M; formally, $\sum_{r\in R} n_r \sum_{s\in R} p_{rs} \left[n_s q_{rs}^{M\,int}(i) + q_{rs}^{Mfin}(i) \right] = \sum_{r\in R} \left(E_r^{Mfin} + E_r^{M\,int} \right)$. Following similar steps as before we find that the world value of M production can be expressed as:

$$G \equiv \sum_{r\in R} G_r = \sum_{r\in R} \left(E_r^{Mfin} + E_r^{M\,int} \right) \qquad (18)$$

3.G. Instantaneous and Spatial Equilibrium

As it is standard in FC-NEG models, though there are no real dynamics, the equilibrium is analysed at two different moments, namely the short-run and the long-run. The first one is understood as a circumstance in which: capital services hired in each region are given and immobile and capital owners everywhere earn the world average reward while regional operating profits can differ.[30] Therefore, the instantaneous equilibrium is characterised by consumers maximising their utility, firms maximising their profits and all market clearing for an exogenously given distribution of firms, n_r.

On the other hand, the long-run 'spatial' equilibrium implies that operating profits are indeed equalised across regions. During this period, capital services are perfectly mobile and capital owners seek the higher nominal returns. Therefore, inter-regional distribution of capital services, and hence n_r, adjust so that $\pi_r = \pi$ for any active firm. Formally, if $\pi_r(\Gamma)$ denotes operating profits in region r when the spatial distribution of firms is $\Gamma = \{n_1, n_2, ..., n_R\}$, a spatial equilibrium arises at $n_r \in]0,N[$ $\forall r$ (i.e., is interior) when optimal rewards are equalised across regions, $\Delta\pi(\Gamma) \equiv \pi_r(\Gamma) - \pi_s(\Gamma) = 0 \quad \forall s \neq r$.[31] The solution of that

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[29] Many NEG and NTT models allow for factor price equalisation (FPE) across regions by assuming costless trade of good W. This paper precludes FPE by assuming the non-tradability of W. Thus, our model is, to some extent, in the vein of Redding and Venables (2004), Hanson and Xiang (2004), Hanson (2005) and Knaap (2004).

[30] In other words, it is assumed capital owners hold a perfectly diversified portfolio; each of them has the same share of each firm around the world.

[31] Nonetheless, it is worth noting that a spatial equilibrium could also arise at n_r=0 for some $r \neq s$ when $\Delta\pi(\Gamma) \leq 0$.

system, which characterises the interior equilibrium or spatial division of industry $\Gamma^* = \{n_1^*, n_2^*, ..., n_R^*\}$, is a synthesis of the interaction between ensuing 'accessibility' and 'attraction' forces.

Let get a picture of this: when capital services relocate, in response to profit differentials, competition across varieties increases and the price of some productive factors (hence production costs) tend to rise in the region where new firms arrive. Therefore incentives for further agglomeration fall. On the other hand and due to the presence of vertical linkages, capital services relocation simultaneously reduces the price index of intermediates, fostering further agglomeration. Which of these offsetting forces will prevail depends on the parameters of the model. For instance, if trade costs and the share of varieties (with high elasticity of substitution) in production are low, manufacturing production may be distributed proportional to the population size. On the contrary, if trade costs are high and intermediate varieties (with low elasticity of substitution) are an important input, then production can agglomerate in one or few regions. Thus, the spatial equilibrium is the result of complex dynamics where 'accessibility' and 'attraction' forces together with initial conditions are determinant.

The production of $m(i)$ units of variety i requires a fixed amount F of capital-services and a variable amount $\beta x(i)$ of a Cobb-Douglas composite input. This variable input combines labour and natural resources (l_r) with composite price ω_r and share α, infrastructure services (z_r) with price v_r and input share γ, and a composite of intermediate varieties (M_r^{int}) with price P_r and input share ρ[32]; and it is assumed $\alpha+\gamma+\rho=1$. Thus, the implicit cost function of a firm producing variety i in region r is given by:

$$TC_r^M(i) = \pi_r F + \beta m_r(i) \omega_r^{\alpha} v_r^{\gamma} P_r^{\rho} \qquad (6)$$

where π_r is both rental rate of capital in region r and firm's operating profit under free entry.[33] From now on, let $\Psi_r \equiv \omega_r^{\alpha} v_r^{\gamma} P_r^{\rho}$ denotes the price of the Cobb-Douglas composite input.

Throughout the relocation process, the role of infrastructure is twofold. On the one hand, regional availability of lower-cost infrastructure services, Z_r, creates profit differentials and thus, *ceteris paribus*, fosters spatial concentration of firms within that region. More intuitively, firms' access to cheaper sources of gas and electricity, paved and inter-connected roads, and competitive telecommunication systems reduces variable operating costs, amplifies capital reward, π_r, and thus fosters agglomeration. On the other hand, infrastructure also affects the level of trade costs; it determines how intensely firms react to

[32] This intermediate composite has exactly the same form as the one consumed by individuals. Indeed, $M_r^{int} = \left[\sum_{s \in R} \int_{i \in n_s} q_{sr}^{M\,int}(i)^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}}$, where the elasticity of substitution between varieties is the same for consumption and production.

[33] The free entry-exit assumption precludes pure profits in sector M; then, operating profits just cover capital reward.

changes in surrounding 'stimulus', i.e., market access and competition effects. Other things been equal, the lower transport costs and the far-reaching spatial accessibility, the less spatially concentrated should be manufacturing production. In other words, upgraded transportation networks –such as roads, railways, waterways and their interfaces– improved border crossings, ports and airports, and enhanced competition in the transport industry multiply the number and increase the quality of alternative paths connecting regions, $\mathcal{P}_{rs}$. This, lastly, reduces the costs of available paths, and thus diminishes the effective transport cost, δ_{rs}, modifying the *RMP* or 'real opportunities' of firms located at region *r*.

3.H. THEORETICAL EXPORTS AND THEIR GRAVITATIONAL SPECIFICATION

To empirically specify the model, we start finding the theoretical expression for bilateral exports, which are given by $X_{rs} = \frac{p_{rs}}{\tau_{rs}} n_r \tau_{rs} \left[n_s q_{rs}^{M\,int}(i) + q_{rs}^{Mfin}(i) \right]$. First, $\frac{p_{rs}}{\tau_{rs}} n_r$ is replaced by the total value of production in region *r*, G_r. Next, we replace (3) and (7) and consecutively (12) into the expression for bilateral exports. Using expenditure notation and arranging terms we get:[34]

$$X_{rs} = aG_r \tau_{rs}^{\;1-\sigma} \Psi_r^{\;-\sigma} \left(E_s^{Mfin} + E_s^{M\,int} \right) P_s^{\;\sigma-1} \qquad (19)$$

with $a \equiv \left(\frac{\sigma - 1}{\sigma\beta} \right)^{\sigma}$.

