Available online at www.centmapress.org

Int. J. Food System Dynamics 10 (3), 2019, 278-286

DOI: https://dx.doi.org/10.18461/ijfsd.v10i2.18

INTERNATIONAL JOURNAL ON FOOD SYSTEM DYNAMICS

Estimating the Impact of Trade Costs on Agricultural Productivity

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Received September 2018 , accepted March 2019, available online June 2019

ABSTRACT

Utilizing a new measure of trade costs, this study tries to provide first evidence of the link between trade costs and productivity in the agricultural sector. Using a panel data of readily available data, across the 34 OECD member countries, this paper tries to assess and estimate the impact of trade costs on agricultural sector productivity for the 1995 – 2014 period. According to the results, there is strong evidence that when the agricultural sector faces lower trade costs, it tends to be more productive and there is some evidence that it experiences higher productivity growth too.

Keywords: *productivity; trade costs; gravity equation model.*

1 International trade and productivity

In spite of the recent progress in estimating the causal effect of trade on productivity, a lot of aspects are still under considerable controversy (Badinger, 2008). The relevant literature distinguishes three channels by which international trade affects productivity (Faundez et al., 2011). Firstly, imports expose domestic firms to competition, which forces them to raise their productivity to survive in the market.

Secondly, imported inputs and capital goods allow firms to optimize their productive processes and incorporate new technologies, which in turn raises their productivity. Sjoeholm (1999) shows that if foreign technologies are more efficient than those available in the domestic market, imported capital goods and inputs raise labor productivity. Eaton and Kortum (2001) attribute 25% of cross-country productivity differences to the variation in the relative prices of equipment, about half of which they ascribe to barriers to trade in equipment.

The third channel by which international trade impacts on productivity is the use of new technologies through direct foreign investment (FDI). Direct foreign investment produces positive externalities in the domestic economy. When trade is accompanied by FDI, the transfer of knowledge and learning-by-exporting process is reinforced (Nordas et al., 2006). Wacziarg (1998) argues that a plant that wants to export needs to invest, which increases in turn its productivity.

The afore-mentioned verify researches like this from Ferreira and Trejos (2011), who attempt to investigate the impact of international trade and the barriers of trade on productivity[1] of different countries with a similar and comparable endowment of natural resources. The study suggests that the effect of trade barriers is more significant on poor and under-developed countries.

Moreover, Madsen (2009), utilizing a dataset from 1870 to 2007 for 16 countries, researches the effect of the trade openness index on TFP variation. His study concludes that there is no direct impact of the index in question to the productivity growth, but only an impact which is connected with the transfer of a foreign knowledge stock or research intensity, a factor of large effect on TFP growth.

Faundez et al. (2011) analyze the relationship between the intensity of international trade flows and labor productivity for 28 industries in the five main economies in the region of Argentina, Brazil, Chile, Colombia and Mexico. The results show that international trade flows contributed through various channels to labor productivity growth in the period 1990 to 2008. These channels, which have been developed in the theoretical literature, are export intensity (share of production exported), import penetration (share of domestic demand covered by imports), diversification of the export basket and intra-industry trade.

Kowalski and Büge (2013) work on the same lines, studying the effect of a number of international trade indices on the productivity of developing countries. In detail, they distinguish the international trade to import and export flows and infer that a 10% growth of exports leads to a 0,1% productivity (labor productivity) growth and an equivalent import growth of the same percentage leads to a 0,5% productivity growth in countries with a developing economy.

Ferreira and Rossi (2003) find significant evidence on the positive effect of international trade on productivity growth for Brazil over the period preceding and following its trade liberalization in 1988-90. There were large productivity improvements across industries after trade barriers were drastically reduced (6% increase in multi-factor productivity growth).

Finally, Ge et al. (2011), assessing the effect of imports of intermediate goods on the productivity of industrial firms in China, conclude that a tax reduction on input can improve productivity levels. The afore-mentioned target is achieved through the increase of the variety of goods, the enhancement of technological knowledge, as well as the wider access to the international market of inputs.

[1] The specific researchers have used as a productivity measure the GDP per worker. Badinger (2008) investigates the impact of free trade agreements (FTA) on productivity using as a productivity measure the output per worker for a sample of 100 countries.

2 Trade costs and productivity

In an increasingly globalized world, trade costs matter as a determinant of the pattern of bilateral trade and investment, as well as of the geographical distribution of production (Arvis et al., 2012). Trade costs play a crucial role in determining the level of trade that occurs between countries.

