СТРУЧНИ РАДОВИ
WORKING PAPERS

2011

Народна банка Србије
National Bank of Serbia

Народна банка Србије
National Bank of Serbia

СТРУЧНИ РАДОВИ
WORKING PAPER SERIES **19**

Обрасци и цене у светској трговини: улога продуктивности и квалитета

Кристиана Бенедети Фазил и Теодора Борота

World Trade Patterns and Prices: The Role of Productivity and Quality Heterogeneity

Cristiana Benedetti Fasil and Teodora Borota

Канцеларија главног економисте

НАРОДНА БАНКА СРБИЈЕ

Београд, Краља Петра 12,

Тел.: (+381 11) 3027 100

Београд, Немањина 17,

Тел.: (+381 11) 333 8000

www.nbs.rs

Office of the Chief Economist

THE NATIONAL BANK OF SERBIA

Belgrade, 12 Kralja Petra Street,

Telephone: (+381 11) 3027 100

Belgrade, 17 Nemanjina Street,

Telephone: (+381 11) 333 8000

www.nbs.rs

Обрасци и цене у светској трговини: улога продуктивности и квалитета

Кристиана Бенедети Фазил* и Теодора Борота**

Рад је изабран за најбољи рад Прве годишње конференције младих српских економиста, одржане у Народној банци Србије од 22. до 23. јуна 2011.

Апстракт: У овом раду анализира се улога квалитета производа и ефикасности радне снаге у обликовању трговинских образаца и интензитета трговине унутар и између две групе земаља, развијенијег и богатијег Севера, и Југа у развоју. Новије, емпиријске студије указују на позитивне односе између прихода по глави становника и извозних цена, увозних цена, као и увозних цена за датог извозника. Уместо ослањања на специфичне механизме тражње попут нехомотетичних преференција, овде је фокус на разликама у технологијама Севера и Југа у Север-Југ трговинском моделу са четири државе, у наведене две димензије хетерогености фирми. Разлике у квалитету производа и ефикасности фирми доводе до дистрибуције цена која ствара разлике у композицији потрошачких корпи и извозним и увозним ценама између богатих и сиромашних земаља. Даље, коначна квалитативна расподела потрошње показује да Север (Југ) троши већи део прихода на куповину производа високог (ниског) квалитета чак и уз једнаке, хомотетичне преференције у обе групе земаља.

Кључне речи: Обрасци у међународној трговини, Север-Југ трговина, цене увоза и извоза, хетерогене фирме, квалитет производа

JEL Code: F10, F12, F14, L11, L15

* European University Institute, Италија.
** Uppsala University, Department of Economics, Шведска.

World Trade Patterns and Prices: The Role of Productivity and Quality Heterogeneity

Cristiana Benedetti Fasil* and Teodora Borota**

The paper was selected the best paper at the First Annual Conference of Young Serbian Economists, held in the NBS from 22 to 23 June 2011.

Abstract:
This paper analyzes the role of product quality and labor efficiency in shaping the trade patterns and trade intensities within and across two groups of countries, the developed and richer North and the developing South. Recent empirical literature identifies a positive relation between income per capita and both export and import prices, and also the import prices conditional on exporter. Instead of relying on specific demand side mechanisms such as non-homothetic preferences, we focus on the North-South differences in technology in a four country North-South trade model with two dimensions of firm het- erogeneity. Differences in firms' product qualities and cost efficiencies result in a price distribution generating different consumption bundles and the observed export and import prices across rich and poor countries. Furthermore, the resulting total expenditure allocation across quality shows that the North (South) spends a larger share of its income on high (low) quality even with the same homothetic preferences across regions.

Key words: International trade patterns, North-South trade, import and export prices, heterogeneous firms, product quality

JEL Code: F10, F12, F14, L11, L15

* European University Institute, Italy.
** Uppsala University, Department of Economics, Sweden.

Contents:

1. Introduction 1

2. The Model Set-up 5

2.1. Consumers 5
2.2. Firms 6
2.2.1 Production decision 6
2.2.2 The exit decision 7
2.2.3 Firms entry 8
2.3 Cross sectional distribution and aggregates 9
2.4. Steady-state equilibrium 9
3. Equilibrium in the Open Economy 10

3.1 Symmetric countries 10
3.1.1 Cross sectional distribution and aggregates 12
3.2. Asymmetric countries 13
3.2.1 Firms entry 13
3.3 Four countries, open economy model 14
3.3.1 Production and export 14
3.3.2 Cross sectional distribution and aggregates 15
3.3.3 Steady-state equilibrium 16
3.4. Calibration 17
4. Four-country scenario results 18

5. Conclusion 23

References 24

Apendix 26

1. Introduction

World trade patterns and their relation to the technological development and income per capita levels of the trading partners have been studied extensively in the theoretical and empirical literature. In several recent studies, data on export and import prices has been exploited as evidence of countries' technological development (particularly as the ability to produce higher quality), trade specialization and demand schedules.[1] On the export side, Schott (2004) presents evidence on positive variation of US import prices depending on the exporter's income per capita, suggesting positive relation between prices and exporters income per capita within the same product category. Fieler (2007) finds that export prices increase with income per capita of the origin country. On the import side, the same paper reports that import prices are positively related to income per capita, as well as that countries of different income per capita import goods of different prices from the *same* exporter. To the extent that prices may be used as a proxy for quality, this evidence suggests that rich countries not only specialize in the production and export of relatively higher quality goods, but that they devote larger share of income on higher quality imports and possibly high quality total consumption.[2] Most of the literature that proposes a theoretical basis for this analysis starts from either non-homothetic preferences, where different income levels generate different demand structures, or standard preferences with arbitrarily imposed different "love for quality" parameters in the North and the South. The supply side mechanisms result in a comparative advantage in the production of goods that are in high domestic demand.[3] Non-homothetic preferences might be the immediate natural assumption for explaining reported increase in traded goods' prices with income per capita, but are certainly not the only factor. Although the arbitrary parametrization of preferences might be regarded as a way around modeling the black box of demand het- erogeneity across countries, non-homothetic preferences do have some empirical support in the micro-level data. The purpose of this paper is not to contradict these findings, but to show that when the attention is shifted from modeling preferences to modeling technology more closely, standard

[1] We focus on empirical evidence that refers to product-level trade prices, and also the aggregate prices. Manova and Zhang (2009) analyze the firm-level prices and relate the quality dimension of firm's productivity to it's export status, import and export prices, trade values and the choice of trading partners, which also relates to the present study.

[2] These findings, however, should not be taken as a straightforward support for the differences in expenditure distribution over quality in the North and the South, as traded goods might present only a minor share of total consumption.

[3] See Fajgelbaum, Grossman and Helpman (2009) for a recent discussion.

preferences model with fixed operational and trade cost can yield the stated predictions as well.

We wish to give more weight to the supply side mechanisms and their role in shaping the demand structure and therefore, we use homothetic preference structure. Specifically, the focus is on the technology endowments of the North and the South which are the main determinants of the production and export specialization, and the relative income per capita of the two regions. The North has a higher level of technological development, while the South lags behind the North and uses a lower level of technology. Firms in each region are heterogeneous in two technology (productivity) dimensions: product quality and labor efficiency which together determine the firms' domestic and foreign market profitability. Existing models of trade and heterogeneous firms that introduce only one productivity dimension, such as Melitz (2003), pre- dict a negative relation between export prices and income per capita since higher technological development implies higher income but also higher cost efficiency and thus lower prices. Empirical evidence on export prices calls for the introduction of a different productivity dimension in a way that it generates positive rela- tion between productivity and price. Several papers introduce the quality dimension of firm heterogeneity. In this sense, Northern technology allows this region to produce relatively higher productivity-higher price varieties, while the South specializes in the production of lower quality-lower price varieties.

Baldwin and Harrigan (2007) develops a model of trade and heterogeneous firms in the quality dimen- sion. They assume that quality rises faster than marginal cost and thus high quality-high cost varieties are the most profitable ones. Therefore, export profitability is increasing in quality (and price) monotonically. Johnson (2010) introduces two dimensions of firm heterogeneity, but for the purpose of empirical analysis, two dimensions again collapse to a single by assuming that quality is mechanically related to capability (quality-cost ratio). Using this set-up for the analysis of the North-South trade, counterfactual predictions are derived. Lower aggregate expenditure of the South implies that only the most profitable, so highest price firms can cover the fixed cost of trade and export to the South, while the pool of exporters to the North is larger. This prediction does not match the empirical evidence, as it results in the negative relationship between import prices and income per capita *conditional* on exporter.
We wish to separate the quality and efficiency dimensions and introduce a measure of cost efficiency which affects the marginal cost independently of the quality. Each firm (variety) is characterized by a quality level which affects positively both utility and the cost of production, and by a labor efficiency level which decreases the marginal cost. These two dimensions together determine the productivity level of the

firms, which are distributed across quality-efficiency pairs, with the Southern joint distribution having a lower mean due to its technological lag behind the North. In this framework, the export decision of any firm depends on its productivity pair which determines the profitability and thus the ability to cover the fixed cost of exporting. Less profitable firms that export only to the North, also include those with highest quality but lower efficiency, and therefore a higher price. This contributes to a rise in the average import price with income per capita conditional on exporter. In this sense, Northern average import price is higher not because it consumes higher quality than the South, but due to the fact that it consumes also the high priced - high quality varieties. Given the right-skewed distribution of firms in equilibrium, varieties of this type are relatively numerous and this amplifies the effect on the average import price and insures that North imports higher price varieties on average.