Further, we replace Ψ_r and τ_{rs} into, and thus express bilateral exports as a function of factor prices, price indices, level of expenditure at destination, size of the region of origin (G_r) and the costs of trade:

$$X_{rs} = aG_r e^{(1-\sigma)t_{rs}} \delta_{rs}^{\;(1-\sigma)\phi} e^{(1-\sigma)\sum_k \varphi_k \lambda_{rs}^k} \left(\omega_r^{\;\alpha} \upsilon_r^{\;\gamma} \right)^{-\sigma} \left(E_s^{Mfin} + E_s^{M\,int} \right) P_r^{\;-\rho\sigma} P_s^{\;\sigma-1} \qquad (20)$$

As it can be regarded, this equation is a reminiscence of the well-known gravity equation, where G_r and E_s are indicative of economic size. Intuitively, region *r* has a better export performance the higher are: local production of *M* goods, partner's expenditure and partner's manufacturing price index; and the smaller are: local prices of L_r's and infrastructure services, local price index, and costs of trade with *s*. Coming back to expression (13), one realises that price indices are inverse functions of competition coming

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[34] Since preferences and technology are assumed identical in every region, and hence every firm has the same optimal volume of production, $m_r^* = m^*$, expression $G_r = n_r p_r m_r^*$ can be written as $G_r = n_r p_r m^*$. Therefore, $\frac{p_{rs}}{\tau_{rs}} n_r = \frac{G_r}{m^*}$ can be approximated by G_r when m^* is just a very small fraction of G_r. The replacement of n_r by G_r (or Y_r) is common among authors when accomplishing the empirical application of structural gravity equations.

from firms located everywhere[35]; that is, manufacturing price indices are smaller the smaller are costs of trade and production costs in the own region, and the larger is the number of firms everywhere[36].

The production of $m(i)$ units of variety i requires a fixed amount F of capital-services and a variable amount $\beta x(i)$ of a Cobb-Douglas composite input. This variable input combines labour and natural resources (l_r) with composite price ω_r and share α, infrastructure services (z_r) with price v_r and input share γ, and a composite of intermediate varieties (M_r^{int}) with price P_r and input share ρ[37]; and it is assumed $\alpha+\gamma+\rho=1$.

Taking the logarithm of that last expression, we find a linear specification for bilateral exports:

$$\ln X_{rs} = a' + \ln G_r - (\sigma-1)t_{rs} - (\sigma-1)\phi\ln\delta_{rs} - (\sigma-1)\sum_k \varphi_k \lambda_{rs}^k - \sigma\alpha\ln\omega_r - \sigma\gamma\ln v_r + \ln\left(E_s^{Mfin} + E_s^{Mint}\right) - \sigma\rho\ln P_r + (\sigma-1)\ln P_s \quad (21)$$

where $a' \equiv \ln\left(\dfrac{\sigma-1}{\sigma\beta}\right)^{\sigma}$.

Re-writing (21) we get the empirical specification of our gravity equation:

$$\ln X_{rs} = b_0 + b_1\ln G_r + b_2 t_{rs} + b_3\ln\delta_{rs} + b_4\sum_k \varphi_k\lambda_{rs}^k + b_5\ln\omega_r + b_6\ln v_r + b_7\ln\left(E_s^{Mfin} + E_s^{Mint}\right) + b_8\ln P_r + b_9\ln P_s + \varepsilon_{rs} \quad (22)$$

where: $b_0 > 0$, $b_1 = b_7 = 1$, $b_2 = b_4 < 0$, $b_3 < 0$, $b_5 < 0$, $b_6 < 0$, $b_8 < 0$, $b_9 > 0$ and ε_{rs} is the error term.

4. ARGENTINEAN REGIONS: DATA AND METHODOLOGICAL ISSUES

Having presented the model, this section focuses on its application for Argentinean regions. The country, with a land area of 3.761.274 squared kilometres, is populated by around 38,5 million inhabitants (INDEC, 2005) non-homogeneously distributed across twenty four political-administrative districts called 'provinces'. The provinces, which geographical positions are represented in the map in Appendix *A.2*, are commonly grouped into five 'natural' regions, namely: the Pampean region, the Northwest, the Northeast, Cuyo

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[35] The price index in region r is: $P_r = \dfrac{\sigma}{\sigma-1}\beta\left[\sum_{s\in R} n_s \tau_{sr}^{\,1-\sigma}\Psi_s^{\,1-\sigma}\right]^{\frac{1}{1-\sigma}}$. Interestingly, the competition effect implied by P_r is exactly the same is portrayed by the denominator of the Real Market Potential measure: $RMP_r \equiv \sum_{s\in R} RMP_{rs} = \sum_{s\in R}\left[\dfrac{\tau_{rs}^{\,1-\sigma}\left(E_s^{Mfin} + E_s^{Mint}\right)}{\sum_{q\in R} n_q \tau_{qs}^{\,1-\sigma}\Psi_q^{\,1-\sigma}}\right]$.

[36] That is why manufacturing price indices are regarded as remoteness and 'multilateral trade resistance' variables by Wolf (1997) and Anderson and van Wincoop (2003), respectively.

[37] This intermediate composite has exactly the same form as the one consumed by individuals. Indeed, $M_r^{int} = \left[\sum_{s\in R}\int_{i\in n_s} q_{sr}^{Mint}(i)^{\frac{\sigma-1}{\sigma}} di\right]^{\frac{\sigma}{\sigma-1}}$, where the elasticity of substitution between varieties is the same for consumption and production.

and Patagonia.[38] In terms of both production and export performance, the former region can be considered the richest and most productive territory within the country, while the Northwest and the Northeast are the less developed ones. To have a rough idea, in 2005 the Pampean region concentrated around 70 percent of national GDP and 80 percent of the manufacturing GDP, in opposition to the 6 and 4 percent that correspond to each of those two poor regions. Moreover, a bit more than 70 percent of total exports and 80 percent of manufacturing exports were originated in the 'national centre'; while a total of 5 and 7 percent, respectively, came from that 'periphery'.[39]

4.A. ARGENTINEAN REGIONAL DATA

In doing empirical work, many researchers are confronted with a not minor difficulty: the discrepancy between data-availability and data-requirements. The present work, unfortunately, is not the exception. Argentinean regional databases are virtually inexistent; thus one of the contributions this paper makes is the reunion of a rather systematic and comprehensive collection of statistical information at regional (and provincial) level.[40] Nevertheless, and as it will be clear throughout this section, the complete and careful data scrutiny accomplished has not precluded from taken some arbitrary decisions.

