E/B/R ECONOMIC AND BUSINESS REVIEW

Volume 17 | Issue 3 Article 4

12-23-2015

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Recommended Citation

Lindič, M. (2015). How Do Trading Firms Upgrade Skills and Technology: A Theoretical Model. *Economic and Business Review, 17*(3). https://doi.org/10.15458/85451.5

HOW TRADING FIRMS UPGRADE SKILLS AND TECHNOLOGY: THEORETICAL MODEL

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Received: 13 March 2015
Accepted: 28 October 2015

ABSTRACT: *This paper studies the mechanisms of skill upgrading in trading firms by developing a theoretical model that relates the individual's incentives for acquiring higher skills to the profit-maximizing behaviour of trading firms. The model shows that only the high ability individuals have incentives for acquiring higher skills, as long as they are compensated with higher wages after entering employment. Furthermore, high-productive firms have incentives for investing in higher technology, to employ high-skilled labour, and to engage in international trade. The decisions for technology dress-up and skill upgrading coincide with firm's decisions to start importing and exporting as the latter requires higher technology and high-skilled labour. Contributions of the paper are twofold: gaining new insights by combining fragments of models on individual's and firm's behaviours, and broadening the content of the Melitz (2003) model by introducing importers and controlling for skilled and unskilled labour.*

Keywords: *skill upgrading, technology upgrading, trading firms.*
JEL Classification: F12; J24; O30
DOI: 10.15458/85451.5

1. INTRODUCTION

The liberalisation of international trade increases firm's productivity for two reasons; one is due to easier access to a better selection of advanced technologies and another is due to a better allocation of production factors. The latter channel was among others emphasized in the Melitz (2003) model, while the former was for example stressed in Bustos (2011b). The Melitz (2003) model explores the effects of trade on intra-industry reallocations and aggregate industry productivity by taking into account heterogeneous firms that differ regarding their level of productivity. The model concludes that only the most productive firms engage in exporting activities. The Melitz (2003) model represents groundwork in the recent trade literature and was used as a basis also in the Bustos (2011b) model, which explores the effects of trade liberalisation on skill upgrading in exporting firms, where the model also differentiates between high- and low-technology firms.

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This paper aims to fill the void in the international trade theory by broadening the theoretical models of Melitz (2003) and Bustos (2011b), and correspondingly including imports to the model. By doing this, the model also explains recent empirical findings on the importance of importing as one of the drivers of firm's productivity gains. Evaluating trade liberalisation after China's entry to the World Trade Organization, Bloom, Draca and Van Reenen (2011) find that the increased Chinese import competition increased the innovations and adoption of new technologies, which in turn increased the productivity within firms, while between firms it transferred employment toward innovative and technologically advanced firms. The positive impact of importing on the firm's productivity was confirmed also by Halpern, Koren and Szeidl (2011), studying the Hungarian data, Kasahara and Rodrigue (2008), studying the Chilean data, and Amiti and Konings (2007), studying the Indonesian data. The latter study points out that these productivity increases are a consequence of importing high-quality intermediates, the enhanced diversification of inputs, and higher learning opportunities (Amiti, & Konings, 2007). Taking into account importers and exporters, Smeets and Warzynski (2010) confirm that both, exporting and importing, increase the firm's productivity, while firms with the highest level of productivity are engaged in both trading activities. In relation to these findings, empirical papers also certify the positive impact of importing on exporting. Bas and Strauss-Kahn (2014) emphasize three channels through which importing affects exporting positively. First is the indirect productivity channel of increased productivity after importing, which can in turn have a positive effect on overcoming export costs. Second is a direct cost channel due to changing the input structure towards more cost-effective importing intermediates. Finally, through the quality/technology transfer, imported intermediate inputs can enable exporting products to be of such quality and technology levels, as desired in the export markets. Positive effects of importing on exporting were for example confirmed also by Feng, Li and Swenson (2012), studying the Chinese data.

In addition, since the individual's decisions for acquiring higher skills later have an important impact on the behaviour of profit-maximizing firms, another motivation for writing this paper was to combine specific individual's and firm's decisions. Since the existing trade models are based on broader, firm-level decisions, the impetus of the present paper is to explore more in depth also the behaviour of individuals and their decision for skill upgrading, as these decisions have in turn the effect on skill upgrading within a firm.

The model in this paper bases its framework on the models of Bustos (2011a, 2011b) and Melitz (2003), and on the work of Stark and others (see for example Stark, & Wang, 2001; Stark, Helmenstein, & Prskawetz, 1998; Stark, & Chau, 1998; and Stark, Helmenstein, & Prskawetz, 1997 for reference), who developed models on human capital formation. The model first explores the behaviour of individuals, who decide whether to invest in acquiring higher skills or not. In this part, the model differentiates between high ability and low ability individuals, where the individual's ability level defines the cost level for acquiring skills. Upon the level of these costs, individuals decide whether to invest in obtaining the skills or not, where this decision relies also on their future wage level. Results suggest that only high ability individuals find it profitable to invest in acquiring additional skills, while they in turn demand higher wages after entering employment. These findings are then incorporated in the second part of the model, which focuses on exploring the behaviour of heterogeneous firms that decide on when to start investing in higher technology, and when to start engaging in trading activities. In this part of the model, profit-maximizing firms differ upon their level of labour productivity, where the proxy for higher labour productivity are higher labour costs, indicating a higher employment level of skilled employees. The latter judgement is backed up by the results from the first part of the model. Investing in higher technology and starting to import and export brings higher fixed costs, but decreases the level of firm's marginal costs, and/or increases the employment of skilled workers, and/or increases revenues. Findings from the second part suggest that the technologically advanced firms employ a higher number of skilled workers and that only the most productive firms find it profitable to start trading, investing in higher technology and skill upgrading.

This paper contributes to the literature in two ways. Firstly, since the mentioned empirical papers emphasized the importance of differentiating between importing and exporting, this model accounts for both. Therefore, the model broadens the content of the papers of Bustos (2011a, 2011b) and Melitz (2003), who take into account only exporters. Secondly, while other theoretical trade models only analysed decisions from a firm's point of view, this paper's contribution is to combine behaviour of individuals and firms in one model of trade. The model therefore broadens the existing trade models by analysing the behaviour of individuals and their decision for skill upgrading. This is later incorporated in the firm-level decisions, by taking into account the firm's labour demand and productivity.

The remainder of the paper is organised in the following manner: the next section presents a brief introduction of the theoretical background, which is further on used as a reference point to the theoretical model, included in the third section. The last section summarises the main findings and includes a conclusion.

2. LITERATURE REVIEW

Melitz (2003) developed an important theoretical model, which explores the effects of trade on intra-industry reallocations and aggregate industry productivity. The model uses heterogeneous firms that differ regarding the level of productivity, where firms with higher levels of productivity produce the same amount of products at lower marginal costs. After observing their level of productivity, firms decide to exit or enter the market, where new entrants have a lower level of productivity and a higher probability to exit than firms that are already on the market. When exploring the effects of trade, the author only focuses on exports. After firms start exporting, they are faced with higher costs for two reasons; one reason is higher per-unit trade costs, and the other reason are higher fixed costs. The latter can be explained as a consequence of establishing new networks, adapting the product to the new market, setting up new distribution channels, etc. After introducing the possibility to export to the model, firms again observe their level of productivity. Once more, the least productive firms decide to exit the market, the firms with medium-level of productivity decide to serve the domestic market, while the most productive firms serve the domestic market and export (Melitz, 2003).