Notwithstanding the importance of trade costs, there are very few researches dealing with their contribution on productivity in comparison with the extended literature of the impact of other factors that form the international trade. For instance, Melitz (2003) concludes that lower trade costs lead to contraction and exit by smaller, less-productive firms, and the transfer of resources to larger, more productive ones.

According to Pavcnik (2002), for the goods sectors, there is extensive empirical evidence that lower trade costs are associated with higher productivity at the firm- and industry-levels. Examining the same relationship, Miroudot et al. (2012), with regard to the sector of services, infer that the reduction of the trade costs is related to the increase of productivity and of the sector in question. More specifically, they mention that a 10% reduction in trade costs is associated with a TFP increase of around 0.5%, which is an effect of similar magnitude to that for the goods sectors.

And if – as alleged – researches about trade costs and productivity are very few, the relevant literature is lacking adequate studies with regard to the agricultural sector. The investigation of the afore-mentioned impact has great importance on a sector level because the levels of productivity do not differ only among the countries but among the sectors of economic activity within a country as well. For instance, the labor productivity of the sectors of "knowledge intensity" is rapidly developed from the sectors of "labor intensity" or the sectors of the intensity of natural resources (CEPAL, 2007, p.62).

As a consequence of all of the afore-mentioned, the current paper attempts to give a first indication of the relationship of trade costs and productivity in the agricultural sector of the OECD countries without examining through which transmission channels this impact is created. The remainder of the paper is organized as follows: in the next section (3) is presented the methodology for measuring trade costs, then section 4 discusses our data and presents regression results linking trade costs and productivity in the agricultural sector, and the last section (5) concludes the paper.

3 Calculation of trade costs

Novy (2012), following Head and Ries (2001), derives an all-inclusive measure of trade costs based on the observed pattern of trade and production. His methodology is simple, and is based on the standard gravity equation, familiar from the applied international trade literature. Following Novy (2012), the bilateral trade costs is defined as:

$$t_{i,j,k,t} \equiv \left(\frac{\tau_{i,j,k,t}\,\tau_{j,i,k,t}}{\tau_{i,i,k,t}\,\tau_{j,j,k,t}}\right)^{\frac{1}{2}} - 1 = \left(\frac{x_{i,i,k,t}\,x_{j,j,k,t}}{x_{i,j,k,t}\,x_{j,i,k,t}}\right)^{\frac{1}{2(\sigma_K - 1)}} - 1 \qquad (3.1)$$

where, t: denotes geometric average trade costs between country i and country j,

$\tau_{i,j}$: denotes international trade costs from country i to country j,

$\tau_{j,i}$: denotes international trade costs from country j to country i,

$\tau_{i,i}$: denotes intranational trade costs of country i,

$\tau_{j,j}$: denotes intranational trade costs of country j,

$x_{i,j}$: denotes international trade flows from country i to country j,

$x_{j,i}$: denotes international trade flows from country j to country i,

$x_{i,i}$: denotes intranational trade of country i,

$x_{j,j}$: denotes intranational trade of country i,

σ_{κ}: denotes sector-specific elasticity of substitution[2] between goods in the sector κ,

κ: is the sector in issue, and t: is the year in issue.

According to Arvis et al. (2012), a measure like tij needs to be interpreted cautiously for a number of reasons. Firstly, it is the geometric average of trade costs in both directions, i.e. those facing exports from country i to country j and those facing exports from country j to country i. From a policy perspective, it is therefore impossible to say without further analysis whether a change in trade costs between two countries is due to actions taken by one government or the other, or both together.

A second limitation on the extent to which tij can be interpreted for policy purposes is that it measures international relative to domestic trade costs. Strictly speaking, a change in tij might be due to a change in either component, or both simultaneously. As a result, it is again difficult to disentangle the effects of particular policy actions without further analysis.

Thirdly, the interpretation of tij depends to some extent on the theoretical model from which it is derived. Following on from this point is the fact that the numerical value of tij is sensitive to the choice of parameter value for σ, the elasticity of substitution. A related point has been made in the recent gravity literature (Hertel et al., 2007; Anderson and Van Wincoop, 2004), but the choice of parameter value largely remains an issue of assumption rather than measurement.