As it has been already mention, this paper studies Argentinean regional export performance between 2003 and 2005, a pretty recent period for which most relevant variables have complete statistical coverage.[41] Let's consider a time-varying version of expression (22) as a starting point for describing the variables analysed:[42]

$$\begin{aligned}\ln X_{rst} = b_0 + b_1 \ln G_{rt} + b_2 t_{rst} + b_3 \ln \delta_{rst} + b_4 \sum_k \varphi_k \lambda_{rs}^k + b_5 \ln \omega_{rt} + b_6 \ln \upsilon_{rt} + + b_7 \ln\left(E_{st}^{Mfin} + E_{st}^{M\,int}\right) + \\ + b_8 \ln P_{rt} + b_9 \ln P_{st} + \varepsilon_{rst}\end{aligned} \quad (23)$$

Variables:

X_{rst} is the value of manufacturing exports from region *r* to partner country *s* in year *t*. For this variable, we use a dataset developed by the National Institute of Statistics and Census (INDEC) of Argentina, disaggregated at four-digit level of the ISIC rev.2 and nine-digit level of MERCOSUR's nomenclature.[43]

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[38] The 24 provinces are: Misiones, Corrientes, Entre Ríos, Chaco, Formosa (located in the Northeast), Santa Fé, Buenos Aires, Córdoba, La Pampa, the city of Buenos Aires (in the Pampean region), Salta, Jujuy, Santiago del Estero, Tucumán, La Rioja, Catamarca (in the Northwest), San Luis, Mendoza, San Juan (in Cuyo), Neuquén, Río Negro, Chubut, Santa Cruz and Tierra del Fuego (in Patagonia).

[39] This paragraph refers to "*manufacturing exports of industrial origin*" which is the notion normally employed by the INDEC and other areas of the Ministry of the Economy in Argentina.

[40] Collected data is available from the author upon request.

[41] This is not the case for some previous years, for which data on infrastructure and resources is not available.

[42] Alternatively, expression (20) can be re-written as a time-varying empirical specification as follows: $X_{rst} = b_0 G_{rt}^{b_1} e^{b_2 t_{rst}} \delta_{rst}{}^{b_3} e^{b_4 \sum_k \varphi_k \lambda_{rs}^k} \omega_{rt}{}^{b_5} \upsilon_{rt}{}^{b_6} \left(E_{st}^{Mfin} + E_{st}^{M\,int}\right)^{b_7} P_{rt}{}^{b_8} P_{st}{}^{b_9} e^{\varepsilon_{rst}}{}_{rst}$.

[43] This dataset, which provides for annual provincial exports (values and physical quantities) distinguishing country of destination and type of product, is constructed on the basis of the 'Maria' System, applied by the

G_{rt} is the value of total manufacturing production in region *r* in year *t*. This study employs information offered by the Ministry of the Economy of Argentina on the annual Gross Geographic Product of every province, disaggregated at two-digit level of the ISIC rev.2.

τ_{rst}, which comprises t_{rst}, δ_{rst}, and λ_{rs}^{k}, are the ad-valorem trade costs for shipments from region *r* to partner country *s* in year *t*. As it has been already portrayed in the theoretical section, the trade cost function is replaced into the export equation; hence we directly deal with transport costs and other barriers to trade:[44]

1) t_{rst} denotes policy barriers to trade between region *r* and partner country *s* in year *t*. It is supposed to comprise at least two policy features: a) trade policy barriers imposed by the partner to Argentinean exports; and b) the negative of regional (and national) incentives to export and/or to produce manufactures. However, the lack of systematic information on domestic policies, together with the absence of complete and updated time series on partners' barriers to trade –i.e., tariff, non-tariff and technical barriers– make the inclusion of this variable impracticable.[45] Therefore, we must rely on a very imperfect option, which some authors take: to proxy t_{rst} by Regional-Trade-Agreement (RTA) dummies variables.
2) δ_{rst} represents transport costs to ship goods from region *r* to country *s* in year *t*, or 'transport infrastructure'. Trying to depart as less as possible from our model, and hanging upon some information about transport modes and border offices in the country, we 'create' an original proxy variable. In the following sub-section we give details about this variable.
3) λ_{rs}^{k} are other cultural and geographical *k* determinants of bilateral trade, such as contiguity, common language and landlocked-ness. They are represented by time-invariant 0-1 dummies, as usual in gravity literature.

ω_{rt} is the price of labour-and-natural-resources composite in region *r* in year *t*. Since the prices of factor services –such as labour, land and other resources like oil, gas, etc.– are not available at spatially disaggregated level, we rest on a proxy variable suggested and used by Hanson and Xiang (2004), namely: regional factor supply of these resources.[46] How this proxy is constructed and the sources consulted are described in the following sub-section.

v_{rt} is the price of infrastructure services, or 'production infrastructure', in *r* in year *t*. Again, because these prices are not available for each Argentinean region, we relay on a

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Directorate-General of Customs, together with additional information on firms' geographical location. On the methodology applied by the INDEC, refer to http://www.indec.gov.ar/nuevaweb/cuadros/19/comext_metod.pdf.

[44] The decision of introducing the trade cost function into the export equation, instead of estimating trade costs as it was suggested by Head and Mayer (2004) and accomplished by Bosker and Garretsen (2007), is mainly due to lack of data on internal trade flows, both across Argentinean regions and within partner countries.

[45] In the case of domestic (regional) promotion policies, we reviewed two main sources: FIEL (2003)'s study on business atmosphere in Argentinean provinces and the WTO (2007)'s trade policy review of the country.

[46] The authors argue that: "*In general equilibrium, national factor supplies map into national factor prices and these factor prices map into industry production costs. (…). This is clearly a reduced-form treatment of production costs, but one that is necessitated by a lack of detailed cross-national cost data…*" (page 1114).

proxy like the latter. This 'solution' we employ is in line with studies that intend to measure the impacts of infrastructure improvements on trade –reviewed in section 2– thus the focus of this paper is not threatened. In the following sub-section, details about the construction of this proxy variable are given.

$\left(E_{st}^{Mfin} + E_{st}^{M\,int}\right)$ denotes the sum of final (or consumers') *M* expenditure and intermediate (or firms') *M* expenditure in region *s* in year *t*. Since we were not able to find data on this variable for every partner and every year, national GDP was taken as a proxy –i. e. a common practice within gravity literature.

P_{rt} and P_{st} are the manufacturing price indices in each region in year *t*. To represent them in the gravity equation well-known authors –Combes, et al. (2006); Baldwin and Taglioni (2006); and Shepherd and Wilson (2006) among others– suggest these alternatives: 1) to separately estimate the non-linear price indices; 2) to use direct measures of that indices, which, however, might crucially differ from their theoretical definition; and 3) to replace them by time varying nation dummies. In this study, however, we have to omit including the price indices into the export equation. While alternatives one and two were disregarded due to lack of detailed regional data; the third one was ignored in order to preserve one of our focuses: regional 'production infrastructure', which is represented by a time varying regional variable as well.