The Melitz (2003) model presents the groundwork for many subsequent theoretical models on trade. Bustos upgraded the Melitz (2003) model by including technology upgrading (Bustos, 2011a) and skill upgrading (Bustos, 2011b) into the model. In the first model, Bustos (2011a) takes into account profit maximizing firms which decide whether to start exporting and whether to invest in higher technology. By adopting higher technology, firms pay higher fixed production costs, while their marginal costs are reduced. After proving that using high technology and serving the domestic market is always dominated by some other choice, firms form four different groups: the least productive firms exit, the low productive firms use low technology and serve the domestic market, the medium productive firms still use low technology but also export, while only the most productive firms upgrade their technology level and export (Bustos, 2011a).

The gains of different production factors, labour and capital to be precise, were included already in the Heckscher-Ohlin model (the H-O model), which predicts that countries adjust their production and trading on behalf of their factor endowments. The Stolper-Samuelson theorem in the H-O model indicates that the real returns of the factor-abundant owners increase, and the real returns of the owners of the other factor decrease as a consequence of trade (Krugman, Obstfeld, & Melitz, 2012). Relating to the conclusions of the H-O model, the relative demand for skilled workers – a scarce factor in developing countries – should decrease after trade liberalisation. However, the empirical findings show the opposite (see for example Goldberg, & Pavcnik, 2007). Bustos (2011b) has filled the gap in trade literature, by exploring the effects of trade liberalisation on skill upgrading in exporting firms. The model accounts for two categories of workers, skilled and unskilled. As in the previous model (Bustos, 2011a), firms form four different groups before trade liberalisation, whereas after liberalisation, they form six groups in total. The least productive firms exit. Among the firms that did not export before trade liberalisation, a fraction of these firms continue serving the domestic market, use low technology and downgrade skills; another fraction of these firms still uses low technology, but they start exporting and downgrade skills, while the most productive of these firms start to export, upgrade their technology and skills. Firms that were already exporting before trade liberalisation and used low technology continue to export, switch to high technology and upgrade skills. Finally, the most productive firms that were exporting and using high technology before trade liberalisation continue exporting and using high technology, but they downgrade skills. The conclusions of the theoretical model were later tested also with the empirical model, which studies the effect of Brazil's tariff reduction on Argentinian firms. The model's predictions that low-technology firms downgrade skills and that firms in the upper-middle range of productivity distribution upgrade skills after trade liberalisation are consistent with the empirical findings. On the other hand, the prediction that the most productive high-technology firms downgrade skills after trade liberalisation is not consistent with the empirical findings (Bustos, 2011b).

Finally, as presented in the introduction, it is important to control for the imports in trade models, as imports usually serve as a prerequisite to exporting activities (see for example empirical studies of Damijan, & Kostevc, 2015; and Altomonte, & Békés, 2010). To be precise, by studying the connections between importing, exporting and innovation in

Spanish firms, Damijan and Kostevc (2015) find that importing enables firms to first start with process and product innovation, and later also with exporting. In addition, exporting stimulates further innovation. Although empirical studies show the importance of importing, the latter is infrequently included in the theoretical models of trade. One of the models that does account for importing is the theoretical model by Amiti and Davis (2011), who base their theoretical model on the Melitz (2003) model and control for imports, by including additional costs of importing in the model.

The theoretical model in this paper combines different aspects of the models, presented in the literature review and adds also a thorough analysis of individual's behaviour and their decision for skill upgrading. It is necessary to study these decisions, as they later have an important impact on the firm's productivity level, labour demand and labour costs. For this purpose, several papers of Stark and others were taken into account (see for example Stark, & Wang, 2001; Stark, Helmenstein, & Prskawetz, 1998; Stark, & Chau, 1998; and Stark, Helmenstein, & Prskawetz, 1997 for reference). The primary focus is on the paper by Stark and Wang (2001), who developed a model of human capital formation in an environment with and without migration. I bring the model into use as a benchmark and use it for explaining the individual's choice for skill upgrading.

3. THE MODEL

This section presents a simple theoretical model, the first part of which studies the decision of individuals to invest in acquiring additional skills. The findings of the first part of the model are later incorporated in the second part, which analyses the decision of heterogeneous firms to start trading and investing in higher technology.

3.1 Setup of the Model

The model takes into account the country, endowed with heterogeneous workforce and heterogeneous firms. Firms differ according to the different productivity levels, which are the end result of different technologies used, and in regards to firms being included in international trade. Concerning the latter, the model differentiates between importing and exporting firms, whereas concerning the former, it differentiates between high-technology and low-technology firms.

3.2 Individuals

This part of the theoretical model follows the work of Stark and others (see for example Stark, & Wang, 2001; Stark, Helmenstein, & Prskawetz, 1998; Stark, & Chau, 1998; and Stark, Helmenstein, & Prskawetz, 1997 for reference). Each individual in the economy is endowed with a certain amount of efficiency units (θ), which represents the ability of a worker. If the average ability of workers in the economy is $\underline{\theta}$, and the abilities of high ability and low ability workers are θ_S and θ_U, respectively, the following applies: $\theta_U < \underline{\theta} < \theta_S$. For brevity, the model denotes all individuals with above-average abilities by θ_S, and individuals with below-average abilities by θ_U. Derivations of the model therefore assume two ability levels.

After individuals evaluate their level of ability, they decide whether to invest in acquiring higher skills or not. It is assumed that the costs for acquiring higher skill levels are different for individuals with different abilities. To be precise, costs for acquiring human capital for high ability individuals (k_S) are lower than the costs of low ability individuals (k_U); i.e. $k_U > k_S > 1$. All individuals have an opportunity to achieve higher levels of education and become skilled. However, since the costs for acquiring the highest levels of human capital are too high for low ability individuals, they will be able to obtain the human capital only up to a certain level and will not be able to achieve above-average skill levels.

Individuals with higher abilities will have incentives for acquiring above-average levels of human capital, if their costs for acquiring high skill levels will be later compensated with higher gross earnings when they are employed. In order to emphasise the period after individuals acquire skills, the model denotes high ability, high skilled individuals with Θ_S and low ability, low skilled individuals with Θ_U. The gross earnings of high ability, high skilled workers (w_S) should therefore be higher than the gross earnings of low ability, low skilled workers (w_U); i.e. $0 < w_U < w_S$. Thus, each individual initially bears the costs of acquiring human capital. However, the costs are later transmitted onto firms in the form of higher expected gross earnings of high ability, high skilled individuals.