Two dimensions of firm productivity have been identified also in the industry surveys. Several empirical studies document that firms distinguish between two different types of investment in R&D - process or prod- uct innovation, which raise the firms' efficiency or product quality, respectively. Huergo and Jaumandreu (2004a) report a survey of Spanish firms while Parisi et al. (2006) present a classification of Italian firms based on their R&D strategy (process, product, both or none). Similar data are also available for Germany, Great Britain and Nederlands. Moreover, Huergo and Jamandreu (2004b) estimate that process and product innovation have different contributions to firms' growth.

An important justification for the introduction of two productivity dimensions is found in the recent debates in the literature on how valid unit values actually are as a proxy for the product quality. Hallak and Schott (2010) oppose the large literature that associates cross-country variation in export unit-values with variation in product quality, implicitly assuming away cross-country variation in quality-adjusted prices. They allow for price variation induced by factors other than quality, e.g., comparative advantage or currency misalignment, and find that observed unit value ratios can be a poor approximation for relative quality differences, that quality is converging more rapidly than income levels across countries, and that countries differ in growth strategies - high-quality versus low-price. These findings directly provide support for our modeling of firms' productivity.[4]

In aggregate terms, the greater income of the North compared to the South implies not

[4] See also Khandelwal (2010) who estimates the quality of U.S. imports using a procedure that relaxes the strong quality- equals-price assumption.

only a greater expenditure on any good that is available in both regions, but higher levels in equal proportion across goods, due to homothetic preferences. However, with fixed cost of export only a subset of varieties is exported to foreign markets, and the resulting expenditure shares on certain quality are not equal across regions. The North spends a lower share of income on low quality varieties originated from the South, while the South spends a lower share on high quality produced in the North, both relative to the other region's share of expenditure on those varieties. If the income difference between the regions is sufficiently large, the statement above holds also in absolute terms.

The analysis of trade intensities within and across regions refers to the Linder hypothesis. Linder (1961) argues that on the demand side, countries with high (low) income per capita spend a larger fraction of their income on high (low) quality goods. On the supply side, countries develop a comparative advantage in the goods that are in high domestic demand, so high (low) income countries produce high (low) quality goods. Both these premises are predicted by our model, but Linder's hypothesis goes further. The demand and supply premises are combined in order to argue that the overlap of production and consumption patterns between countries of similar income per capita should induce them to trade more intensively with one another. Rich trade more with rich, while poor trade with poor. Our model predicts the highest intensity and value of the North-North trade. The ordering of the South-South and the North-South trade depends on the fixed and/or variable costs of trade, in particular on their asymmetries that are conditional on the origin and destination country. With symmetric costs, North-South trade is of higher value, but the result is reversed when stronger restrictions on Southern exports to the North are imposed. However, there is no robust empirical support of the Linder hypothesis. Namely, it is important to ascertain the level of aggregation at which the "Linder" mechanism might operate. Hallak (2008) shows that the trade intensities prediction is valid on both sides of income per capita distribution at the sectoral level (for some sectors), but is strongly rejected when data is aggregated over sectors.

The rest of the paper is organized as follows, Section 2 presents the closed economy model set-up, Section 3 present the open versions of the model with symmetric and asymmetric countries, Section 4 discusses the results of the numerical exercise with a 4-country North-South scenario, while Section 5 concludes.

2. The Model Set-up

2.1. Consumers

Consumers have homothetic preferences and every period they choose consumption and supply labor inelas- tically at the wage rate w. The aggregate measure of population (labor) is L. Consumers allocate optimally the aggregate consumption X across differentiated varieties produced by operating firms. The utility func- tion is given by a quality augmented Dixit-Stiglitz utility function,

$$U(t) = \left(\int_{i\in I} (q(i)x(i,t))^{\alpha} di\right)^{\frac{1}{\alpha}}, \tag{1}$$

where x(i, t) is the quantity and q(i) is the quality of a variety i∈I consumed at time t. The standard CES utility index is augmented to account for the quality variation across products where quality acts as a utility shifter: a consumer prefers high quality over low quality products. The elasticity of substitution between any two goods is constant and equal to $\sigma = 1/(1 - \alpha) > 1$, with $\alpha \in (0, 1)$.

Consumers derive the optimal demand for each good, maximizing their utility subject to the individual budget constraint $E(t) = \int_{i\in I} p(i,t)x(i,t)di$, where E(t) presents total expenditure in the country and p(i, t) is the price of variety i∈I at time t. The demand for product x(i, t) is given by

$$x(i,t) = \left(\frac{P(t)q(i)^{\alpha}}{p(i,t)}\right)^{\frac{1}{1-\alpha}} X(t) = \left(\frac{q(i)^{\alpha}}{p(i,t)}\right)^{\frac{1}{1-\alpha}} P(t)^{\frac{\alpha}{1-\alpha}} E(t) \tag{2}$$

with P (t) as the price-quality index defined by

$$P(t) = \left(\int_{i\in I} \left(\frac{p(i,t)}{q(i,t)}\right)^{\frac{\alpha}{\alpha-1}} \mathrm{d}i\right)^{\frac{\alpha-1}{\alpha}} \quad \text{and} \quad X_t = U_t. \tag{3}$$

Given the aggregates, the optimal expenditure (r(i, t)) decision across varieties is

$$r(i,t) = \left(\frac{P(t)q(i)}{p(i,t)}\right)^{\frac{\alpha}{1-\alpha}} E(t). \tag{4}$$

This paper focuses on the analysis of the steady-state equilibrium in which all variables are constant and we omit the time subscripts in the further text.

2.2. Firms

Firms differ in two dimensions of heterogeneity. The first source of heterogeneity is *labor efficiency* (in further text, efficiency), a(i) $\in$ R++, which increases the marginal productivity of labor, as in the seminal paper of Hopenhayn (1992). The second source is *quality* of a firm's variety, q(i) $\in$ R++ \ (0, 1), which decreases the marginal productivity of labor. In this respect, a higher quality variety implies a higher variable cost as in Verhoogen (2008), but contributes positively to consumers' utility. The production technology has the following form

$$x(i) = \frac{a(i)^{\chi}}{q(i)^{\eta}} n(i), \tag{5}$$

where n(i) is the production labor employed by firm i and $\chi,\eta \in (0, 1)$. Firms distribute over quality and efficiency, and we assume that each firm produces only one variety so that the index i identifies both the firm and the corresponding variety it produces. Firms enter and exit the market and the industry is characterized at the steady-state equilibrium.

2.2.1 Production decision

Each firm is the monopolistic producer of its own variety. Firms pay a fixed operational cost, cf , expressed in terms of labor in order to produce and this cost is responsible for firms' exit from the market. Solving the standard monopolistic problem, firms charge a price p(i), that is

$$p(i) = \frac{wq(i)^{\eta}}{\alpha a(i)^{\chi}}, \tag{6}$$

where common wage rate, w, is hereafter normalized to one. Substituting the expression for prices in the demand function,

$$x(i) = (a(i)^{\chi} q(i)^{\alpha-\eta} \alpha)^{\frac{1}{1-\alpha}} P^{\frac{\alpha}{1-\alpha}} E, \tag{7}$$

it follows that x(i) is increasing in a and it is decreasing in q *iff* $\eta > \alpha$. We restrict our attention to the specification when this condition holds. Firms revenues and profits are then given by

$$\begin{aligned} r(a,q) &= (a^{\chi}q^{1-\eta})^{\frac{\alpha}{1-\alpha}}(\alpha P)^{\frac{\alpha}{1-\alpha}}E \\ \pi(a,q) &= (1-\alpha)(a^{\chi}q^{1-\eta})^{\frac{\alpha}{1-\alpha}}(\alpha P)^{\frac{\alpha}{1-\alpha}}E - c_f, \end{aligned} \tag{8}$$

where the ratio of the revenues of any two firms is a function of the ratio of their productivities,

$$\frac{r(a_i,q_i)}{r(a_j,q_j)} = \left(\frac{a_i^{\chi}q_i^{1-\eta}}{a_j^{\chi}q_j^{1-\eta}}\right)^{\frac{\alpha}{1-\alpha}}. \tag{9}$$

It is important to note here that profitability of a firm is increasing with its productivity (in either dimension), but it is not a monotonous function of the price. Price is increasing in quality but decreasing in efficiency, while profits increase in both productivity dimensions. In this sense the patterns present in previous literature, monotonously negative (Melitz 2003) or positive (Baldwin and Harrigan 2007) relation between price and profitability, is broken in this paper. This relationship will become crucial for shaping the average price pattern across the firm partitioning space, particularly concerning the exporter/non-exporter partitioning in the open economy scenario. The most profitable firms are the most productive in both dimensions, so their varieties have neither the highest nor the lowest price. Less productive firms have lower efficiency and/or quality, and they include both the firms that charge lower price compared to the most productive, but also those with the highest prices (high quality-low efficiency firms). Therefore, in the context of the closed economy, the average price of the exiting firms may as well be higher than the average price of the surviving varieties.
On the other hand, the specification of χ and η affects the concavity of profits and the price function in the two productivity dimensions, but also the ratio of the elasticities with respect to each dimension. With χ bigger (smaller) than $1-\eta$ the profits increase faster along the efficiency (quality) dimension, which shapes the isoprofit curves in the (a, q) space and thus the exit productivity threshold functions.