To sum up, the computation of every variable attempts to depart as less as possible from the spirit of our model; however, as reported above, many difficulties appear. In case available data do not exactly coincide with variables' theoretical definitions, we look for selecting proxy variables over which there seems to be consensus within the literature. At this stage, though some variations are indeed introduced, our last aim is to favour the completion of the paper's objectives. Besides, in the absence of any reliable data, we just omit the variable. Therefore, it is due to note that the omission and/or the erroneous measurement of some variables, such as t_{rst}, P_{rt} and P_{st}, may bring biased estimates.

4.B. Measuring Endowments, Infrastructure and Transport Costs

To measure 'production infrastructure', v_{rt}, we have taken data on the length of the paved road network –in kilometres per hundred of square kilometres– from INDEC, on the per capita consumption of electricity (MW per hour) and the share consumed by industry from the Secretariat of Energy, on the number of fixed and mobile telephone subscribers –per 10.000 people– from the National Communications Commission (CNC), and on the per capita consumption of natural gas (thousands of cubic metres) and the share consumed by industry from the National Gas Regulatory Authority (ENARGAS). In order to build a summary index, we apply principal component analysis (PCA), following Sánchez-Robles

(1998) and posterior studies –such as Calderon and Serven (2004), Benedictis et al. (2006) and Francois and Manchin (2007).[47]

Table 1: **REGIONAL INFRASTRUCTURE AND RESOURCES INDICES. 2003-2005**

Argentinean Regions	'Production infrastructure'			Resources		
	2003	2004	2005	2003	2004	2005
CUYO	13,69	18,06	25,48	0,045	0,043	0,043
NORTHEAST	8,86	12,85	18,44	0,028	0,027	0,030
NORTHWEST	9,87	13,65	19,40	0,006	0,008	0,012
PAMPEAN	17,57	22,59	30,55	0,114	0,116	0,113
PATAGONIA	20,19	26,12	35,36	0,027	0,027	0,029

Source: Author's calculations.

As it is shown by Table 1, the Northeast and Northwest regions are the less endowed territories in terms of infrastructure, while the Pampean and Patagonian regions are the best endowed ones. The picture given by the 'production infrastructure' Index (PCA^{INF}) is, in general terms, in line with what one can expect. Nevertheless, the relative position of the Northeast with respect to the Northwest and of Patagonia in relation with the Pampean region could be questioned. In the case of the northern regions, one of the factors that may be explaining this apparent divergence is that the Northeast –excepting the province of Entre Ríos– is the only region in the country that does not have access to natural gas supply. As regards the Pampean region vs. Patagonia, the seemingly counterintuitive indices seem to be the result of actual differences in terms of per capita energy consumption.

In the case of regional factor supply, the procedure to obtain a summary index of labour and natural resources was again the application of principal component analysis. The main difficulty is to find updated data on labour and/or human capital resources at regional level. The most complete datasets, which are provided by the INDEC, or the National University of La Plata, run until the late nineties or the very early 2000s. Hence, the construction of ω_{rt} must rely on rather 'imperfect' figures, namely: the number of enrolled students taken from INDEC; the cultivated area –of different crops, in kilometres per square kilometre of land area– provided by the Secretariat of Agriculture, Livestock, Fisheries and Food; the production of oil (cubic metres) and gas (thousands of cubic metres) supplied by the Secretariat of Energy; and the nominal electric potency installed (MW) taken from the same Secretariat. Table 1 shows that by far the Pampean region is the best endowed, Cuyo occupies the second place, followed by the Northeast and Patagonia, while the Northwest region is the poorest territory. Again, in general terms, this picture seems quite reliable. However, it should be noted that since the first component and, even more, the last one received relatively higher weights –within the principal component analysis– northern regions would be relatively prejudiced.

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[47] Our indices are given by the first principal component of the underlying variables.

To complete this section, let's consider the construction of the variable that represents transport costs, δ_{rs}, or 'transport infrastructure'. One alternative, perhaps the most accurate, would have been to estimate expression (11); nevertheless, the lack of detailed data and the highly time-and-resource-consuming computations required preclude us from this possibility. Therefore, trying to depart as less as possible from our setting, we create a proxy variable that divides total transport costs into two 'spatial portions'. Specifically, we assume only two edges must be 'hiked' to joint nodes *r* and *s*, namely: an 'interior' edge connecting node *r* with 'exit-node' *q*, and an 'exterior' or 'extra-territorial' edge joining *q* with final destination *s*.[48] Intuitively, shipping goods from, for instance, Cuyo to Asunción (Paraguay) implies travelling inside the country from Cuyo to Clorinda's border station, and then from Clorinda to Asunción. This, within our theoretical setting, implies total transport costs between *r* and *s* are the minimal product between 'internal' and 'external' transport costs, $\delta_{rs} = min(c_{rq}c_{qs})$.[49]

Relying on some information about modes of transport more frequently used to ship goods, both inside Argentina and abroad (Cristini et al., 2002; Hoffman et al., 2002; Sánchez and Cipoletta, 2003; and CEP, 2004), main road corridors of South America and MERCOSUR (Cristini et al., 2002; and Sánchez and Cipoletta, 2003), and more important border stations in each Argentinean region (Sánchez and Cipoletta, 2003; Bolsa de Comercio de Córdoba, 2003; and Gendarmería Nacional, 2007), we create a measure for 'internal' transport costs, c_{rq}.[50] The procedure to construct it seems to be in line with recent studies on country trading capabilities, such as Brun et al. (2006), Grigoriou (2007) and Dennis and Shepherd (2007), among others. Specifically, our measure of c_{rq} stands for *the minimal road distance from the most distant provincial capital city*, inside each region[51], *to the closest and most transited 'exit-node'* to reach final destination *s* –i.e., port or road border crossing which is the most relevant exporting gate more closely located to the majority of provincial capital cities in that region.[52] The list of chosen 'exit-nodes' for every region and every foreign destiny is presented in Appendix *A.3*. Since this variable is quite relevant for this work, we consider an alternative to this measure, namely the *average minimal road distance from every provincial capital city to that closest 'exit-node'*. Finally, to compute 'external' transport costs, c_{qs}, we opt for applying the most commonly used strategy within the gravity literature: to calculate geodesic (great circle) distance between the 'exit node' and each partner's capital city.

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[48] Thus, any path connecting *r* and *s*, $\mathcal{P}\in\mathcal{P}_{rs}$, is double-edge.

[49] Recall that c_{oq}>1 is the 'iceberg coefficient' of edge (*o*,*q*), which joints node *o* with node *q*.

[50] It is worth to mention that, instead of applying a monetary indicator for c_{rq} as it is proposed in the model, we have to rely on a 'physical' or 'real' measure quantified in terms of kilometres.