Apart from the "weaknesses" that have been mentioned before in Novy's methodology (2012), its practical use cannot be questioned. One practical use that is proved through a series of published papers as from Arvis et al. (2012), who examine the trade costs in developing countries during the years of 1995-2010 for 178 countries. Jacks et al. (2008) use it to track trade costs in the first wave of globalization (1870-1914) using data on GDP and total trade flows for major economies. More recently, the same authors have applied the same technique to investigate the role of changes in trade costs as drivers of trade booms and busts in major economies over the long term (Jacks et al., 2011). Similarly, Chen and Novy (2011) analyze trade costs among European countries using detailed trade and production data that distinguish between sectors, and in addition provide an econometric decomposition of trade costs that highlight the role played by factors such as distance, non-tariff measures, and membership in particular European initiatives, such as the Schengen Agreement. Finally, Miroudot et al. (2012) use the same methodology relatively to the international trade costs in the sector of services.

4 Methodology - Results

For the investigation of the relationship between trade costs and productivity in the agricultural sector of the OECD countries there is readily available data utilized for the 1995-2014 period. The choice of the specific period has been done with the criterion of the achievement of the maximum data availability.

The empirical approach which is adopted in the current paper with regard to the investigation of the relationship between the agricultural trade costs and productivity has been structured as having as a basis the relevant literature that has been followed for the exploration of the same relationship in other sectors of economic activity. In order to assess the impact of trade costs on productivity in the agricultural sector the following models in log-linear form with the OLS method have been estimated:

[2] Anderson and van Wincoop (2003) initiated the idea of a micro-founded measure of trade costs while Jack, Meissner and Novy (2008) solve the algebra result. Anderson and van Wincoop (2003) assume that each country is specialized in one good. Thus elasticity of substitution could be considered as elasticity of substitution between foreign and domestic goods as the setting is aimed to measure average trade friction. Chen and Novy (2011) study trade costs at the disaggregated sectoral level. In this case σ_{κ} becomes elasticity of substitution between varieties within sector κ.

$$\text{Log}(AVA_{i,j,t}^{k}) = b_1\, t_{i,j,t-1}^{k} + d_{i,j}^{k} + d_t + e_{i,j,t}^{k} \quad (4.1)$$

$$\Delta \log\,(AVA_{i,j,t}^{k}) = c_1\, t_{i,j,t-1}^{k}\; c_2 \log(AVA_{i,j,t-1}^{k}) + d_{i,j}^{k} + d_t + e_{i,j,t}^{k}$$

where,

$AVA_{i,j,t}^{k}$ is the geometric average of the productivity measures (agricultural value added per worker) for country i and country j respectively, for the sector k in year t,

$t_{i,j,t}^{k}$ is the measure of trade costs, as an ad valorem equivalent, between countries i and j, for the sector k, in year t,

$d_{i,j}^{k}$ + d_t indicate fixed effects by countries i and j, sector k and year t respectively, and

$\varepsilon_{i,j,t}^{k}$ is the error term of the equation.

The dataset consists theoretically[3] of a panel of 33*34*20 = 22440 records. Each record corresponds to a combination of reporter country–partner country–sector and year. The dependent variable of the estimated model has been constructed using agriculture value added per worker figures that have been derived from the World Bank. According to the World Bank, the measure of agriculture value added per worker consists measure of agricultural productivity. The specific variable used in the current paper is expressed in current American dollars, in constant prices of 2010. Substantially, agriculture value added per worker is a measure of labor productivity 'expressed' in monetary figures for the agricultural sector.

It goes without saying that the labor productivity measure in this assignment is not so complete as for example the multi-factor productivity (MFP) or total factor productivity (TFP) measure could be. The measure used however has an advantage over the two latter measures referred in its calculation and interpretation as well as in covering a great variety of countries and years in readily available data. Additionally, labor productivity is the measure that is tailor-made (among other productivity measures) for the agricultural sector, since the sector in question is considered as the labor intensity sector by nature.

Concerning the independent variable of the estimated model, it is constructed using agriculture trade costs data which have been derived from ESCAP[4].

Since we are using bilateral data, and the trade costs measure – adopted in the present paper - reflect the geometric mean of costs in both directions, it makes sense to use a bilateral measure of productivity as well. To do this, we take the geometric average of agricultural value added per worker of the importer and exporter country. Miroudot et al. (2012) adopt a similar approach.