2.2.2 The exit decision

Every firm faces an exogenous probability of a bad shock δ which forces the firm to exit the market. Besides this exogenous exit, firms exit the market when their profits are not enough to cover the fixed operational cost, c_f . The two sources of firm heterogeneity imply that the thresholds that characterize the border between exit and survival in the market are given by the infinite combinations of the (a,q) couples. For this reason, it becomes convenient to express the reservation values in terms of efficiency as a function of quality[5], a(q), and to obtain a *cutoff function* rather than cutoff values as in one factor heterogeneous firm models. For a given q∈Q it is possible to define the following exit cutoff functions

$$a_x(q) = \left[\left(\frac{c_f}{(1-\alpha)P^{\frac{\alpha}{1-\alpha}} E} \right)^{\frac{1-\alpha}{\alpha}} \frac{1}{\alpha} \frac{1}{q^{1-\eta}} \right]^{\frac{1}{\chi}}. \tag{10}$$

The exit cutoff functions are decreasing in quality produced: high quality allows for an easier survival. A firm characterized by a low level of efficiency but a high quality may still find it optimal to produce. However, with $\chi > 1 - \eta$, the cutoff efficiency is decreasing in quality at a decreasing rate. We assume this condition holds, as it captures the idea of increasing difficulty in keeping the market shares for the firms that produce high quality varieties with low efficiency which results in a high price. In other words, this assumption represents minimum (cost) efficiency requirements for survival. This also relates to the literature on the types of R&D investment and their contributions to firms' profitability and growth. Huergo and Jamandreu (2004b) estimate that process innovation contributes for about 77% of the yearly growth rate of aggregate productivity, while product innovation can account for about 23%. The estimates do not apply directly to our specification, but may point to higher returns to firm's efficiency then product quality.

2.2.3 Firms entry

Each period, M firms enter the industry and pay a sunk entry cost, ce, expressed in terms of labor. After paying the entry cost they draw the product quality and efficiency level (productivity vector (a,q)) from a bivariate distribution G(a, q), with corresponding density g(a, q).

We assume that the free entry condition holds in equilibrium. Firms enter the industry until the expected value of the firm, v, is equal to the entry costs. With the value of the firm given as the discounted future flow of profits, and with no time discounting as in Melitz (2003), the free entry condition reads

$$\overline{v} = \int_{a_x(q)} \int_Q \frac{\pi(a,q)}{\delta} g(a,q) \mathrm{d}q \mathrm{d}a = c_e. \tag{11}$$

---

[5] It is equivalent to express product quality as a function of efficiency, q(a). Using a specific formulation for the cut-off function does not affect the implications of the model.

2.3 Cross sectional distribution and aggregates

The density of firms conditional on successful entry is computed as

$$\mu(a,q) = \begin{cases} \frac{g(a,q)}{P_{in}} & \text{if } a \geq a_x(q) \\ 0 & \text{otherwise} \end{cases} \tag{12}$$

where $P_{in} = \int_{ax(q)} \int_Q g(a, q)dqda$ is the ex-ante probability of firm survival.
The average productivity measure as a function of the exit cutoff is computed as

$$\tilde{\mu} = \left(\int_{a_x(q)} \int_Q (a^\chi q^{1-\eta})^{\frac{\alpha}{1-\alpha}} \mu(a,q)\mathrm{d}q\mathrm{d}a \right)^{\frac{1-\alpha}{\alpha}}. \tag{13}$$

The average productivity level is determined by the cutoff function, $a_x(q)$, and thus the average revenue and profit, as the functions of the average productivity, also depend on the cutoff function. Using (9), for any given q, we obtain

$$\begin{aligned} \bar{r} &= r(\tilde{\mu}) = \left(\frac{\tilde{\mu}}{a_x(q)^\chi q^{1-\eta}} \right)^{\frac{\alpha}{1-\alpha}} r(a_x(q), q) \\ \bar{\pi} &= \pi(\tilde{\mu}) = \left(\frac{\tilde{\mu}}{a_x(q)^\chi q^{1-\eta}} \right)^{\frac{\alpha}{1-\alpha}} (1-\alpha) r(a_x(q), q) - c_f. \end{aligned} \tag{14}$$

As the profit of a cutoff firm equals zero and it's revenue is equal to $c_f /(1-\alpha)$, it follows that the relationship between the average profits and the exit cutoff function can be expressed as

$$\bar{\pi} = \left[\left(\frac{\tilde{\mu}}{a_x(q)^\chi q^{1-\eta}} \right)^{\frac{\alpha}{1-\alpha}} - 1 \right] c_f.$$

2.4. Steady-state equilibrium

The free entry condition also represents a relation between the average profits and the cutoff productivity, i.e. cutoff efficiency for any given level of quality. Therefore, the two equilibrium conditions,

$$\begin{aligned} \bar{\pi} &= \left[\left(\frac{\tilde{\mu}}{a_x(q)^\chi q^{1-\eta}} \right)^{\frac{\alpha}{1-\alpha}} - 1 \right] c_f && \textit{Zero Cutoff profit} \\ \bar{\pi} &= \frac{\delta c_e}{1 - G(a_x(q,q))} && \textit{Free Entry}, \end{aligned} \tag{15}$$

define the equilibrium average profits and the cutoff productivity. The aggregate stability condition requires that the mass of successful entrants in the market equals the mass of exiting firms, i.e. $P_{in}M = \delta I$. The labor market clearing condition assumes that the total labor is used either in production, where aggregate income equals the difference between aggregate revenue and aggregate profits, or to pay the fixed cost of entry, Mce. Therefore, using the stability and free entry conditions,

$$L = (R - \Pi) + Mc_e = (R - \Pi) + \frac{\delta I}{P_{in}} c_e = (R - \Pi) + I\bar{\pi} = (R - \Pi) + \Pi = R.$$

The mass of operating firms is then derived as

$$I = \frac{R}{\bar{r}} = \frac{L(1-\alpha)}{\bar{\pi} + c_f}$$

which in turn determines the equilibrium price-quality index as $P = 1/(\alpha\tilde{\mu})I^{(\alpha-1)/\alpha}$. This closes the characterization of the steady-state equilibrium.

3. Equilibrium in the Open Economy

3.1 Symmetric countries

We now assume that there are two regions open to trade, home and foreign (denoted by *), which are symmetric in all preference and technology dimensions except that they produce different varieties. Consumers have the same homothetic preferences and they supply labor inelastically at the wage rate w, with $w = w^*$. Labor is not mobile across regions and the aggregate measure of population in a region is L, $L = L^*$. Consumers now allocate consumption X across differentiated varieties produced by domestic firms and those imported from abroad. The measure of available goods is hence given by domestic goods of measure ID and imports from abroad I^{*X}, and similarly for the foreign region, $I^* = I^{*D} + I^X$. Although consumer preferences are the same in both regions, the bundles of varieties consumed are different. Due to firm selection into exporters and non-exporters firms, a subset of varieties in each country is not exported, resulting in a different consumption composition. However, due to symmetry in technology, productivity levels and prices of non-exported and exported goods will be the same across countries, and thus the price- quality indices will be the same, although relating to different bundles. This also assumes that we abstract from the variable trade costs which may differ across origin and destination market and

thus distort the relative prices of tradables, and compared to non-tradables. Namely, we are interested in trade patterns and prices that are a result of regions' technologies and firm partitioning, and thus we assume no trade cost except for the fixed cost of becoming an exporting firm. Therefore, conditional on being exporter, a firm charges the same price in domestic and foreign market.
Firms still pay a fixed operational cost, c_f , expressed in terms of labor in order to produce, but now also incur a fixed export cost c_{ex}, expressed in terms of labor, in order to export. The fixed export cost generates the partition between exporter and non exporter firms and it is assumed to be the same across regions.
Firms total profits are the sum of the profits obtained in the domestic market and the profits from the foreign markets when it is profitable to export. The optimal profits for home region are given by

$$\begin{aligned} \pi(a,q) &= \pi^D(a,q)+\max\{0,\pi^X(a,q)\} \\ \pi^D(a,q) &= \left(\frac{a^\chi q^{1-\eta}\alpha}{w}\right)^{\frac{\alpha}{1-\alpha}}(1-\alpha)P^{\frac{\alpha}{1-\alpha}}E-wc_f \\ \pi^X(a,q) &= \left(\frac{a^\chi q^{1-\eta}\alpha}{w}\right)^{\frac{\alpha}{1-\alpha}}(1-\alpha)P^{*\frac{\alpha}{1-\alpha}}E^*-wc_{ex} \end{aligned} \quad (16)$$