[51] This is done to take into account the accessibility difficulties faced by the most disadvantageously located capital city inside each region.

[52] Indeed, the present study does not consider rail and airborne modes of transport. They are disregarded because their participation is marginal –either railways for internal/external transit or planes for external one– as it can be corroborated going through references above. Even so, it is worth to note that some high-priced manufacturing items, mainly some sold to USA or EU, are actually transported by plane, and the virtually unique airport that operates international cargo is Ezeiza, in Buenos Aires.

4.C. ESTIMATION PROCEDURE

The model, in its log-linear specification presented below, is estimated for period 2003-2005 using a data set of 310 bilateral export flows, which took place between Argentinean regions and 23 partner countries. As it is common in trade studies, the analysis is limited to a set of foreign trade partners that explain around 75 and 80 percent of national manufacturing exports; these countries are: Brazil, Uruguay, Paraguay, Bolivia, Chile, Mexico, the United States, China and the 15 European Union members of 1995 –Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Portugal, Spain, Sweden, the Netherlands and the United Kingdom.

$$\begin{aligned}\ln Exp_{rst} &= b_0 + b_1 \ln GMP_{rt} + b_2 GDP_{st} + b_3 \ln dist_{rq} + b_4 \ln dist_{qs} + b_5 \ln PCA_{rt}^{INF} + b_6 \ln PCA_{rt}^{END} + b_7 Locked_r \\ &\quad + b_8 Locked_s + b_9 Border_{rs} + b_{10} Langue_{rs} + b_{11} MERCO_s + b_{12} ASOMER_s + b_{13} NAFTA_s + b_{14} EU_s + \varepsilon_{rst}\end{aligned} \quad (24)$$

where: Exp_{rst} stands for regional exports; GMP_{rt} is gross manufacturing product; GDP_{st} stands for gross domestic product of partner countries; $dist_{rq}$ are 'internal' transport costs (the measure of c_{rq}); $dist_{qs}$ represents 'external' transport costs (c_{qs}); PCA_{rt}^{INF} is 'production infrastructure'; PCA_{rt}^{END} stands for regional factor supply (ω_{rt}); $Locked_r$ is a dummy that takes the value of 1 for those regions without coastline, and zero otherwise; $Locked_s$ is a dummy which equals 1 for those partners without coastline; $Border_{rs}$ is a dummy which takes the value of 1 for those region-partner pairs that are contiguous; $Langue_{rs}$ is a dummy that equals 1 for those region-partner pairs where the same language is spoken; $MERCO_s$ is a RTA dummy that takes the value of 1 for those partners that are members of MERCOSUR; $ASOMER_s$ is a RTA dummy which equals 1 for those partners which are just 'associated' members of MERCOSUR; $NAFTA_s$ is a RTA dummy which takes the value of 1 for the members of NAFTA; EU_s is a dummy that equals 1 for the members of the European Union; and ε_{rst} is a log-normally distributed error term. Data sources and other details on these variables are presented in Appendix *A.4*.

Ordinary Least Square regressions are carried out using pooled data and correcting for heteroskedasticity. With respect to zero trade flows, they are disregarded due to their negligible amount; only 35 observations represent inexistent trade flows out of the potential 345 observations –remember we are working with 5 regions and 23 partner countries.[53] Additionally, Poisson pseudo-maximum likelihood (PPML) estimators are applied to the non-linear form of the gravity equation –i.e., prior to taking logarithms– the expression (25). This variation, suggested by Santos Silva and Tenreyro (2006), intends to find out more consistent estimates than the one obtained under OLS. In the presence of heteroskedasticity

[53] If this were not the case and the amount of zero trade flows were indeed relevant, we would have evaluated applying an alternative estimation strategy, such as those suggested by Helpman et al. (2007) and Francois and Manchin (2007), among others.

–even controlling for fixed effects– the interpretation of OLS parameters in the log-linear equation as elasticities can be misleading due to likely biases.[54]

$$Exp_{rst} = \exp\begin{bmatrix} b_0 + b_1 \ln GMP_{rt} + b_2 GDP_{st} + b_3 \ln dist_{rq} + b_4 \ln dist_{qs} + b_5 \ln PCA_{rt}^{INF} + b_6 \ln PCA_{rt}^{END} + b_7 Locked_r \\ + b_8 Locked_s + b_9 Border_{rs} + b_{10} Langue_{rs} + b_{11} MERCO_s + b_{12} ASOMER_s + b_{13} NAFTA_s + b_{14} EU_s \end{bmatrix} + v_{rst} \quad (25)$$

5. Regional Export Performance: Infrastructure and Transport Costs

The table in the following page summarises the results of our estimations. The first column shows estimated coefficients, t-statistics and the R^2 for the case of 'internal' transport cost measured as the *minimal road distance from the most distant provincial capital city* to the closest 'exit node'; while the second column gives the results when that transport cost is measured as the *average minimal road distance from every provincial capital city* to that closest 'exit-node'. The R^2 of both regressions presents values, between 62% and 66%, that confirm the ability of the gravity model to explain regional manufacturing exports from Argentina towards those selected countries.

To begin with, let's analyse the first column of results. 'Production infrastructure' (PCA^{INF}) behaves as it was expected: positively affecting export performance; specifically, a 1% improvement in infrastructure is associated with a 1,7% increase in exports. The other policy-relevant variable, 'internal' transport costs ($dist_{rq}$), is also statistically significant. A 1% reduction of this trade costs implies a boost of 5% in regional exports. The average distance elasticity, taking together 'internal' and 'external' transport costs, is around -1,5, which is stronger than the central tendency of the gravity literature (around -0,9). The difference, we presume, is due to two issues: the use of overland distances for the 'internal' fraction, instead of the more common great circle measure; and our focus over just one large country like Argentina, in which road distance may very likely play a decisive role. With respect to the economic mass variables, *GMP* and *GDP*, results are mixed. On the one hand, the effect of partner's economic size is the expected one, with a point estimate close to 1. On the other, regional *GMP* is statistically significant and seems to deter manufacturing exports. This is an awkward outcome, some of which explanations could be: first, that manufacturing exports may comprise very specialised products, which sales are is not necessarily correlated with the size of manufacture activity as a whole; and second, that ignoring domestic (inter-regional) trade flows may introduce some non-innocuous biases since regional *GMP* is more closely related to overall Argentinean market-size, instead of just regional market-size.

[54] As it is explained by Shepherd and Wilson (2006), the main difference between (25) and (24) relates to the error term. While the latter assumes the error is additive in the log-linear specification –or exp(ε_{rst}) is multiplicative in the original non-linear specification– equation (25) assumes the error is additive in the non-linear specification. Hence, if (25) represents the 'true' model, the OLS estimator of (24) is generally inconsistent.