Following Fernandez (2007) as well as Miroudot et al. (2012) we relate our productivity measures (agricultural value added per worker) to lagged trade costs so as to reduce endogeneity concerns. The extensive use of fixed effects is also a way of limiting the likelihood that endogeneity influences our results. The OLS regression results are presented in Table 1 that follows:

Table 1.
Estimation results

	AVApw	AVApw growth
Log trade costs	-0.065*** (0.006)	-0.074*** (0.017)
Log Geo. Ave. AVApw		-0.125** (0.028)
N	21865	21865
R^2	0.252	0.208
Fixed Effects	Ctry-part-sect-year	Ctry-part-sect-year

* , ** and *** represent significance at the 10%, 5% and 1% level respectively

[3] In practice, the number of the records is smaller due to problems in the availability of the data.
[4] The trade costs database is available in http:/unescap.org/tid/artnet/trade-costs.asp

In line with the literature on manufacturing firms and services sectors, the results support the hypothesis that lower trade costs are associated with higher productivity, and faster productivity growth in the agricultural sector. As regression results indicate, a reduction of agricultural trade costs by 10% can stimulate agricultural productivity (AVApw) by 0.65%. This is an effect of greater magnitude to that for the goods and services sectors. Additionally, a reduction of agricultural trade costs by the same rate (10%) can lead to a 0.74% rise in agricultural productivity growth.

According to Ricardo's comparative advantage theory, countries trade because they are different in terms of technology and their relative supplies of the factors of production (labor, capital, land, etc.). The theory also predicts that increased trade will result in increased specialization and better allocation of resources. The afore-mentioned lead to productivity stimulation.

With the emergence of the `New Trade Theory' (Helpman and Krugman, 1985) (in this approach, the unit of trade analysis was no longer the country but the industry), the discussion started with the question of whether the concepts of product differentiation, scale economies, and monopolistic competition are appropriate to model agricultural trade. The main critical points regarding the latter are that agricultural commodities are rather homogenous than heterogenous at least from a technical viewpoint, and that agricultural markets are rather perfectly competitive than imperfectly competitive (Prehn and Brummer, 2012).

According to the 'New New trade theory' the unit of trade analysis shifted from the country to the firm (Nordas et al., 2006; Melitz, 2003). This literature has identified an important additional source of gains from trade - a rise in productivity as increased trade forces leave the least efficient firms out of the market and reallocate resources to the most efficient firms. For the goods and services sectors, there is extensive empirical evidence that lower trade costs are associated with higher productivity at the firm and sector levels (Pavcnik, 2002: Miroudot et al., 2012).

5 Conclusions

This paper has used a new measure of trade costs, which was presented by Novy (2012) in order to provide some first evidence on the links between trade costs and productivity in the agricultural sector. According to our results, there is strong evidence that the agricultural sector which is facing lower trade costs tends to be more productive. Additionally, results indicate that a reduction of trade costs in the agricultural sector is associated with higher productivity growth. The analysis suggests that to raise agricultural productivity, it is important to encourage policy interventions that reduce the wedge between the producer's price in the exporting country and the consumer's price in the importing country. This fact will raise agricultural productivity and will free resources in the non-agricultural sector.

In the present study the investigation of the impact of the agricultural trade costs on productivity of the agricultural sector has been conducted at the industry level, meaning at the 'representative firm' level and not at the firm level as the 'New New Trade Theory' professes. Trade experts have learned that countries don't trade, industries don't trade, but firms do. Further research in this area, using farm-level data, could confirm our findings.

Certainly, as far as the agricultural sector is concerned, the relevant literature questions the extent of how much the 'New New Trade Theory' can be applied (Gopinath, 2007; Prehn and Brummer, 2012). Researchers such as Gopinath (2007) mention that the applicability of the 'New New Trade Theory' in agricultural trade would require the development of appropriate databases that not only encompass aggregate trade data, but also farm-level data. On the same line, Ciuriak et al. (2011), allege that they await the emergence of the 'New New Agricultural Trade Theory' in relevance with the 'New New Trade Theory' which happened to be of a wider acceptance in the industrial sector.

It would be worth noting that in the relevant literature to date, there is no example of the application of the 'New New Trade Theory' in the agricultural sector, and the interconnection of productivity and international agricultural trade is almost non-existent, despite the fact that it is a relationship which has met a special effect in other sectors of the economic activity.