The max operator in π indicates the choice of each firm to specialize only in the domestic market, or to open to foreign markets when the profits derived from exporting exceed the fixed cost of export, c_{ex}. As the specification of χ and η shapes the isoprofit curves in the (a,q) space, this also has implications for the export productivity threshold functions.
Similarly to the closed economy cutoff functions, it is convenient to express the export reservation value in terms of efficiency as a function of quality, a(q). For a given $q\in Q$ it is possible to define the following export cutoff function for the home region,

$$a_{ex}(q)=\left[\left(\frac{wc_{ex}}{(1-\alpha)P^{*\frac{\alpha}{1-\alpha}}E^*}\right)^{\frac{1-\alpha}{\alpha}}\frac{1}{\alpha}\frac{w}{q^{1-\eta}}\right]^{\frac{1}{\chi}} \quad (17)$$

As in the case of exit cutoff, the export cutoff function is decreasing in quality which implies that a firm characterized by a low level of efficiency but a high quality may still find it optimal to export. With $\chi > 1 - \eta$, the cutoff efficiency is decreasing in quality at a decreasing rate which represents the minimum (cost) efficiency requirements for exporting.
The cutoff functions are increasing in the wage as higher wage implies higher fixed cost of export and higher export price, while they decrease in the total expenditure and the price index. Higher expenditure (income) of the destination market implies

higher purchasing power of the market, while higher price index represents lower competition pressures on the exporting firm. As the total expenditure depends on the size of the population in the destination country, it follows that a larger export market implies higher profitability and lower cutoff productivity levels.

With symmetric wages and technology level of exporters and non-exporters across regions, and thus price-quality indeces and expenditures, the optimal profits and cutoff functions are symmetric and the * superscript can be dropped. The export cutoff function differs from the exit cutoff function only in the fixed cost term, c_{ex} and c_f . With $c_{ex} > c_f$, the exit cutoffs are associated with lower productivity levels than the export cutoffs.

3.1.1 Cross sectional distribution and aggregates

The density of firms conditional on successful entry is computed as in the closed economy scenario, equation (12). The ex-ante probability of firm survival is still given by $P_{in} = \int_{ax(q)} \int_Q g(a,q)dqda$, and we define the ex-ante probability that a successful firm exports as $P_{ex} = (1-G(a_{ex}(q),q))/ P_{in}$. To compute the weighted mean of productivity, we define the mass of incumbents in each country. Hence, I^D also represents the measure of varieties produced in each country, so $I_{ex} = P_{ex}I^D$ is the mass of exporting firms and exported varieties. This means that the mass of available varieties in each region is given by the mass of varieties produced domestically plus the mass of varieties imported: $I = I^D + I_{ex}^*$. With symmetry, $I_{ex}= I_{ex}^*$.

The average weighted productivity is computed taking into account not only the output share of the domestic firms, but the additional export share of the more productive firms:

$$\tilde{\mu} = \left(\frac{I^D}{(I^D + I_{ex})} \tilde{\mu}_x^{\frac{\alpha}{1-\alpha}} + \frac{I_{ex}}{(I^D + I_{ex})} \tilde{\mu}_{ex}^{\frac{\alpha}{1-\alpha}} \right)^{\frac{1-\alpha}{\alpha}} \quad (18)$$

$$\tilde{\mu}_x = \left(\int_{a_x(q)} \int_Q (a^{\chi} q^{1-\eta})^{\frac{\alpha}{1-\alpha}} \mu(a,q) \mathrm{d}q\mathrm{d}a \right)^{\frac{1-\alpha}{\alpha}} \quad (19)$$

$$\tilde{\mu}_{ex} = \left(\int_{a_{ex}(q)} \int_Q (a^{\chi} q^{1-\eta})^{\frac{\alpha}{1-\alpha}} \mu_{ex}(a,q) \mathrm{d}q\mathrm{d}a \right)^{\frac{1-\alpha}{\alpha}},$$

with $\mu_{ex}(a,q)$ as the conditional distribution of exporting firms, given that the firm survives in the market. Zero cutoff profit and free entry conditions determine the steady state equilibrium in open economy, but also taking into account the partitioning of firms into exporters and non-exporters and the associated export cutoff function. The model is solved in the same manner as described in the closed economy section.

3.2. Asymmetric countries

We now assume two asymmetric regions, home and foreign, which have the same preference structure but differ in two technology dimensions and produce different varieties. The consumers allocate their expendi- ture on domestic and foreign varieties, but due to asymmetry in productivity levels and thus the wages and prices of goods, the resulting consumption composition and price schedules will be different across regions. This yields different price indices as averages of the quality weighted prices of all varieties consumed by a region, domestically produced and imported.

Firms in both regions distribute over quality and efficiency, and since the regions' asymmetry takes the form of different level of productivity, we refer to the regions as North (N) and South (S), the techno- logically developed and the developing region, respectively. Firms in the North lead in both productivity dimensions while firms in the South lag behind the more advanced Northern technology.

The wage rate is w^N in the North and w^S in the South, with $w^N > w^S$. Labor is not mobile across regions and the aggregate measure of population in each country in the North and the South regions is L^N and L^S, respectively. The fixed operational cost incurred by firms triggers firm exit while the fixed export cost generates the partition between exporter and non exporter firms. Given the same labor requirement for the fixed cost of operation and export in the North and the South, it follows that both costs are higher in the North due to its higher wage.

3.2.1 Firms entry

After paying the entry cost, firms in both regions draw the product quality and efficiency level (productivity vector (a,q)) from a bivariate distribution $G^J(a, q)$, J = {N, S}, with corresponding density $g^J(a, q)$. The density function in the North, $g^N(a, q)$, is assumed to be log-normal and exogenous while $g^S(a, q| \overline{\mu}^N)$ is log-normal but its mean, $\overline{g}^S$, is determined as a θ fraction of the incumbents joint mean in the North, $\overline{\mu}^N$.[6] The assumption attempts to capture the idea of imitative R&D in the South which copies the technology of the North at a certain lag due to high difficulty of copying the advanced goods. As we don't model the R&D process endogenously, we might justify this assumption by the evidence on differences in North-South TFP levels documented in the literature.[7]

When solving the model, we define another equilibrium condition besides the zero cutoff profit and free entry conditions. This is the trade balance requirement which

---

[6] This specification is similar to the one used in Gabler and Licandro (2005).

[7] See for example, Cordoba and Ripoll (2008), Jerzmanowski (2007), Hall and Jones (1999).

equates the values of Northern and Southern exports. At the same time, it is the third equation linking the relative South-North wage (Southern wage when Northern is taken as numeraire and normalized to one) and the parameter measuring the technological lag of the South, θ. This allows for solving the model for the South-North relative wage.

3.3 Four countries, open economy model

We wish to analyze the trade patterns and prices of tradables at the regions' aggregate level but also condi- tional on importer/exporter GDP per capita, and thus we construct a four countries scenario. We propose a two region North-South trade model where each region, the North and the South, consists of two symmet- ric countries (two symmetric North and two symmetric South).[8] The measure of available goods in each country is hence given by domestic goods of measure I^{JD}, imports from the other country of the same region, I^{JJ}, and from the two countries of the other region, I^{JK}, with J,K = {N,S}, J≠K. Thus, $I^{N}=I^{ND}+I^{NN}+2I^{SN}$ for the North and similarly for the South, $I^{S}=I^{SD}+I^{SS}+2I^{NS}$. We use the same index to represent both the region and the country of a particular region, as we assume symmetry in all environment dimensions of the countries within a region. However, the varieties they produce are perceived as different by the consumers and thus are all in demand, i.e. each country's consumers demand varieties from the other country of the same region as well as the goods of both countries of the other region.