***Table 2:* A R G E N T I N E A N R E G I O N A L E X P O R T P E R F O R M A N C E. 2003-2005**

Estimator	**OLS**	**OLS**	**Poisson pseudo-ML**	**Poisson pseudo-ML**
	Maxim. distance	Av. minim. dist.	Maxim. distance	Average minim. dist.
$\ln GMP_{rt}$	-4,28***	-4,13***	-1,55***	-1,57***
	(-5,25)	(-4,47)	(-3,61)	(-3,63)
$\ln GDP_{st}$	1,17***	1,16***	0,46***	0,44***
	(9,20)	(8,49)	(6,53)	(6,36)
$\ln dist_{rq}$	-4,98***	-2,96***	-3,82***	-2,83***
	(-8,04)	(-5,38)	(-16,69)	(-11,07)
$\ln dist_{qs}$	-2,03*	-1,97	-1,70*	-1,65*
	(-2,07)	(-1,88)	(-2,21)	(-2,20)
$\ln PCA_{rt}^{INF}$	1,69*	1,29	1,22**	1,23***
	(2,30)	(1,67)	(3,28)	(3,24)
$\ln PCA_{rt}^{END}$	0,28	1,16**	0,04	0,68*
	(0,80)	(3,04)	(0,21)	(3,15)
$Locked_r$	1,95	3,92**	0,90	0,55
	(1,66)	(3,05)	(-1,41)	(0,87)
$Locked_s$	-0,59	-0,76	-0,41	-0,53*
	(-0,83)	(-1,07)	(-1,55)	(-2,13)
$Border_{rs}$	-3,83***	-3,12***	-2,87***	-2,84***
	(-6,63)	(-4,90)	(-14,54)	(-10,56)
$Langue_{rs}$	2,28***	2,20***	1,06***	1,07***
	(6,07)	(5,25)	(5,85)	(5,90)
$MERCO_s$	3,8***	3,72**	1,40	1,71
	(3,19)	(3,01)	(1,53)	(1,86)
$ASOMER_s$	4,1***	4,04***	1,35*	2,02**
	(3,92)	(3,73)	(1,98)	(2,88)
$NAFTA_s$	-2,34***	-2,35***	-1,32***	-1,34***
	(-4,47)	(-4,05)	(-6,01)	(-6,28)
EU_s	-3,22***	-3,21***	-2,05***	-2,06***
	(-5,17)	(-4,82)	(-5,03)	(-5,22)
const	133,1***	117,0***	80,7***	73,8***
	(7,57)	(6,06)	(6,93)	(6,44)
R^2	0,667	0,621	0,90 (pseudo R^2)	0,89 (pseudo R^2)
N° obs,	310	310	310	310

Notes: t-statistics under the point estimates. * for p-values < 0,05, ** for p-values < 0,01 and *** for p-values < 0,001. There are no zeros in this dataset.

The other statistically significant variables are most of the dummies; which coefficients have, in general terms, the expected signs. Nevertheless, in the case of '*Border*' the effect is estimated to be negative rather than positive. One possible explanation for this can be that many Argentinean regions contiguous to partners are economically under-developed; hence, they both suffer relatively more from neighbours' competition and display weaker exporting capabilities. Finally, the behaviour of RTA dummies is reasonable. After controlling for other effects, to be a member country of the 'enlarged' MERCOSUR –namely, Brazil, Paraguay, Uruguay, Chile and Bolivia– tend to boost regional exports; on the contrary, to be a member of either NAFTA or EU does spoil those trade flows. In other words, trade preferences within MERCOSUR facilitate regional exports, while preferences among European and North-American countries reduce trade flows towards those destinations.

The second column of Table 2 presents results that should be viewed as a robustness check to the measurement of 'internal' transport costs. The most important changes with respect to the first regression are shown by 'external' transport costs and PCA^{INF}, which are now statistically insignificant, though the sign of their point estimate remains unaltered and, hence, economically meaningful. The other variables which change their explicative value are PCA^{END} and '$Locked_r$'; showing both positive coefficients. While the first result is reasonable, the last one seems rather strange. Nonetheless, it should be interpreted as follow: the reduction of 'internal' transport costs –which is indeed the change introduced in the second regression– tends to increase exports from land-locked territories vis-à-vis 'un-locked' regions.[55] To sum up, based on OLS estimates, we tentatively conclude that lower 'internal' transport costs, improved 'production infrastructure', higher trade preferences and lower trade 'indifferences', among other variables, are all associated with stronger regional export flows.

Poisson pseudo-maximum likelihood estimations, which perform very well (R^2 of around 90%), produce rather similar results to those of the OLS case, with lower coefficients in absolute value –an effect noted by Santos Silva and Tenreyro (2006) and Shepherd and Wilson (2006). The policy-relevant variables, PCA^{INF} and '$dist_{rqt}$' remain statistically significant and have the expected sign; with point estimates lower, in absolute values, than OLS ones. In terms of magnitude, 1% improvement in PCA^{INF} or 1% reduction of 'internal' transport costs are associated with trade increases of around 1,2% and 3,3% (average), respectively. Differently from OLS estimations, PPML ones show MERCOSUR membership is not a statistically relevant stimulus of regional exports. On the contrary, NAFTA and EU membership continues deterring trade; namely, PPML models predict exports towards European or North-American countries are between 274,3 and 676,8 percent lower than exports to non-EU and non-NAFTA countries.[56]

To sum up, most estimated coefficients are quite stable across specifications and carry the expected signs. More importantly, our policy variables seem to be robust determinants of regional export performance. Infrastructure enhancement or the reduction of 'internal' transport costs may effectively help for changing regional competitiveness and market accessibility; thus these are policies which could facilitate turning the destiny of less developed or advantaged Argentinean regions.

6. CONCLUSIONS

This paper has addressed regional export performance focusing on the role played by 'transport infrastructure' and 'production infrastructure' in the competitiveness and interconnection of different geographical spaces. First, and after carefully reviewing theoretical and empirical antecedents, we have set up a theoretical model that concentrates on transport costs and regional infrastructure as determinants of export performance. From that framework, a model-based gravity equation has been derived. This specification,

[55] From our theoretical framework, the reduction of $dist_{rq}$ tends to make the possession of regional assets (PCA^{END}) a more relevant determinant of external competitiveness.

[56] The formula to compute this effect is $(e^{b_i} - 1) * 100\%$, where b_i is the estimated coefficient.

differently from others, emphasises the role played by regional assets and resources, and introduce a creative transport cost function à la Behrens et al. (2005).

After that, and in order to apply the empirical specification for the case of Argentinean regions, we have gathered a systematic and comprehensive collection of statistical information at regional (and provincial) level, which at the moment of our study was inexistent. This careful and laborious data scrutiny –which has been very time-demanding– has nonetheless not precluded from taken some arguable decisions, such as the selection and construction of proxies and the omission of some variables in our application. This is a weakness of our study which may bring biased estimates. Thus there is considerable scope for additional work, first, on data collection and processing, and secondly, on variable construction and measurement.