The function of gross earnings for unskilled workers is the following:

$$w_U(\Theta_U) = \lambda[\ln(\Theta_U + 1)] - k_U\Theta_U, \tag{1}$$

where the first term on the right hand side ($\lambda[\ln(\Theta_U + 1)]$) represents personal returns to human capital, and the last term represents costs of acquiring human capital. The parameter λ is assumed to be positive. Furthermore, for convenience, the following is assumed as well: $\lambda > k_U > k_S > 1$.

Similarly, the function of gross earnings of skilled workers can be written as:

$$w_S(\Theta_S) = \lambda\,[\ln(\Theta_S + 1)] - k_S\Theta_S. \tag{2}$$

The succeeding claim proves that the optimal skill level of workers with low ability and low skills is lower than the optimal skill level of workers with high ability and high skills. It is important to prove that in order to make further inferences on the wage level of skilled workers.

Claim 1: The optimal skill level of individuals with low ability is lower than the optimal skill level of individuals with high ability.

Proof: To get the optimal skill level of high and low ability individuals, first order conditions of gross earnings for each level of skills are derived.

$$\frac{\partial w_U(\Theta_U)}{\partial \Theta_U} = \frac{\lambda}{\Theta_U + 1} - k_U$$

$$\frac{\partial w_S(\Theta_S)}{\partial \Theta_S} = \frac{\lambda}{\Theta_S + 1} - k_S$$

When checking the maxima, the following optimal skill levels of workers are calculated. Optimal skill level of the low ability workers (Θ_U^*) is:

$$\Theta_U^* = \lambda(k_U)^{-1} - 1. \quad (3)$$

Optimal skill level of the high ability workers (Θ_S^*) is:

$$\Theta_S^* = \lambda(k_S)^{-1} - 1. \quad (4)$$

When comparing both optimal levels and taking into account that $k_S < k_U$, it is confirmed that $\Theta_U^* < \Theta_S^*$. ▪

Although the previous claim confirms that the high ability workers will have higher optimal skill levels than the low ability workers, it also has to be proven that the high ability workers will have incentives to invest in their educational attainment and make the best of their potential. As mentioned before, high ability workers will have incentives to invest in their educational attainment and become skilled, if their future income would increase because of that investment. By inserting optimal skill levels of high ability and low ability individuals (expressions (3) and (4)) in the functions of gross earnings (expressions (1) and (2)), the following can be derived:

$$w_U(\Theta_U^*) < w_S(\Theta_S^*)$$
$$\lambda[\ln(\lambda / k_U)] - k_U\,[(\lambda / k_U) - 1] < \lambda[\ln(\lambda / k_S)] - k_S\,[(\lambda / k_S) - 1].$$

Taking into account the assumption $\lambda > k_U > k_S > 1$, it can be confirmed that the gross earnings of workers with low optimal ability ($w_U(\Theta_U^*)$) are lower, compared to the gross earnings of workers with high optimal ability ($w_S(\Theta_S^*)$).

For consistency purposes it was also confirmed that $w_U(\Theta_U^*) > 0$. The proof for this claim can be found in Appendix A.

As only the high ability individuals have incentives to invest in acquiring higher skills, total workforce (L) in the country comprises high ability, high skilled workers (L_S) and low ability, low skilled workers (L_U). Workforce in the country as a whole is therefore the following: $L = L_S + L_U$.

3.3 Firms

This part of the model takes into account heterogeneous profit-maximizing firms that differ in their level of labour productivity and decide whether to adopt a skill-intensive technology, and whether to start exporting and importing. The previous part of the model concluded that skilled workers have a higher level of ability and can hence be employed in a more productive way. This finding will be accounted for in the current part of the model, when taking into account the level of firm's labour productivity. This part of the theoretical model follows the work of Melitz and Redding (2014), Amiti and Davis (2011), Bustos (2011a and 2011b), and Melitz (2003).

3.3.1 Preferences

Following Melitz and Redding (2014), and Bustos (2011a, 2011b), this part considers two symmetric countries that engage in bilateral trade after trade liberalisation. Consumer preferences are described by a continuum of horizontally-differentiated varieties and are assumed to take the Constant Elasticity of Substitution (CES) form:

$$Q = \left[\int_0^M q(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}},$$

where ω defines a particular variety of a product, M is the number of existing varieties, and σ is a constant elasticity of substitution. The following applies: $\sigma = 1/(1-\rho)$, where ρ is a parameter which determines the constant elasticity of substitution, so that $\sigma > 1$ applies. These preferences define the following demand function for each variety ω: $q(\omega) = XP^{\sigma-1} p(\omega)^{-\sigma}$. Here, X represents the aggregate spending level of consumers, $p(\omega)$ the price of each variety, and P the price index, equal to:

$$P = \left[\int_0^M p(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}}.$$

3.3.2 Firm entry and exit

Following Melitz and Redding (2014), and Bustos (2011b), firms pay a sunk fixed entry cost f_X to enter an industry. After that, firms draw the level of their productivity φ from a cumulative distribution $G(\varphi)$ and with regard to this level they decide whether to exit the market or to produce.

3.3.3 Technology and factor heterogeneity

Products are produced by using a composite factor of production, L, which is composed of skilled labour (L_S) and unskilled labour (L_U). From the previous subchapter, it follows that skilled workers have a higher level of ability, which is reflected in their higher wage level $w_U < w_S$. Furthermore, following Melitz and Redding (2014), and Bustos (2011b), by paying an additional fixed cost, firms can upgrade to a high-technology level h, which is also more skill-intensive and reduces the firm's marginal costs of production. On the other hand, the low-technology level l is less skill-intensive and demands lower fixed costs for producing goods.

Total costs for low-technology firms are as follows:

$$TC_l = \left[f + \frac{q}{\phi} \right] w_S^{\beta} w_U^{1-\beta} , \quad (5)$$

where f denotes fixed costs, w_S and w_U are wages of skilled and unskilled workers, respectively, q is the level of firm's output, φ is productivity level, and $\beta \in (0,1)$ denotes skill intensity.

On the other hand, firms can invest in higher skill-intensive technology. Total costs for the latter can be defined by:

$$TC_h = \left[f\eta + \frac{q}{\gamma\phi} \right] w_S^{\alpha} w_U^{1-\alpha} , \quad (6)$$

where $\eta > 1$, $\gamma > 1$, $\alpha \in (0,1)$, and $\alpha >$ ß. The model assumes that due to a smaller relative share of skilled employees in low-technology firms, who use low-technology equipment, the labour productivity in low-technology firms is lower than the labour productivity in high-technology firms. On the other hand, as a result of investing in skill-intensive technology, high-technology firms change their skill structure by employing a higher number of high ability, high skilled employees. Accordingly, the model assumes that skill-intensive technology is brought into use more productively when employing relatively more skilled individuals with high abilities. Relating to the findings from the first part, which studied the incentives for individual's skill upgrading, the model also assumes that firms with higher labour productivity have higher labour costs, as a consequence of a higher employment of skilled workers, who earn higher wages; $w_S > w_U$. Higher labour costs can therefore be considered as a proxy for higher employment of skilled workers. These assumptions are consistent with the findings of empirical studies, which confirm that bigger firms use more technology-advanced equipment, pay higher wages and employ more productive workers (Idson, & Oi, 1999). Similar characteristics have also been confirmed in trading firms, which are larger in size and more productive (Altomonte, & Békés, 2010). These conclusions are reflected in the assumption that $\alpha >$ ß (expressions (5) and (6)), when defining the total costs of low- and high-technology firms.