3.3.1 Production and export

Firms total profits are the sum of the profits obtained in the domestic market and the profits from the foreign markets when it is profitable to export. Hence the optimal profits with J, K = {N, S}, J≠K are given by

8 With four countries, we can analyze the difference in variables concerning e.g. Northern exports to both Southern and other Northern country, as well as its imports from countries at different income level. In other words, this model specification at the same time represents both a North-North and a North-South trade model.

$$\begin{aligned}
\pi^J(a,q) &= \pi^{JD}(a,q) + \max\{0, \pi^{JJ}(a,q)\} + 2\max\{0, \pi^{JK}(a,q)\} \\
\pi^{JD}(a,q) &= \left(\frac{a^\chi q^{1-\eta}\alpha}{w^J}\right)^{\frac{\alpha}{1-\alpha}} (1-\alpha) P^{J\frac{\alpha}{1-\alpha}} E^J - w^J c_f \\
\pi^{JJ}(a,q) &= \tau^{\frac{\alpha}{\alpha-1}} \left(\frac{a^\chi q^{1-\eta}\alpha}{w^J}\right)^{\frac{\alpha}{1-\alpha}} (1-\alpha) P^{J\frac{\alpha}{1-\alpha}} E^J - w^J c_{ex} \\
\pi^{JK}(a,q) &= \tau^{\frac{\alpha}{\alpha-1}} \left(\frac{a^\chi q^{1-\eta}\alpha}{w^J}\right)^{\frac{\alpha}{1-\alpha}} (1-\alpha) P^{K\frac{\alpha}{1-\alpha}} E^K - w^J c_{ex}
\end{aligned} \tag{20}$$

where superscript ^{JJ} denotes exports to the symmetric country of the same region, while ^{JK} stands for export to a country of the other region.

Since export profits depend on the aggregate variables of the foreign region, this is the channel through which the aggregate economy of the foreign region affects the profitability of the domestic firms.
For a given q∈Q we define the following export cutoff functions for the North and the South,

$$\begin{aligned}
a_{ex}^{JJ}(q) &= \left[\left(\frac{w^J c_{ex}}{(1-\alpha)P^{J\frac{\alpha}{1-\alpha}}E^J}\right)^{\frac{1-\alpha}{\alpha}} \frac{1}{\alpha}\frac{w^J\tau}{q^{1-\eta}}\right]^{\frac{1}{\chi}} \\
a_{ex}^{JK}(q) &= \left[\left(\frac{w^J c_{ex}}{(1-\alpha)P^{K\frac{\alpha}{1-\alpha}}E^K}\right)^{\frac{1-\alpha}{\alpha}} \frac{1}{\alpha}\frac{w^J\tau}{q^{1-\eta}}\right]^{\frac{1}{\chi}}.
\end{aligned} \tag{21}$$

The order of the cutoffs for export to different regions is determined by the ratio of the aggregates of the two regions, $P^{\alpha/(1-\alpha)}E$. However, the exit cutoffs depend only on the domestic aggregates. For a given quality firm partition in both the North and the South is such that firms with low level of efficiency (a) exit the industry, firms with intermediate levels produce only for the domestic market, while the most efficient firms produce for both the domestic and the foreign markets, first for the market in the North and then for the foreign markets in both regions. The stated order of the firm partition is assured by the conditions on the fixed costs of operation and export.[9]

3.3.2 Cross sectional distribution and aggregates

The density of firms conditional on successful entry is computed as

$$\mu^N(a,q) = \begin{cases} \frac{g^N(a,q)}{P_{in}^N} & \text{if } a \geq a_x^N(q) \\ 0 & \text{otherwise} \end{cases} \tag{22}$$

for the North firms and similarly for the South firms,

[9] See Appendix A. for the discussion on exit and export cutoffs.

$$\mu^S(a,q) = \begin{cases} \frac{g^S(a,q)}{P_{in}^S} & \text{if } a \geq a_x^S(q) \\ 0 & \text{otherwise,} \end{cases} \tag{23}$$

where $P_{in}^N = \int_{axN(q)} \int_Q g^N(a,q)dqda$ and $P_{in}^S = \int_{axS(q)} \int_Q g^S(a,q \mid \bar{\mu}^N)dqda$ are the ex-ante probabilities of surviving for the firms in the North and the South, respectively. In a similar way we can define the ex-ante probability that a successful firm exports. That is, $P_{ex}^{NN}=(1-G(a_{ex}^{NN}(q),q))/P_{in}^N$, $P_{ex}^{NS}=(1-G(a_{ex}^{NN}(q),q))/P_{in}^N$, $P_{ex}^{SN}=(1-G(a_{ex}^{SS}(q),q))/P_{in}^S$ and $P_{ex}^{SS}=(1-G(a_{ex}^{SS}(q),q))/P_{in}^S$ for North and South.
I^{ND} and I^{SD} represent the measure of varieties produced in each country of the North and the South, so $I_{ex}^{NN} = P_{ex}^{NN}I^{ND}$, $I_{ex}^{NS} = P_{ex}^{NS}I^{ND}$, $I_{ex}^{SN} = P_{ex}^{SN}I^{SD}$ and $I_{ex}^{SS} = P_{ex}^{SS}I^{SD}$ are the masses of exporting firms and exported varieties in the North and the South, respectively. This means that the mass of available varieties in each country is given by the mass of varieties produced domestically plus the mass of varieties imported: $I^N = I^{ND} + I_{ex}^{NN} + 2I_{ex}^{SN}$ for the North, and $I^S = I^{SD} + I_{ex}^{SS} + 2I_{ex}^{NS}$ for the South.

The average weighted productivity for the North is given by

$$\tilde{\mu}^J = \left(\frac{I^{JD}}{(I^{JD} + I_{ex}^{JJ} + 2I_{ex}^{JK})} \tilde{\mu}_x^{JD\,\frac{\alpha}{1-\alpha}} + \frac{I_{ex}^{JJ}}{(I^{JD} + I_{ex}^{JJ} + 2I_{ex}^{JK})} \tilde{\mu}_{ex}^{JJ\,\frac{\alpha}{1-\alpha}} + \frac{2I_{ex}^{JK}}{(I^{JD} + I_{ex}^{JJ} + 2I_{ex}^{JK})} \tilde{\mu}_{ex}^{JK\,\frac{\alpha}{1-\alpha}} \right)^{\frac{1-\alpha}{\alpha}} \tag{24}$$

where J, K = {N, S}, J≠K and

$$\begin{aligned} \tilde{\mu}_x^{JD} &= \left(\int_{a_x^J(q)} \int_Q (a^\chi q^{1-\eta})^{\frac{\alpha}{1-\alpha}} \mu^J(a,q) \mathrm{d}q\mathrm{d}a \right)^{\frac{1-\alpha}{\alpha}} \\ \tilde{\mu}_{ex}^{JJ} &= \left(\int_{a_{ex}^{JJ}(q)} \int_Q (a^\chi q^{1-\eta})^{\frac{\alpha}{1-\alpha}} \mu_{ex}^{JJ}(a,q) \mathrm{d}q\mathrm{d}a \right)^{\frac{1-\alpha}{\alpha}} \\ \tilde{\mu}_{ex}^{JK} &= \left(\int_{a_{ex}^{JK}(q)} \int_Q (a^\chi q^{1-\eta})^{\frac{\alpha}{1-\alpha}} \mu_{ex}^{JK}(a,q) \mathrm{d}q\mathrm{d}a \right)^{\frac{1-\alpha}{\alpha}}. \end{aligned} \tag{25}$$

Variables $\mu_{ex}^{JJ}(a,q)$ and $\mu_{ex}^{JJ}(a,q)$ are the conditional distributions of firms exporting to the North and of firms exporting to both regions, respectively, given that the firm survives in the market.

3.3.3 Steady-state equilibrium

The steady state equilibrium is characterized by prices (p^{JD},p^{JX}), wages (w^J), exit and export cutoff functions ($a_x^J(q)$, $a_{ex}^{JJ}(q)$, $a_{ex}^{JK}(q)$), firm distributions (μ^J, μ_{ex}^{JJ}, μ_{ex}^{JK}), number of firms in each region (I^{JD}) and the aggregate expenditure and price indices (E^J,P^J) such that

• consumers choose consumption optimally and firms choose prices to maximize their profits
• exit and export cutoff functions satisfy the conditions given by (10) and (21)
• entry and exit are such that the stability condition $\delta I^{JD} = P^J M^J$ and the free entry condition are satisfied
• distribution of firms in the North and the South are given by (25)
• number of operating firms is such that the labor markets clear, i.e. total labor is used for domestic and export production and also for the fixed cost of entry, operation and

$$\begin{aligned} L^J &= \int_{a_x^J(q)} \int_Q n(a,q)\mu^J(a,q) I^{JD} \mathrm{d}q\mathrm{d}a + \int_{a_{ex}^{JJ}(q)} \int_Q n(a,q)\mu^J(a,q) I^{JD} \mathrm{d}q\mathrm{d}a \\ &+ \int_{a_{ex}^{JK}(q)} \int_Q n(a,q)\mu^J(a,q) I^{JD} \mathrm{d}q\mathrm{d}a + c_e M^J + c_{ex}(P_{ex}^{JJ} + P_{ex}^{JK}) I^{JD} + c_f I^{JD} \end{aligned} \quad (26)$$

• the trade balance condition is satisfied, implying that the bilateral North-North, South-South, North- South and South-North trade is balanced.[10]

We solve the model numerically using the value of parameters which are calibrated to match the recent data on the aggregate trade values (shares of North-North, North-South and South-South exports in the total world exports, relative wage of the South compared to the North) and the firm-level variables.