Finally, the structural gravity equation has been estimated for Argentina between 2003 and 2005. The results found suggest some interesting considerations for policy, namely: the importance of infrastructure enhancement and/or transport-costs reduction for boosting regional export performance –thus, for helping to reduce regional disparities. A second important policy implication is that regional trade preferences (or 'indifferences') –more broadly, trade policy– seem to be also transcendental in determining bilateral exports. While our contribution is suggestive in theoretical and empirical terms, there remain important research questions to be considered in future work. For instance, improvements could be introduced in the measurement of transport costs, regional factor prices and in the construction of variables such as trade policy and price indices. In the case of transport costs, it will be important to consider 'monetary' costs, instead of 'real' ones, together with the inclusion of different transport modes and their interactions.

APPENDIX

A.1. COMPLETING THE MODEL

The non-tradable sector is kept as simple as possible, It produces a homogeneous good under constant returns to scale (CRS) and perfect competition; and its output cannot be traded inter-regionally –or, what is the same, its costs of trade are infinite, It is assumed that the production of W_r units requires a variable amount ζW_r of a Cobb-Douglas composite input, which combines labour and natural resources (l_r) with share $\eta \in]0,1[$, and infrastructure services (z_r) with input share (1-η), Therefore, the production and cost functions of a firm in sector W are, respectively:

$$W_r = \zeta l_r^{\eta} z_r^{1-\eta} \quad \text{(1A)} \quad \text{and} \quad TC_r^W = \zeta W_r \omega_r^{\eta} v_r^{1-\eta} \quad \text{(2A)}$$

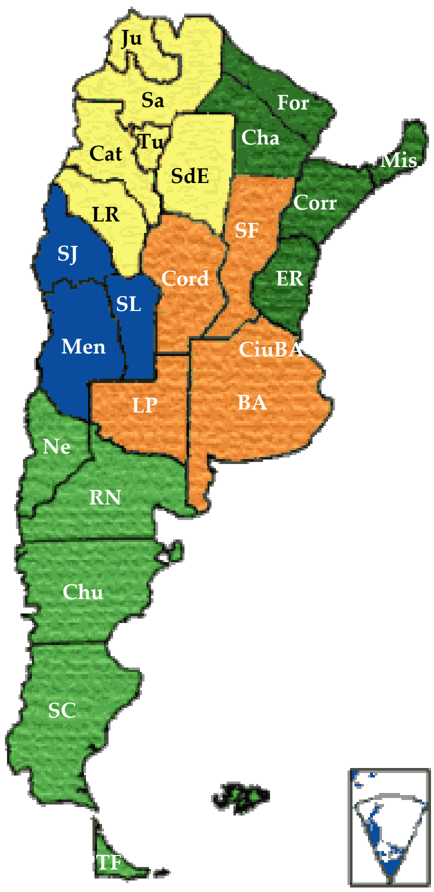
In each region, the W sector maximises its profits, Under CRS and perfect competition, the first order conditions imply that $p_r^W = \zeta \omega_r^{\eta} v_r^{1-\eta}$, and inputs demands take the following form:

$$l_r^W = \eta \frac{W_r}{\omega_r} \zeta \omega_r^{\eta} v_r^{1-\eta} \quad (3A) \quad \text{and} \quad z_r^W = (1-\eta)\frac{W_r}{v_r} \zeta \omega_r^{\eta} v_r^{1-\eta} \quad (4A)$$

The sector's production will equalise final demand of the homogeneous good, $W_r p_r^W = W_r \zeta \omega_r^{\eta} v_r^{1-\eta} = (1-\mu)Y_r$, Therefore, we can express inputs demands in terms of regional income:

$$l_r^W = \eta \frac{(1-\mu)Y_r}{\omega_r} \quad (5A) \qquad \text{and} \qquad z_r^W = (1-\eta)\frac{(1-\mu)Y_r}{v_r} \quad (6A)$$

A.2. ARGENTINEAN REGIONS AND PROVINCES



Natural Regions	Provinces
Northwest	Jujuy (Ju), Salta (Sa), La Rioja (LR), Tucumán (Tu), Catamarca (Cat) and Santiago del Estero (SdE)
Northeast	Formosa (Fo), Chaco (Cha), Misiones (Mis), Corrientes (Corr) and Entre Ríos (ER)
Cuyo	San Juan (SJ), San Luis (SL) and Mendoza (Men)
Pampean	Córdoba (Cord), Santa Fé (SF), Buenos Aires (BA) and La Pampa (LP)
Patagonia	Neuquén (Ne), Río Negro (RN), Chubut (Chu), Santa Cruz (SC) and Tierra del Fuego (TF)

A.3. LIST OF 'EXIT-NODES' WITHIN ARGENTINEAN REGIONS

Natural Region	Partner country	Closest 'exit node'	Av. min kms.	Kms. most distant capital	S. lat. 'exit node'	W. long. 'exit node'
Pampeana	Brazil	Paso de los Libres	797	1193	29°43′	57°07′
Pampeana	Uruguay	Paso Gualeguaychú	444	740	33°10′	58°30′
Pampeana	Paraguay	Paso Clorinda	1211	1560	25°16′	57°42′
Pampeana	Bolivia	Paso La Quiaca	1596	1871	33°10′	50°58′
Pampeana	Chile	PsoCR	1089	1311	32°49′	70°05′
Pampeana	Mexico	Puerto de Buenos Aires	369	716	34°36′	58°22′
Pampeana	EU (15)	Puerto de Buenos Aires	369	716	34°36′	58°22′
Pampeana	USA	Puerto de Buenos Aires	369	716	34°36′	58°22′
Pampeana	China	Puerto de Buenos Aires	369	716	34°36′	58°22′