3.3.4 International activities of firms

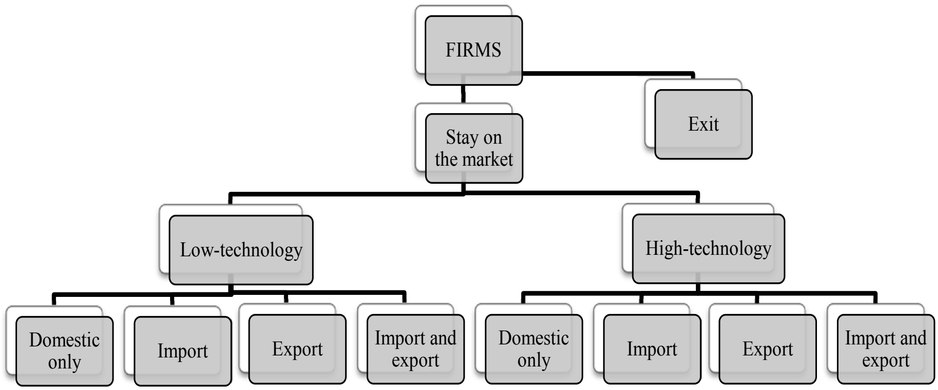
The model is built as a 2-stage model, where costs of trade decrease significantly only in the second stage, as a consequence of trade liberalisation. In the first stage, firms decide whether to invest in skill-intensive high-technology, whereas in the second stage, firms decide whether to engage in trading activities. Similarly as in Melitz and Redding (2014), and Bustos (2011b), firms decide to start exporting after realising their level of productivity, φ, and taking into account the higher costs of exporting. On the one hand, additional fixed costs of exporting, f_E, arise from establishing new sales channels, advertising, adapting to new laws and rules, etc., while on the other, firms also have to pay additional iceberg variable trade costs τ, meaning that τ number of units have to be shipped abroad in order for one unit to arrive, where $\tau > 1$ (Melitz, & Redding, 2014). For very similar reasons as in the case of exports, importing also entails higher fixed costs, denoted by f_I (Amiti, & Davis, 2011). Additional costs of exporting and importing make an assortment of the most productive firms that can afford to endure higher costs.

3.3.5 Firm behaviour

Some additional assumptions concerning costs and the change in productivity levels are made below. As introduced earlier, this model is of a two-stage type, where in the first stage, firms decide whether to invest in high-technology or not and in the second stage, after trade liberalisation, firms decide whether to engage in international activities or not. When firms start importing, they have access to cheaper technology and/or access to cheaper intermediates. It is therefore anticipated that importing increases the productivity of firms for two different reasons. First, importing intermediates allows other factors of production to be used more productively. Second, importing more affordable technology equipment in turn increases the firm's productivity. Accordingly, the level of labour productivity in firms increases after importing. The model also assumes the fixed costs of acquiring high-technology are higher than the fixed costs of importing; i.e. $f_I < f\eta$. The reason behind this assumption is that when comparing the technology level of importing low-technology firms and high-technology firms, which invest in technology within their own R&D departments, it is assumed that the increase in the productivity level will not be as big in low-technology firms that start importing, compared to the productivity increase in firms that start investing in high-technology. Although low-technology firms still have a more affordable option for increasing their level of productivity through importing, the benefits are not as high, compared to investing into developing custom-made high-technology equipment within firms. Finally, due to exporting, firms sell their products to a higher number of customers and therefore reach higher revenues.

The following paragraphs describe a two-stage model, where in each of the steps, firms decide between several options and choose the most profitable one. It is assumed that in the first stage (before trade liberalisation) importing and exporting is beyond the reach due to high costs, so firms can only choose whether to invest in higher technology or not. In the second step, after trade liberalisation, firms have an option to start importing, exporting or both. The following diagram summarises the steps of the model.

Figure 1: *The flow-chart of events in the two-stage model*



In the listed steps, firms compare several different profit options, which are described next. Following Melitz and Redding (2014), and Bustos (2011b), the market structure is of monopolistic competition type, where each firm chooses its price in order to maximise its profits. The profit maximising price is a constant mark-up over marginal costs. In the first stage, low-technology firms charge the price

$$p_l = \frac{\sigma}{\sigma - 1} \frac{w_S^{\beta} w_U^{1-\beta}}{\phi},$$

while high-technology firms charge the price

$$p_h = \frac{\sigma}{\sigma - 1} \frac{w_S^{\alpha} w_U^{1-\alpha}}{\gamma\phi}.$$

Firms compare the following two options:
a) No trade, use low technology:

$$\pi_l(\phi) = \frac{r_l(\phi)}{\sigma} - f w_S^{\beta} w_U^{1-\beta},$$

where $\pi_l(\varphi)$ are the total profits of firms with low-technology levels, φ is the level of labour productivity, and $r_l(\varphi)$ are revenues, with $r_l(\phi) = XP^{\sigma-1}(\frac{\sigma}{\sigma-1}\frac{w_S^{\beta} w_U^{1-\beta}}{\phi})^{1-\sigma}$.

b) No trade, use high technology:

$$\pi_h(\phi) = \frac{r_h(\phi)}{\sigma} - f\eta w_S^{\alpha} w_U^{1-\alpha},$$

where $\pi_h(\varphi)$ are the total profits of firms with high-technology levels, and $r_h(\varphi)$ are the revenues, with $r_h(\phi) = XP^{\sigma-1}(\frac{\sigma}{\sigma-1}\frac{w_S^{\alpha} w_U^{1-\alpha}}{\gamma\phi})^{1-\sigma}$.

According to Melitz and Redding (2014), firms first assess their level of productivity and upon that decide whether to stay and produce or whether to exit the market. If they stay, they maximise the level of their profits with regard to the level of their productivity. This generates a survival bound productivity φ^*, returning zero profits: $\pi(\varphi^*) = 0$.

When comparing zero-profit bounds of low- and high-technology firms in the first stage of the model; i.e.

$$\pi_l(\phi) = \pi_h(\phi) \Leftrightarrow \frac{r_l(\phi)}{\sigma} - fW_l = \frac{r_h(\phi)}{\sigma} - f\eta W_h,$$

it follows that due to the higher fixed costs of adopting new technology, only the most productive firms will be able to afford investing in high-technology. For convenience, W_l is denoted as total labour costs in low-technology firms ($W_l = w_S^{\beta} w_U^{1-\beta}$), and W_h as total labour costs in high-technology firms ($W_h = w_S^{\alpha} w_U^{1-\alpha}$). Least productive firms will therefore use low-technology. Furthermore, the exit bound productivity, φ^*, is defined by:

$$\pi_l(\phi^*) = 0 \Leftrightarrow \phi^* = Af^{\frac{1}{\sigma-1}} W_l^{\frac{\sigma}{\sigma-1}},$$

where $A = (\frac{\sigma}{X})^{\frac{1}{\sigma-1}} \frac{1}{P\rho}$.