3.4. Calibration

In our quantitative exercise we choose the preference parameter, α, exponents on productivity and quality in the production function, χ and η, exogenous exit probability, δ, the size of the countries, L^N and L^S, and the mean of the entrants in the North, $\overline{g}^N$. α is set equal to 0.73 to match a mark-up over the marginal cost of 36%.[11] χ and η are equal to 0.5 and 0.86, respectively. The results do not change qualitatively if χ and η change as long as the conditions on these two exponents are satisfied.[12] The exogenous death probability is fixed equal to 0.5% and hence firms's life expectancy is a priori of 200 years.[13] Finally, L^N, L^S, and $\overline{g}^N$ scale and locate the economy in the space (a,q). The population is assumed to be the same in both the North and the South and normlized to one while $\overline{g}^N$ is set equal to 4.

---

[10] Due to symmetry between the countries of the same region, trade balance depends only on the values of export flows between countries of different regions in equilibrium.

[11] For more details on mark-ups in models with heterogenous firms and fixed costs see Ghironi and Melitz 2005.

[12] This also includes the specification with $\chi = \eta > 0.5$

[13] Atkeson and Burstein 2007 and Luttmer 2007 find the same value calibrating δ.

The remaining parameters are the technological gap between the North and the South, θ, the fixed cost of entry, c_e, the fixed operational cost, c_f, the fixed cost of export, c_{ex}, and the entrants distribution variance for the North and the South (assuming equal variance over productivity and quality and across countries). These parameters are calibrated to match a number of salient features related to the 2006 data on the within and across region export shares in the total world exports, exit and entry rates in the manufacturing industry and the South-North relative wage. The data on export shares are taken from The OECD Policy Brief ”South- South Trade:Vital for Development”, August 2006, available at: www.oecd.org/publications/Policybriefs and Goksel 2008. The reported export shares are 52.69% for the North-North trade, 40.86% for the North- South and 6.45% for the South-South exports. Bartelsman et al. (2004) compute that the average firms exit rate in the data for the North is around 10%, while it is slightly higher in the South, 20%. Accordingly to the World Bank, International Comparison Program database, online edition, 2009 the relative South-North wage in the manufacturing sector is on average 0.4.
Table 2 in Appendix B summarizes the parameters values both exogenously set and calibrated, the empirical targets used for the calibration and the corresponding model moments.

4. Four-country scenario results

This section presents the numerical results of the North-South trade model with four countries, two sym- metric Norths and two symmetric Souths. Given the productivity lag of the entrants in the South behind the incumbents in the North, the selection of the firms in the equilibrium results in the distribution of operat- ing firms over productivity vectors in the North and the South as presented in Figure 1. The equilibrium productivity lag of the South results in the positive North-South wage differential in equilibrium.
When the North and the South are open to trade, the South produces the low productivity varieties that are demanded domestically but also by the North whose international competitiveness in this portion of the distribution is weakened due to lower production cost in the South. On the other hand, Northern firms are more spread out on the whole remaining area of the productivity space, higher efficiency and higher quality. Few firms in the South reach these productivity levels and thus the North specializes in the production and export of higher (a, q) varieties.

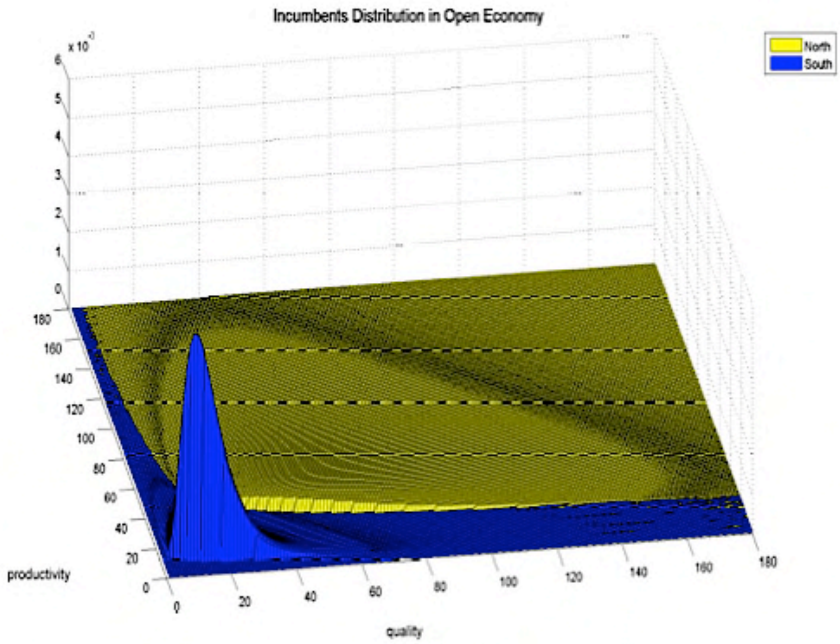

Figure 1: Incumbents distribution over productivity and quality

Figure 2. presents the partitioning of the firms across the (a,q) space into exiting firms, domestic producers and exporters of two types, those that export only to the North and those that export both to the North and the South. Analyzing the partition over the efficiency dimension, the lowest a firms exit the industry in both regions, but the exit cutoff in the North is higher than in the South due to higher absolute value of the fixed operational cost. Therefore, it can be observed that the low efficiency varieties are consumed exclusively by the South as the North exits this market, and as the South does not export due to low profitability. The North-South head-on competition occurs in the intermediate efficiency range of varieties. Southern varieties are more competitive and are exported to the North, while the North produces them only for the domestic consumption at a reduced scale. At even higher levels of efficiency, the number of Southern firms (varieties) decreases. This is principally the market for Northern exporters who employ a large share of the total labor force in the North. Details on labor (size) distribution of firms and the values of average productivities across different areas of the (a,q) space in the North and the South are presented in Appendix C.

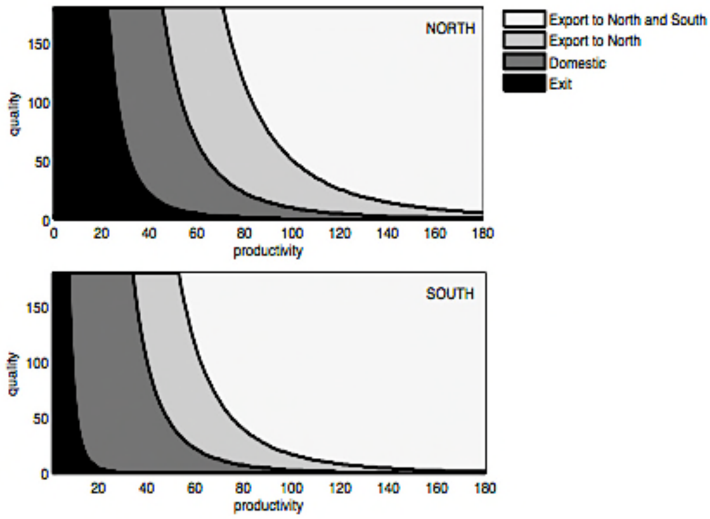

Figure 2: Firms partition

Bearing in mind the price schedule over the (a,q) space, the partitioning graph provides a graphical explanation for positive relationship between the average export and import prices on one side and income per capita on the other. With $\chi > 1 - \eta$ the profits increase faster along the efficiency dimension, which shapes the isoprofit curves (cutoff functions) in the (a, q) space as presented in Figure 3.

The shape of the cutoff functions determines the quality and price composition of the domestic and import bundles of the two regions. The most profitable firms export both to the North and the South, while less profitable export only to the North. With $\chi > 1 - \eta$, the bigger share of the relatively higher priced varieties (high q and low a) are not exported to the South and are shipped only to the North.[14]

Thus, the resulting average import price is higher for the North. This result holds for all exporter, and also conditional on a particular exporting country. Northern imports are of higher average price relative to the imports of the South as more high quality-low efficiency varieties are included in its import bundle. In other words, it imports goods of higher average price not as it consumes higher quality than the South but due to the fact that it additionally consumes the high priced high quality varieties. The analogue reasoning applies to the imports from the South.This effect is not present with only one dimension of firms heterogeneity as the profits are just a monotonic transformation of the price and the unique productivity measure.