Northeast	Brazil	Paso Santo Tomé	489	669	29°43′	57°07′
Northeast	Uruguay	Paso Concordia	598	799	31°18′	51°01′
Northeast	Paraguay	Paso Clorinda	418	817	25°16′	57°42′
Northeast	Bolivia	Paso S, Mazza	1222	1406	33°10′	50°58′
Northeast	Chile	Paso Jama	1443	1645	23°14′	67°01′
Northeast	Mexico	Puerto Rosario	521	926	33°10′	60°28′
Northeast	EU (15)	Puerto Rosario	521	926	33°10′	60°28′
Northeast	USA	Puerto Rosario	521	926	33°10′	60°28′
Northeast	China	Puerto de Buenos Aires	934	1154	34°36′	58°22′
Patagonia	Brazil	Paso de los Libres	2461	3708	29°43′	57°07′
Patagonia	Uruguay	Paso Gualeguaychú	2007	3275	33°10′	58°30′
Patagonia	Paraguay	Paso Clorinda	2830	4090	25°16′	57°42′
Patagonia	Bolivia	Paso La Quiaca	3132	4268	33°10′	50°58′
Patagonia	Chile	Paso Integrac, Austral	1120	1986	52°07′	59°31′
Patagonia	Mexico	Puerto S, Antonio Este	909	2065	40°48′	64°52′
Patagonia	EU (15)	Puerto S, Antonio Este	909	2065	40°48′	64°52′
Patagonia	USA	Puerto S, Antonio Este	909	2065	40°48′	64°52′
Patagonia	China	Puerto de Buenos Aires	1901	3088	34°36′	58°22′
Northwest	Brazil	Paso de los Libres	1265	1458	29°43′	57°07′
Northwest	Uruguay	Paso Concordia	1121	1375	31°18′	51°01′
Northwest	Paraguay	Paso Clorinda	1113	1238	25°16′	57°42′
Northwest	Bolivia	Paso La Quiaca	673	1031	33°10′	50°58′
Northwest	Chile	Paso Jama	738	1096	23°14′	67°01′
Northwest	Mexico	Puerto Rosario	932	1208	33°10′	60°28′
Northwest	EU (15)	Puerto Rosario	932	1208	33°10′	60°28′
Northwest	USA	Puerto Rosario	932	1208	33°10′	60°28′
Northwest	China	Puerto de Buenos Aires	1250	1526	34°36′	58°22′
Cuyo	Brazil	Paso de los Libres	1290	1398	29°43′	57°07′
Cuyo	Uruguay	Paso Gualeguaychú	1048	1177	33°10′	58°30′
Cuyo	Paraguay	Paso Clorinda	1600	1692	25°16′	57°42′
Cuyo	Bolivia	Paso La Quiaca	1540	1627	33°10′	50°58′
Cuyo	Chile	Paso Cristo Redentor	346	466	32°49′	70°05′
Cuyo	Mexico	Puerto Rosario	757	913	33°10′	60°28′
Cuyo	EU (15)	Puerto Rosario	757	913	33°10′	60°28′
Cuyo	USA	Puerto Rosario	757	913	33°10′	60°28′
Cuyo	China	Puerto de Buenos Aires	984	1113	34°36′	58°22′

Source: Author's calculations. For details on the calculation of these road distances please contact the author.

A.4. Data and Sources

Variable	Description	Units	Years	Source
X_{rst}	Current manufacturing exports of each region, calculated applying ISIC 4 digit-level classification. (*)	Dollars; converted into thousands.	2003-2005	National Institute of Statistics and Census (INDEC).
GMP_{rt}	Current manufacturing GGP of each region, calculated applying ISIC at 2 digit-level.	Pesos; converted into thousands of dollars.	2003-2005	Ministry of the Economy and exchange rate from Centre of International Economy http://cei.mrecic.gov.ar/home.htm
GDP_{st}	Current GDP of each country partner.	Dollars; converted into thousands.	2003-2005	World Bank's "World Development Indicators" (WDI).
$dist_{rq}$	Constructed using the length of the shortest Argentinean route between each pair of cities.	Kilometres	2007	Electronic atlases "Ruta 0" (www.ruta0.com) and "Welcome Argentina" (http://www.welcomeargentina.com)
$dist_{qs}$	Great circle distance	Kilometres	2007	Author's calculations.
PCA_{rt}^{INF}	Regional infrastructure index, constructed through PCA.	Index	2003-2005	Author's calculations. See bellow about sources.

PCA_{rt}^{END}	Regional resources index, constructed through PCA.	Index	2003-2005	Author's calculations. See bellow about sources.
$Locked_r$	Dummy variable; 1 for regions without coastline.	0-1	-	Author's calculations.
$Locked_s$	Dummy variable; 1 for countries without coastline.	0-1	-	Author's calculations.
$Border_{rs}$	Dummy variable; 1 for contiguous region-partner pairs.	0-1	-	Author's calculations.
$Langue_{rs}$	Dummy variable; 1 for region-partner pairs with same official language.	0-1	-	Author's calculations.
$MERCO_s$	Dummy variable; 1 for members of MERCOSUR.	0-1	-	Author's calculations.
$ASOMER_s$	Dummy variable; 1 for associated members of MERCOSUR.	0-1	-	Author's calculations.
$NAFTA_s$	Dummy variable; 1 for members of NAFTA.	0-1	-	Author's calculations.
EU_s	Dummy variable; 1 for members of EU15.	0-1	-	Author's calculations.
'Production infrastructure' PCA				
Length of paved road national network in each region.		Kms. per 100 square kms.	2003-2005	Author's calculations based on INDEC.
Regional per capita consumption of electricity.		MW per hour and per capita	2003-2005	Author's calculations based on Secretariat of Energy.
Share of total consumption of electricity used by industry in each region.		Percent, MW per hour	2003-2005	Author's calculations based on Secretariat of Energy.
Number of fixed telephone subscribers in each region.		Per ten thousand people	2003-2005	Author's calculations based on National Communications Commission.
Number of mobile telephone subscribers in each region.		Per ten thousand people	2003-2005	Author's calculations based on National Communications Commission.
Regional per capita consumption of gas natural.		Thousands of cubic metres.	2003-2005	Author's calculations based on National Gas Regulatory Authority.
Share of total consumption of natural gas used by industry in each region.		Percent, thousands of cubic metres.	2003-2005	Author's calculations based on National Gas Regulatory Authority.
Resources PCA				
Regional share of enrolled students (% over Argentinean total)		Percent.	2003-2005	Author's calculations based on INDEC.
Cultivated area of cereals in each region.		Kms. per square km. of land area	2003-2005	Author's calculations based on Sec. of Agric., Livestock, Fisheries and Food.
Cultivated area of oilseeds in each region.		Kms. per square km. of land area	2003-2005	Author's calculations based on Sec. of Agric., Livestock, Fisheries and Food.
Cultivated area of industrial crops in each region. (**)		Kms. per square km. of land area	2003-2005	Author's calculations based on Sec. of Agric., Livestock, Fisheries and Food.
Cultivated area of vegetables in each region.		Kms. per square km. of land area	2003-2005	Author's calculations based on Sec. of Agric., Livestock, Fisheries and Food.
Regional production of oil		Cubic metres	2003-2005	Author's calculations based on the Secretariat of Energy.
Regional production of gas		Thousands of cubic metres	2003-2005	Author's calculations based on the Secretariat of Energy.
Nominal electric potency installed in each region.		MW	2003-2005	Author's calculations based on the Secretariat of Energy.

Note: (*) Between 2003 and 2005, around 42 and 44 percent of total Argentinean exports are manufacturing ones. (**) 'Industrial crops' stands for: cotton, yerba mate, tea, coffee and sugar cane.

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