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Appendix

Theoretical foundation of Novy's trade costs methodology according to Gravity Equation Model

Considering two countries, i and j, could be written down four gravity models for intra- and international trade:

$$X_{i,j} = \frac{Y_i\ E_j}{Y}\left(\frac{\tau_{i,j}}{\Pi_i P_j}\right)^{1-\sigma} \quad (1)$$

$$X_{j,i} = \frac{Y_j\ E_i}{Y}\left(\frac{\tau_{j,i}}{\Pi_j P_i}\right)^{1-\sigma} \quad (2)$$

$$X_{i,i} = \frac{Y_j\ E_i}{Y}\left(\frac{\tau_{i,i}}{\Pi_i P_i}\right)^{1-\sigma} \quad (3)$$

$$X_{j,j} = \frac{Y_j\ E_j}{Y}\left(\frac{\tau_{j,j}}{\Pi_j P_j}\right)^{1-\sigma} \quad (4)$$

where: X represents trade between two countries (i to j or j to i) or within countries (goods produced and sold in i and goods produced and sold in j),

Y represents total production in a country,

E represents total expenditure in a country,

τ represents "iceberg"[5] trade costs,

Π and P represent multilateral resistance.

In the following equations:

$$\Pi_i^{\ 1-\sigma} = \sum_{j=1}^{c}\left\{\frac{\tau_{i,j}}{P_j}\right\}^{1-\sigma}\ \frac{E_j}{Y} \quad (5)$$

$$P_j^{\ 1-\sigma} = \sum_{i=1}^{c}\left\{\frac{\tau_{i,j}}{\Pi_i}\right\}^{1-\sigma}\ \frac{E_i}{Y} \quad (6)$$

[5] The iceberg transport cost model is a simple economic model of transportation costs which suggested by Samuelson (1954). It is based on the idea of paying the cost of transporting a good with a portion of the transported good, rather than any other resources. Far from realistic, but a tractable way of modeling transport costs since it impacts no other market. Specifically, in order for a product unit to reach from one country to another, a bigger portion than this of the unit itself has to be sent. As the bigger the distance between these two countries that trade bilaterally, the largest quantity is required to 'melt' for the transportation of a product unit.

outward multilateral resistance Π captures the fact that trade flows between i and j depend on trade costs across all potential markets for i's exports, and that inward multilateral resistance P captures the fact that bilateral trade depends on trade costs across all potential import markets too.

Novy (2012) shows that some simple algebra makes it possible to eliminate the multilateral resistance terms from the gravity equations, and in so doing derive an expression for trade costs. Multiplying equation (1) and equation (2), and then equation (3) and equation (4) gives:

$$X_{i,j}\, X_{j,i} = \frac{Y_i E_j}{Y} \frac{Y_j E_i}{Y} \left(\frac{\tau_{i,j}\tau_{j,i}}{\Pi_i P_j \Pi_j P_i}\right)^{1-\sigma} \quad (7)$$

$$X_{i,i}\, X_{j,j} = \frac{Y_i E_i}{Y} \frac{Y_j E_j}{Y} \left(\frac{\tau_{i,j}\tau_{j,i}}{\Pi_i P_i \Pi_j P_j}\right)^{1-\sigma} \quad (8)$$

Dividing equation (7) by equation (8) eliminates terms and allows us to derive an expression for trade costs in terms of intra- and international trade flows:

$$\left(\frac{X_{i,j}\, X_{j,i}}{X_{i,i}\, X_{j,j}}\right)^{\frac{1}{1-\sigma}} = \frac{\tau_{i,j}\; \tau_{j,i}}{\tau_{i,i}\; \tau_{j,j}} \quad (9)$$

Taking the geometric average of trade costs in both directions and converting to an ad valorem equivalent by subtracting unity gives:

$$t_{i,j} = t_{j,i} = \left(\frac{\tau_{i,j}\; \tau_{j,i}}{\tau_{i,i}\; \tau_{j,j}}\right)^{\frac{1}{2}} - 1 = \left(\frac{X_{i,i}\, X_{j,j}}{X_{i,j}\; X_{j,i}}\right)^{\frac{1}{2(\sigma-1)}} - 1 \quad (10)$$

The final measure of trade costs tij thus represents the geometric average of international trade costs between countries i and j relative to domestic trade costs within each country. Intuitively, trade costs are higher when countries tend to trade more with themselves than they do with each other, i.e. as the ratio $\frac{X_{i,i} X_{j,j}}{X_{i,j}\, X_{j,i}}$ increases. As the ratio falls and countries trade more internationally than domestically, international trade costs must be falling relative to domestic trade costs.

According to Arvis et al. (2012) tij provides a useful summary indicator of the level of trade costs between countries i and j in the sense that includes all factors (both observable and unobservable) that drive a wedge between the producer price in the exporting country and the consumer price in the importing country. According to the same authors is important to note that since this measure of trade costs is based on mathematical operations and theoretical identities, it is not subject to the usual problems that plague econometric estimates, such as omitted variable bias or endogeneity bias.