---

[14] As opposed to the case with $\chi < 1 - \eta$ when relatively low priced varieties are excluded from exports to the South in a larger share than the high priced varieties.

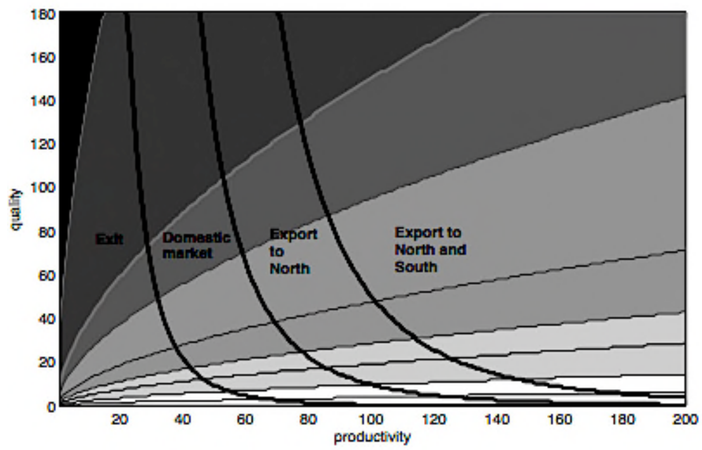

Figure 3: Distribution of prices

On the export side, the North abandons the export of low price varieties due to competition from the South, which results in higher export prices of the North. Average prices of export and import are presented in Table 1.

Average Price	North	South
Exports	4.0739	0.9495
Imports	1.0072	0.9101
Imports from North	4.2514	3.9861
Imports from South	1.0008	0.9054

Table 1: Average Import Prices

The following graph (Figure 4.) presents the expenditure shares distribution of the two regions across different levels of quality for a given efficiency of the firm. Northern demand is relatively higher for the varieties produced by the high quality firms, and the South is demanding relatively more of the goods in the lower quality portion of the distribution, which is the effect of the fixed cost of trade. With no fixed cost, the homothetic preferences would result in a lower demand from the South but still in levels exactly proportional quality to those of the North. Once the fixed cost of export is introduced in both the North and the South, this results in subsets of firms with only domestic sales, which subsequently distorts the proportionality of the consumption shares of the two regions across varieties.

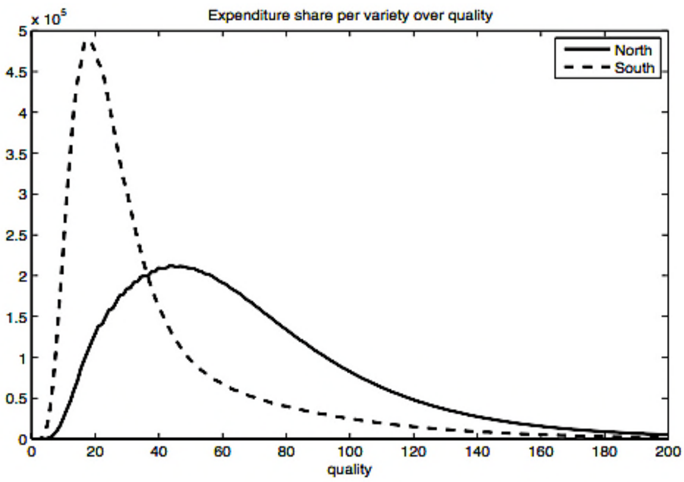

Figure 4: Expenditure shares distribution over quality

Figure 5. shows the total trade values within and across two groups of countries with no asymmetries in the variable costs of trade. The model implies that larger shares of Northern export revenue is coming from the North due to higher profitability requirements for the export to the South and low absolute expenditure of the South. This implies higher trade intensity between countries of the North. As a result, the North-North trade is the largest compared to the other trade flows, North-South and South-South. In this set-up North- South trade is of higher value than the South-South trade, but the ranking reverses when the asymmetric variable costs of trade are introduced, with the highest cost imposed on Southern exports to the North. Some empirical evidence points to these asymmetries in the form of higher export barriers imposed on the exporters from the South (such as iceberg trade cost, quality requirements, tariffs). In sectors with these asymmetries, our model's results might support the final conjecture of the Linder hypothesis, besides predicting the demand and supply premises.

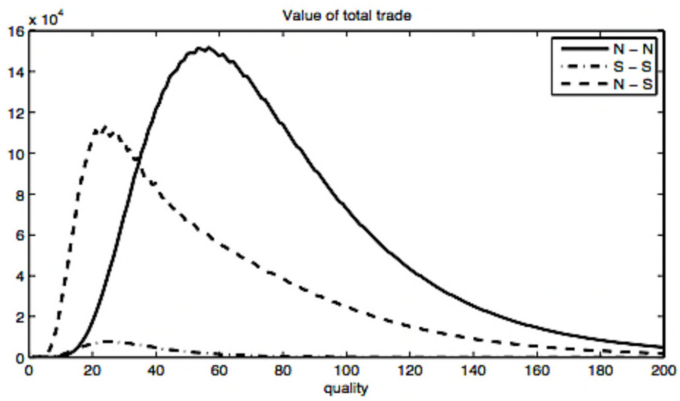

Figure 5: Total trade values within and across regions

5. Conclusion

This paper analyzes the role of efficiency and quality in shaping the trade patterns and trade intensities within and across two groups of countries, the developed and richer North and the developing South. We employ a four country North-South trade model with two dimensions of firm heterogeneity. Matching the empirical values of within and across region export shares in the total world exports, we show that the equilibrium results support the ranking of the average prices of tradables within and across regions as found in the data. This result is not previously found in the literature since using only one technology dimension does not simultaneously allow for increasing relation between export prices, import prices and import prices conditional on exporter on one side and income per capita on the other.

Furthermore, we find differences in the consumption bundles across regions even though the preferences are of standard, homothetic form. Namely, the resulting total expenditure allocation across quality shows that the North spends a larger share of its income on high quality while the South allocates more of its expenditure on low quality varieties. Therefore, we wish to stress that the trade patterns in this model are not determined by the non-homotheticity of preferences and therefore do not originate exclusively from the demand structures. The results mainly come from the supply side through the productivity distribution of incumbents and its effect on prices. This in turn allows the fixed cost of exporting to act in a way that the empirically observed trading pattern is replicated. In other words, it is not that the consumers alone have different preferences over qualities based on their income but differences in productivity and income (coming endogenously from the productivity level) are the principal deciding factors.

The future research agenda calls for the development of an endogenous R&D mechanism which will determine technology level of the North and the South in equilibrium. In this hypothetical set-up, firm would choose the level of their investment in technology, which would affect the initial productivity draw through the innovation in the North and technology adoption in the South. R&D incentives would come partly from the domestic demand structure but also as a response to foreign demand, which would together shape the comparative advantage of each region over quality segments. This allows for the analysis of several issues such as trade liberalization, income inequality and R&D subsidies to promote welfare. Furthermore, it should be noted that the set-up is easily extendable to include n countries which allows for more empirically testable predictions.

References

Aghion, P. and Howitt, P. (1992),"A Model of Growth through Creative Destruction", *Econometrica*, 60, 323-351.

Baldwin, R. and Harrigan, J. (2007),"Zeros, Quality and Space: Trade Theory and Trade Evidence", *CEPR Discussion Paper No. 6368*.

Bartelsman, E., Haltiwanger, J. and Scarpetta, S. (2004),"Microeconomic Evidence of Creative Destruction in Industrial and Developing Countries, Eric Bartelsman", *Tinbergen Institute Discussion Paper*, 04-114/3.

Bernard, A.B., Redding, S.J. and Schott, P.K. (2009),"Products and Productivity, mimeo.

Brooks, E.L. (2006),"Why don't firms export more? Product quality and Colombian plants", *Journal of Development Economics*, 80, 160- 178.

Choi, Y.C., Hummels, D. and Xiang, C. (2006),"Explaining Import Variety and Quality: The Role of the Income Distribution", *NBER Working Paper 12531*.

Coibion, O., Einav, L. and Hallak, H.C. (2007),"Equilibrium demand elasticities across quality segments", *International Journal of Industrial Organization*, 25, 13-30.

Cordoba, J.C. and Ripoll, M. (2008),"Endogenous TFP and cross-country income differences", *Journal of Monetary Economics*, 55, 11581170.

Fajgelbaum, P.D., Grossman G.M. and Helpman E. (2009), "Income Distribution, Product Quality, and International Trade", *NBER Working Paper Series*, Working Paper 15329.

Fieler, C. (2007),"Non-Homotheticity and Bilateral Trade: Evidence and a Quantitative Explanation", *New York University, mimeo*.