To get the level of productivity, above which a firm finds it profitable to invest in high-technology, φ_h, the subsequent two expressions are compared: $\pi_l(\phi_h) = \pi_h(\phi_h)$, yielding the following:

$$\phi_h = A\left[f(\eta W_h - W_l)\right]^{\frac{1}{\sigma-1}} (\frac{W_h}{\gamma} - W_l).$$

Now, it must apply that $\phi^* < \phi_h$, which is true as long as $(W_l)^{\frac{\sigma}{\sigma-1}} < (\eta W_h - W_l)^{\frac{1}{\sigma-1}} (\frac{W_h}{\gamma} - W_l)$.

The latter expression stands when the wages in high-technology firms (W_h) are significantly higher than the wages in low-technology firms (W_l). This is consistent with the findings from the first part of the paper, which concludes that higher wages signal a higher employment of skilled workers. I believe this assumption is valid as it confirms previous empirical findings that firms, which use more technology-advanced equipment, also pay higher wages, and employ more productive workers (see for example Idson, & Oi, 1999). Therefore, only the most productive firms use skill-intensive technology and upgrade skills. In addition, taking into account the last term in the upper expression $(\frac{W_h}{\gamma} - W_l)$, the relative increase in wages due to investing in higher technology has to be higher than the relative decrease in marginal costs; i.e. $\frac{W_h}{W_l} > \gamma$, which additionally emphasises the importance of higher employment of skilled workers in high-technology firms.

After trade liberalisation in the second stage, low-technology firms compare the following four options:

a) No trade, use low technology:

$$\pi_l(\phi) = \frac{r_l(\phi)}{\sigma} - f w_S^{\beta} w_U^{1-\beta} \,,$$

where $\pi_l(\varphi)$ are the total profits of firms with low-technology levels, φ is the level of labour productivity, and $r_l(\varphi)$ are the revenues, with $r_l(\phi) = XP^{\sigma-1}(\frac{\sigma}{\sigma-1}\frac{w_S^{\beta} w_U^{1-\beta}}{\phi})^{1-\sigma}$.

b) Start importing, use low technology:

When low-technology firms start importing, their costs and productivity level increase and add up to: $TC_l^I = \left[f + f_I + \frac{q}{\gamma_l^I \phi} \right] w_S^{\beta^I} w_U^{1-\beta^I}$, where $\beta < \beta^I < \alpha$, and $1 < \gamma_l^I < \gamma$.

Introducing the factors β^I and γ_l^I enables controlling for the decrease in marginal costs and the changes of the skill structure in favour of the skilled employees after low-technology firms start importing. However, as explained above, the increase in the productivity level is not as big as it would be if the firms invested in developing the custom-made technology within their own R&D departments. Firms charge the price: $p_l^I = \frac{\sigma}{\sigma-1}\frac{w_S^{\beta^I} w_U^{1-\beta^I}}{\gamma_l^I \phi}$. Taking these facts into account, profit is as follows:

$$\pi_l^I(\phi) = \frac{r_l^I(\phi)}{\sigma} - (f + f_I) w_S^{\beta^I} w_U^{1-\beta^I} \,,$$

where $\pi_l^I(\phi)$ are the total profits of low-technology firms that start importing, and $r_l^I(\phi)$ are the revenues, with $r_l^I(\phi) = XP^{\sigma-1}(\frac{\sigma}{\sigma-1}\frac{w_S^{\beta^I} w_U^{1-\beta^I}}{\gamma_l^I \phi})^{1-\sigma}$.

c) Start exporting, use low technology:

When low-technology firms start exporting, their costs add up to:

$$TC_l^E = \left[f + f_E + \frac{\tau q}{\phi} \right] w_S^{\beta} w_U^{1-\beta} \,.$$

Consequently, firms charge the price: $p_l^E = \frac{\sigma}{\sigma-1}\frac{\tau w_S^{\beta} w_U^{1-\beta}}{\phi}$.

Taking these facts into account, the profit is:

$$\pi_l^E(\phi) = \frac{r_l^E(\phi)}{\sigma} - (f + f_E) w_S^{\beta} w_U^{1-\beta} \,,$$

where $\pi_l^E(\phi)$ are the total profits of low-technology firms that start exporting, and $r_l^E(\phi)$ are the revenues, with $r_l^E(\phi) = XP^{\sigma-1}(\frac{\sigma}{\sigma-1}\frac{\tau w_S^{\beta} w_U^{1-\beta}}{\phi})^{1-\sigma}$.

d) Start importing and exporting, use low technology:

When low-technology firms start importing and exporting, their costs add up to: $TC_l^{IE} = \left[f + f_I + f_E + \frac{\tau q}{\gamma_l^I \phi} \right] w_S^{\beta^I} w_U^{1-\beta^I}$.

Consequently, firms charge the price: $p_l^{IE} = \frac{\sigma}{\sigma - 1} \frac{\tau w_S^{\beta^I} w_U^{1-\beta^I}}{\gamma_l^I \phi}$.

Taking these facts into account, the profit is:

$$\pi_l^{IE}(\phi) = \frac{r_l^{IE}(\phi)}{\sigma} - (f + f_I + f_E) w_S^{\beta^I} w_U^{1-\beta^I},$$

where $\pi_l^{IE}(\phi)$ are the total profits of low-technology firms that start importing and exporting, and $r_l^{IE}(\phi)$ are the revenues, with $r_l^{IE}(\phi) = XP^{\sigma-1}\left(\frac{\sigma}{\sigma-1} \frac{\tau w_S^{\beta^I} w_U^{1-\beta^I}}{\gamma_l^I \phi}\right)^{1-\sigma}$.

When comparing the zero-profit bounds in this stage of the model, the assumption of identical countries is considered (Bustos, 2011a), from which it follows that the price index (P) and the expenditure level (X) are the same at home and abroad. First, the zero-profit bounds of low-technology firms that do not engage in international activities are compared to the bounds of those which start importing in the second stage of the model:

$$\pi_l(\phi) = \pi_l^I(\phi) \Leftrightarrow \frac{r_l(\phi)}{\sigma} - fW_l = \frac{r_l^I(\phi)}{\sigma} - (f + f_I) W_l^I.$$

For convenience, I again used the abbreviation for the total labour costs in low-technology firms (W_l) and denoted the total labour costs of importing low-technology firms by $W_l^I = w_S^{\beta^I} w_U^{1-\beta^I}$. It follows that only the most productive low-technology firms will be able to afford paying higher fixed costs of importing, while the least productive low-technology firms will continue serving the domestic market. To get the level of productivity, above which a low-technology firm finds it profitable to start importing, ϕ_l^I, one compares the subsequent two expressions: $\pi_l(\phi_l^I) = \pi_l^I(\phi_l^I)$, and gets the following:

$$\phi_l^I = A\left[f(W_l^I - W_l) + f_I W_l^I \right]^{\frac{1}{\sigma-1}} \left(\frac{W_l^I}{\gamma_l^I} - W_l\right).$$

The expression $\phi^* < \phi_l^I$ applies, as long as $f^{\frac{1}{\sigma-1}} (W_l)^{\frac{\sigma}{\sigma-1}} < \left[f(W_l^I - W_l) + f_I W_l^I \right]^{\frac{1}{\sigma-1}} \left(\frac{W_l^I}{\gamma_l^I} - W_l\right)$.

This is true when the wages in importing low-technology firms (W_l^I) are significantly higher than the wages in low-technology firms (W_l), which again signals a higher employment level of skilled workers, as follows from the first part of the model. This assumption is also valid, since the empirical data confirms that importing firms are on average larger and pay higher wages (see for example Altomonte, & Békés, 2010). In addition, taking into account the last term in the upper expression $\left(\frac{W_l^I}{\gamma_l^I} - W_l\right)$, the relative increase in wages due to importing has to be higher than the relative decrease in marginal costs after the start of importing; i.e. $\frac{W_l^I}{W_l} > \gamma_l^I$. This statement corresponds to the initial assumption that the decrease in marginal costs due to imports is lower than it would be, should the firms invest in developing custom-made technology within their own R&D departments.

Furthermore, when comparing the zero-profit bounds of low-technology firms that do not engage in international activities and of those which start exporting in the second stage of the model:

$$\pi_l(\phi) = \pi_l^E(\phi) \Leftrightarrow \frac{r_l(\phi)}{\sigma} - fW_l = \frac{r_l^E(\phi)}{\sigma} - (f + f_E)W_l,$$

it follows that exporting low-technology firms do not invest in upgrading their skill structure nor do they invest in acquiring lower marginal costs. Therefore, since the productivity level of low-productive firms stays the same after they start exporting, low-technology firms will export only if the costs of exporting are lower than the increase in revenues after the start of exporting. However, following Melitz and Redding (2014), it is assumed that the fixed costs of exporting are too high for low-technology firms and therefore present a selection, so that only the most productive firms start exporting. As a result, firms that do not invest in acquiring a higher level of productivity – either through importing or through investing in higher technology – cannot start exporting since their productivity level is too low.

In addition, the zero-profit bounds of low-technology firms which do not engage in international activities and of those that start importing and exporting in the second stage of the model, are compared with the following expressions:

$$\pi_l(\phi) = \pi_l^{IE}(\phi) \Leftrightarrow \frac{r_l(\phi)}{\sigma} - fW_l = \frac{r_l^{IE}(\phi)}{\sigma} - (f + f_I + f_E)W_l^I.$$

In relation to the upper comparison, low-technology firms will find engaging in importing and exporting activities profitable only if the increase in revenues and productivity level is bigger than the increase in costs of exporting and importing. To get the level of productivity, above which a low-technology firm finds it profitable to start importing and exporting, ϕ_l^{IE}, the subsequent two expressions are compared: $\pi_l(\phi_l^{IE}) = \pi_l^{IE}(\phi_l^{IE})$, yielding the following:

$$\phi_l^{IE} = A\left[f(W_l^I - W_l) + (f_I + f_E)W_l^I\right]^{\frac{1}{\sigma-1}}\left(\frac{\tau}{\gamma_l^I}W_l^I - W_l\right).$$

This allows us to check when the productivity level of low-technology firms that import (ϕ_l^I) is lower than the productivity level of low-technology firms that export and import (ϕ_l^{IE}):

$$\phi_l^I < \phi_l^{IE} \Leftrightarrow \left[f(W_l^I - W_l) + f_I W_l^I\right]^{\frac{1}{\sigma-1}}\left(\frac{1}{\gamma_l^I}W_l^I - W_l\right) < \left[f(W_l^I - W_l) + (f_I + f_E)W_l^I\right]^{\frac{1}{\sigma-1}}\left(\frac{\tau}{\gamma_l^I}W_l^I - W_l\right).$$

Since $f_E > 0$ and $\tau > 1$, it follows that $\phi_l^I < \phi_l^{IE}$, when the wages in importing low-technology firms (W_l^I) are significantly higher than the wages in low-technology firms (W_l), which was already assumed. Therefore, only the most productive low-technology firms that will be able to compensate for higher exporting costs will start exporting and importing.

To sum up, after trade liberalisation in the second stage of the model, only the most productive low-technology firms choose to upgrade skills and to start exporting and importing, less productive low-technology firms only import, and the least productive low-technology firms continue serving the domestic market. On the other hand, low-technology firms will not decide to engage in exporting activities without increasing their level of productivity by importing, as their productivity level would be too low to bear exporting costs.

The model now focuses on evaluating the following four options of high-technology firms after trade liberalisation in the second stage:

a)No trade, use high technology:

$$\pi_h(\phi)=\frac{r_h(\phi)}{\sigma}-f\eta w_S^{\alpha}w_U^{1-\alpha},$$

where $\pi_h(\varphi)$ are the total profits of firms with high-technology levels, and $r_h(\varphi)$ are the revenues, with $r_h(\phi)=XP^{\sigma-1}(\frac{\sigma}{\sigma-1}\frac{w_S^{\alpha}w_U^{1-\alpha}}{\gamma\phi})^{1-\sigma}$.

b) Start importing, use high technology:
When high-technology firms start importing, their costs and productivity level increase and add up to: $TC_h^I=\left[f\eta+f_I+\frac{q}{\gamma_h^I\phi}\right]w_S^{\alpha^I}w_U^{1-\alpha^I}$, where $\beta<\beta^I<\alpha<\alpha^I<1$, and $\gamma_l^I<\gamma<\gamma_h^I$. Introducing factors α^I and γ_h^I enables controlling for the increase in productivity level and the changes in skill structure in favour of the skilled employees after high-technology firms start importing. In addition, firms charge the price: $p_h^I=\frac{\sigma}{\sigma-1}\frac{w_S^{\alpha^I}w_U^{1-\alpha^I}}{\gamma_h^I\phi}$. Taking these facts into account, the profit is:

$$\pi_h^I(\phi)=\frac{r_h^I(\phi)}{\sigma}-(f\eta+f_I)w_S^{\alpha^I}w_U^{1-\alpha^I},$$

where $\pi_h^I(\phi)$ are the total profits of high-technology firms that start importing, and $r_h^I(\phi)$ are the revenues, with $r_h^I(\phi)=XP^{\sigma-1}(\frac{\sigma}{\sigma-1}\frac{w_S^{\alpha^I}w_U^{1-\alpha^I}}{\gamma_h^I\phi})^{1-\sigma}$.

c)Start exporting, use high technology:
When high-technology firms start exporting, their costs add up to: $TC_h^E=\left[f\eta+f_E+\frac{\tau q}{\gamma\phi}\right]w_S^{\alpha}w_U^{1-\alpha}$.
Consequently, firms charge the price: $p_h^E=\frac{\sigma}{\sigma-1}\frac{\tau w_S^{\alpha}w_U^{1-\alpha}}{\gamma\phi}$.