Fieler, C. (2007),"Quality Differentiation in International Trade: Evidence from the Demand and Supply Sides", *New York University, mimeo*.

Flam, H. and Helpman, E. (1987),"Vertical Product Differentiation and North-South Trade", *The American Economic Review*, 77(5), 810-822.

Fontagne, L. and Freudenberg, M. (2002),""Long-term Trends in IIT", Chapter 8 of Frontiers of Research on Intra-industry Trade", *Peter Lloyd Hyun Lee eds, Palgrave*, 131-158.

Fontagne, L., Guillaume, G. and Zignago, S. (2008),"Specialization across varieties and North-South competition", *Economic Policy*, 23 (53), 51-91.

Gabler, A. and Licandro, O. (2005),"Endogenous Growth through Selection and Imitation", *European University Institute, mimeo*.

Ghironi, F. and Melitz. M.J. (2005),"International Trade and Macroeconomics Dynamics with Heterogenous Firms", *Quarterly Journal of Economics*, 120(3), 865-915.

Goksel, T. (2008),"Income, Trade Barriers, and International Trade", *University of*

Minnesota, mimeo.
Grossman, G. M. and Helpman, E. (1991),“Innovation and Growth in the Global Economy”, *MIT Press*, Cambridge MA.
Hall, R.E. and Jones, C.I. (1999),“Why Do Some Countries Produce So Much More Output Per Worker Than Others?”, *The Quarterly Journal of Economics, MIT Press*, 114(1), 83-116.
Hallak, J.C. (2006),“A Product-Quality View of the Linder Hypothesis”, *NBER Working Paper No.12712*.
Hallak, J.C. (2006),“Product Quality and the Direction of Trade”, *Journal of International Economics*, 68(1), 238-265.
Hallak, J.C. AND Schott, P. (2010), “Estimating Cross-Country Differences in Product Quality”, *Quarterly Journal of Economics (forthcoming)*.
Halak, J. C. and Sivadasan, J. (2008),“Firms’ Exporting Behavior under Quality Constraints”, *International Policy Center*, Working Paper No. 88.
Hopenhayn, H. A. (1992),“Entry and Exit and Firm Dynamics in Long Run Equilibrium”, *Econometrica* 60(5), 1127-1150.
Huergo, E. and Jaumandreu, J. (2004a), “How does Probability of Innovation Change with Firm Age?”, *Small Business Economics*, 22, 193-207.
Huergo, E. and Jaumandreu, J. (2004b), “Firms Age, Process Innovation and Productivity Growth”, *International Journal of Industrial Organization*, 22, 541-559.
Hummels, D. and Klenow, P.J. (2005),“The Variety and Quality of a Nation’s Exports”, *American Economic Review*, 95(3), 704-723.
Hummels, D. and Skiba, A. (2004),“Shipping the Good Apples Out? An Empirical Confirmation of the Alchian-Allen Conjecture”, *Journal of Political Economy*, 112(6), 1384-1402.
Jerzmanovwski, M. (2007),“Total factor productivity differences:Appropriate technology vs. efficiency”, *European Economic Review*, 51, 20802110.
Johnson, R.C. (2010),“Trade and Prices with Heterogeneous Firms”, *Dartmouth College, mimeo*.
Khandelwal, A. (2010), “The Long and Short (of) Quality Ladders”, *Review of Economic Studies (forthcoming)*.
Krugman, P. (1979),“A Model of Innovation, TechnologyTransfer, and the World Distribution of Income”, *Journal of Political Economy*, 87(2), 253-266.
Linder, S. (1961),“An Essay on Trade and Transformation”, *Stockholm: Almqvist Wiksell*.
Manova, K. and Zhang, Z. (2009), “Quality Heterogeneity across Firms and Export Destinations”, *NBER Working Paper Series*, Working Paper 15342.
Melitz, M. (2003),“The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity”, *Econometrica* 71(6), 1695-1725.

Parisi, M., Schiantarelli, F. and Sembenelli, A. (2006), "Productivity, Innovation and R&D: Micro Evidence for Italy", *European Economic Review*, 50, 2037-2061.
Romer, P. (1990),"Endogenous Technological Change", *Journal of Political Economy* 98, 71-102.
Schott, P. K. (2004),"Across-product Versus Within-product Specialization in International Trade", *The Quarterly Journal of Economics*, 119(2), 646-677.
Segerstrom, P. and Dinopoulos, E. (2006),"North-South Trade and Economic Growth", *Stockholm School of Economics, mimeo*.
Verhoogen, E. (2008),"Trade, Quality Upgrading, and Wage Inequality in the Mexican Manufacturing Sectors", *The Quarterly Journal of Economics* 123(2), 489-530.

Appendix

A. Conditions on fixed costs and technological lag

The setup of the model requires that the exit cutoff in any region, aJx (q), is lower than the export cutoff,
aJK(q), in order to rule out the possibility of firms not operating domestically, and producing only for the ex
export market. To insure this we impose conditions on the fixed costs of production and export, and on the level of the technological lag of the South behind the North. With fixed export cost cex higher than the fixed operational cost cf , the cutoff for exporting to the other country of the same region (North-North and South-South trade) will be higher than the exit cutoff. However, to insure higher cutoff for exporting to the other region (North-South trade) than the exit cutoff, the following condition is required

$$\frac{c_f}{c_{ex}} < \frac{P^{N\frac{\alpha}{1-\alpha}} L^N w^N}{P^{S\frac{\alpha}{1-\alpha}} L^S w^S} < \frac{c_{ex}}{c_f} \tag{27}$$

As the equilibrium wage and price indices are functions of the technological lag θ, it follows that the three parameters together determine whether the condition above holds. The relative size of the population in the two regions affects the relative size of the aggregates and therefore the ratio of exit cutoffs in the North and the South, and the ordering of export cutoffs conditional on the destination country. In general, if the South is sufficiently larger than the North, the aggregates of the South might be larger than those of the North even with the relative wage smaller than one. However, the calibration exercise shows that such a large South would neither match the data on the actual size of trading partners in the North and the South nor the model could be considered as the model of North-South trade as the share of the Southern firms exporting to the North would be approaching zero. Therefore, without the loss of generality, we assume equal sizes of the regions. We find that under the wide range of cf , cex and θ that satisfy the stated condition, the resulting ordering of the cutoffs is such that the exit cutoff is higher in the North than in the South. Moreover, the exporters of relatively lower productivity export only to the North, while the highest productivity firms export also to the South.

B. Calibration

Table 2: Targets and Parameters

Targets	**Data**	**Model**
North-North Export Share	52.69%	54.95%
North-South Export Share	40.86%	42.49%
North Exit Rate	10%	10.43%
South Exit Rate	20%	23.43%
Wage Ratio w^s/w^N	0.4	0.41
Calibrated Parameters		
θ	0.18	
σ	0.5	
c_f	11.42%	of avg North domestic employment
c_{ex}	29.51%	of avg North domestic employment
c_e	38%	of avg North domestic employment
Other Parameters		
α	0.73	
χ	0.5	
η	0.86	
δ	0.5%	
τ	1	
$\overline{g}^N$	4.1	
$L^N = L^S$	1	

C. Size distribution and average productivities

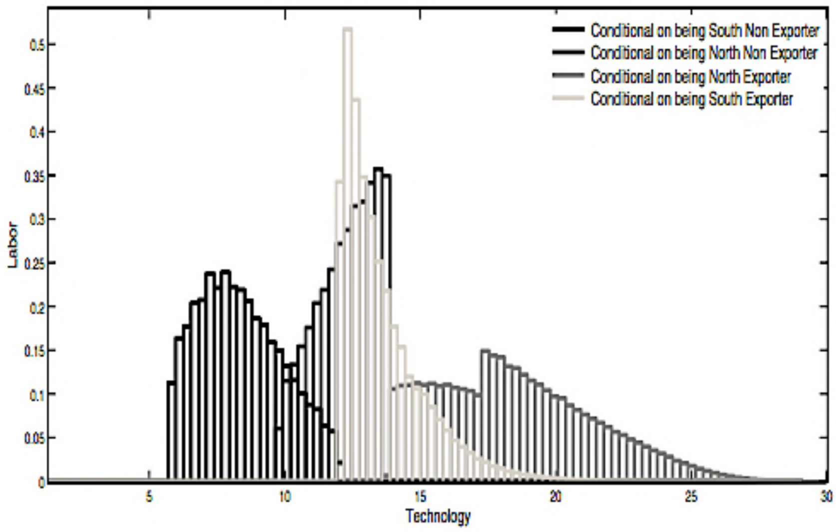

Figure 6: Conditional Labor Distribution over Technology

Weighted Average Technology	North	South
Total	16.76	8.38
Domestic	15.01	8.05
Export to North	17.23	13.29
Export to N and S	19.79	16.18

Table 3: Weighted Average Technology Across Firm Partition