Taking these facts into account, profit is as follows:

$$\pi_h^E(\phi) = \frac{r_h^E(\phi)}{\sigma} - (f\eta + f_E) w_S^{\alpha} w_U^{1-\alpha},$$

where $\pi_h^E(\phi)$ are the total profits of high-technology firms that start exporting, and $r_h^E(\phi)$ are the revenues, with $r_h^E(\phi) = XP^{\sigma-1}(\frac{\sigma}{\sigma-1}\frac{\tau w_S^{\alpha} w_U^{1-\alpha}}{\gamma\phi})^{1-\sigma}$.

d) Start importing and exporting, use high technology:

When high-technology firms start importing and exporting, their costs add up to:

$$TC_h^{IE} = \left[f\eta + f_I + f_E + \frac{\tau q}{\gamma_h^I \phi} \right] w_S^{\alpha^I} w_U^{1-\alpha^I}.$$

Consequently, firms charge the price: $p_h^{IE} = \frac{\sigma}{\sigma-1}\frac{\tau w_S^{\alpha^I} w_U^{1-\alpha^I}}{\gamma_h^I \phi}$.

Taking these facts into account, the profit is:

$$\pi_l^E(\phi) = \frac{r_l^E(\phi)}{\sigma} - (f + f_E) w_S^{\beta} w_U^{1-\beta},$$

where $\pi_h^{IE}(\phi)$ are the total profits of high-technology firms that start importing and exporting, and $r_h^{IE}(\phi)$ are the revenues, with $r_h^{IE}(\phi) = XP^{\sigma-1}(\frac{\sigma}{\sigma-1}\frac{\tau w_S^{\alpha^I} w_U^{1-\alpha^I}}{\gamma_h^I \phi})^{1-\sigma}$.

The following two expressions are considered when comparing the zero-profit bounds of high-technology firms that do not engage in international activities and of those which start importing in the second stage of the model:

$$\pi_h(\phi) = \pi_h^I(\phi) \Leftrightarrow \frac{r_h(\phi)}{\sigma} - f\eta W_h = \frac{r_h^I(\phi)}{\sigma} - (f\eta + f_I) W_h^I.$$

For convenience, the abbreviation for the total labour costs in high-technology firms (W_h) is applied, while total labour costs of importing high-technology firms are denoted by $W_h^I = w_S^{\alpha^I} w_U^{1-\alpha^I}$. To calculate the level of productivity in importing high-technology firms, ϕ_h^I, the subsequent two expressions are compared: $\pi_h(\phi_h^I) = \pi_h^I(\phi_h^I)$, yielding the following:

$$\phi_h^I = A\left[f\eta(W_h^I - W_h) + f_I W_h^I \right]^{\frac{1}{\sigma-1}} \frac{\gamma W_h^I - \gamma_h^I W_h}{\gamma_h^I \gamma}.$$

In order for this expression to be positive, $\phi_h^I > 0$, γ_h^I and γ must not be too far apart. This means that the marginal cost reduction of high-technology firms that do not engage in international activities and of those which start importing in the second stage of the model, should not differ substantially. This coincides with the assumption from the previous part of the paper, stating that importing brings lower marginal cost reduction, compared to the marginal cost reduction due to investment into high-technology. In addition, the level of

productivity of high-technology domestic firms, ϕ_h, and the level of productivity of high-technology importing firms, ϕ_h^I, is compared as well. The expression $\phi_h < \phi_h^I$ applies, as long as $\left[f(\eta W_h - W_l)\right]^{\frac{1}{\sigma-1}}(\frac{W_h}{\gamma} - W_l) < \left[f\eta(W_h^I - W_h) + f_I W_h^I\right]^{\frac{1}{\sigma-1}}(\frac{\gamma W_h^I - \gamma_h^I W_h}{\gamma_h^I \gamma})$.
The latter expression is valid when the wages in high-technology firms (W_h) are significantly higher than the wages in low-technology firms (W_l). Also, the wage level in high-technology firms should increase substantially as a consequence of importing (W_h^I). Again, following the conclusions made when studying the skill upgrading at the level of individuals, both presumptions signal a higher employment level of skilled workers and were already assumed in the previous part of the paper.

Next, the following two expressions are considered when comparing the zero-profit bounds of high-technology firms that do not engage in international activities and of those which start exporting in the second stage of the model:

$$\pi_h(\phi) = \pi_h^E(\phi) \Leftrightarrow \frac{r_h(\phi)}{\sigma} - f\eta W_h = \frac{r_h^E(\phi)}{\sigma} - (f\eta + f_E)W_h.$$

To get the level of productivity, above which a high-technology firm finds it profitable to start exporting, ϕ_h^E, the subsequent two expressions are compared: $\pi_h(\phi_h^E) = \pi_h^E(\phi_h^E)$, yielding the following:

$$\phi_h^E = A\left[f_E W_h\right]^{\frac{1}{\sigma-1}} \frac{\tau W_h}{\gamma}(1 - \frac{1}{\tau}).$$

Since it was already assumed that $\tau > 1$, the productivity level of high-technology exporting firms will be positive; $\phi_h^E > 0$. In addition, the level of productivity of high-technology domestic firms, ϕ_h, and the level of productivity of high-technology exporting firms, ϕ_h^E, is compared as well. The expression $\phi_h < \phi_h^E$ applies, as long as $\left[f(\eta W_h - W_l)\right]^{\frac{1}{\sigma-1}}(\frac{W_h}{\gamma} - W_l) < \left[f_E W_h\right]^{\frac{1}{\sigma-1}} \frac{\tau W_h}{\gamma}(1 - \frac{1}{\tau})$. The latter expression confirms that only the most productive high-technology firms, which will be able to compensate for higher exporting costs, start exporting.

By confirming that the most productive high-technology firms engage in trading activities after trade liberalisation in the second stage due to their initial higher level of productivity, it is possible to compare the zero-profit bounds of high-technology firms that start importing and of those which start exporting in the second stage of the model:

$$\pi_h^I(\phi) = \pi_h^E(\phi) \Leftrightarrow \frac{r_h^I(\phi)}{\sigma} - (f\eta + f_I)W_h^I = \frac{r_h^E(\phi)}{\sigma} - (f\eta + f_E)W_h.$$

High-technology firms choose between the start of importing and exporting on behalf of their productivity level; high-technology firms decide to import if their productivity level is not yet high enough to start exporting, whereas more productive high-technology firms start exporting in order to increase their revenues. This makes it possible to compare the productivity levels of high-technology firms that start importing (ϕ_h^I) and high-technology firms that start exporting (ϕ_h^E) and see that high-technology firms start importing, when the level of bound productivity is higher; i.e.

$$\phi_h^E < \phi_h^I \Leftrightarrow \left[f_E W_h\right]^{\frac{1}{\sigma-1}} \tau W_h (1-\frac{1}{\tau}) < \left[f\eta(W_h^I - W_h) + f_I W_h^I\right]^{\frac{1}{\sigma-1}} (\frac{\gamma}{\gamma_h^I} W_h^I - W_h).$$

The latter expression applies if the wage level in high-technology firms (W_h) is significantly lower than the wage level in high-technology importing firms (W_h^I): $W_h < W_h^I$, which is again a sign of a higher employment level of skilled workers. Moreover, the decision between the start of importing and exporting will depend on external factors; i.e. the cost level of importing and exporting. If the costs of importing are significantly higher than the costs of exporting, only the most productive high-technology firms will be able to afford importing. In contrast, when the opposite holds, only the most productive high-technology firms will be able to afford exporting.

The next step compares the zero-profit bounds of importing high-technology firms and of high-technology firms that start importing and exporting in the second stage of the model:

$$\pi_h^I(\phi) = \pi_h^{IE}(\phi) \Leftrightarrow \frac{r_h^I(\phi)}{\sigma} - (f\eta + f_I)W_h^I = \frac{r_h^{IE}(\phi)}{\sigma} - (f\eta + f_I + f_E)W_h^I.$$

It follows that high-technology firms will find exporting and importing profitable only if the increase in revenues will be bigger than the increase in costs of exporting. To get the level of productivity, above which a high-technology firm finds the start of importing and exporting profitable, ϕ_h^{IE}, the subsequent two expressions are compared: $\pi_h^I(\phi_h^{IE}) = \pi_h^{IE}(\phi_h^{IE})$, obtaining the following:

$$\phi_h^{IE} = A\left[f_E W_h^I\right]^{\frac{1}{\sigma-1}} \frac{\tau W_h^I}{\gamma_h^I} (1-\frac{1}{\tau}).$$

This shows when the productivity level of high-technology firms that import (ϕ_h^I) is lower than the productivity level of high-technology firms that export and import (ϕ_h^{IE}):

$$\phi_h^I < \phi_h^{IE} \Leftrightarrow \left[f\eta(W_h^I - W_h) + f_I W_h^I\right]^{\frac{1}{\sigma-1}} (W_h^I - \frac{\gamma_h^I}{\gamma} W_h) < \left[f_E W_h^I\right]^{\frac{1}{\sigma-1}} \tau W_h^I (1-\frac{1}{\tau}).$$

Again, the latter expression applies if the wage level in high-technology firms (W_h) is significantly lower than the wage level in high-technology importing firms (W_h^I); $W_h < W_h^I$. Findings from the part of the model, studying the skill upgrading at the level of individuals, again indicate higher wages being a signal of a higher employment level of skilled workers. In addition, if the costs of importing are significantly higher, compared to the costs of exporting, only the most productive firms will be able to afford the start of importing.

Finally, since the decision of high-technology firms on when to start exporting and importing depends also on external factors; i.e. the cost level of exporting and importing, the analysis from the previous paragraph has to be repeated for high-technology firms that decide between starting to export, and starting to export and import. Therefore, the zero-profit bounds of exporting high-technology firms and of high-technology firms that start importing and exporting in the second stage of the model are compared with the following expressions:

$$\pi_h^E(\phi)=\pi_h^{IE}(\phi)\Leftrightarrow\frac{r_h^E(\phi)}{\sigma}-(f\eta+f_E)W_h=\frac{r_h^{IE}(\phi)}{\sigma}-(f\eta+f_I+f_E)W_h^I .$$

From this it follows that high-technology firms find exporting and importing profitable only if the increase in the level of productivity is bigger than the increase in costs of importing. To get the level of productivity, above which a high-technology firm finds it profitable to start importing and exporting, ϕ_h^{IE}, the subsequent two expressions are compared: $\pi_h^E(\phi_h^{IE})=\pi_h^{IE}(\phi_h^{IE})$, yielding the following:

$$\phi_h^{IE}=A\left[(f\eta+f_E)(W_h^I-W_h)+f_IW_h^I\right]^{\frac{1}{\sigma-1}}\frac{\tau}{\gamma\gamma_h^I}(\gamma W_h^I-\gamma_h^IW_h).$$

One can now check when the productivity level of high-technology firms that export (ϕ_h^E) is lower than the level of high-technology firms that export and import (ϕ_h^{IE}):

$$\phi_h^E<\phi_h^{IE}\Leftrightarrow\left[f_EW_h\right]^{\frac{1}{\sigma-1}}\tau W_h(1-\frac{1}{\tau})<\left[(f\eta+f_E)(W_h^I-W_h)+f_IW_h^I)\right]^{\frac{1}{\sigma-1}}\tau(\frac{\gamma}{\gamma_h^I}W_h^I-W_h).$$

The latter expression applies if the wage level in high-technology firms (W_h) is significantly lower than the wage level in high-technology importing firms (W_h^I), which again signals a higher employment level of skilled workers after importing. Concerning external factors, if the costs of importing are significantly high, only the most productive high-technology firms will be able to engage in both, exporting and importing.

To sum up, after trade liberalisation in the second stage of the model, only the least productive high-technology firms serve only the domestic market, where the decision on whether to start importing, exporting or both depends on the level of wages before and after importing, on the firm's productivity level and on external factors; i.e. the level of export and import costs. Interestingly, when high-technology firms decide whether to start exporting or not, the final decision is not based on the wage level of high-technology non-trading firms and high-technology exporting firms. Making inferences from the first part of the paper which studied the skill upgrading at the level of individuals, this would be a sign of a higher employment level of skilled employees. Therefore, skill upgrading occurs only in firms that import or firms that engage in both; importing and exporting.

4. CONCLUSION

The theoretical models of trade have been evolving through history in a desire of a thorough interpretation of international flows. Recent theoretical trade models account for firm heterogeneity, and also for technology and skill upgrading. Guided by these theories, I developed a theoretical model, which explores the individual's decisions for investing in skill upgrading and the firm's decisions to start technology upgrading and trading.

The model in this paper is divided in two parts. First part explores the behaviour of individuals and their decisions on whether to invest in acquiring higher skill levels. The findings suggest that since the education costs of low ability workers for acquiring higher skills are excessive, only high ability workers achieve higher skill levels. In addition, in order to have incentives for acquiring higher skills, high ability, high skilled workers demand higher wages after entering employment. The latter conclusion is then brought into use in the second part of the model, which takes into account the firm's decisions on whether to invest in higher technology and whether to engage in international activities. The model suggests that before trade liberalisation, only the most productive firms invest in acquiring higher technology levels, where higher labour costs of these firms signal a higher employment level of skilled workers. After trade liberalisation, costs of importing and exporting diminish and firms have an option to start engaging in international activities. Taking into account low-technology firms first, the most productive low-technology firms choose to skill upgrade and to start exporting and importing, less productive low-technology firms also upgrade skills but start only importing, and the least productive low-technology firms continue serving only the domestic market. Low-technology firms therefore use importing as means of increasing their productivity level before the start of exporting. This finding on learning-by-importing was confirmed also in empirical studies (see for example Damijan, & Kostevc, 2015; and Altomonte, & Békés, 2010). On the other hand, low-technology firms do not engage exclusively in exporting, as their productivity level is too low to cover exporting costs. With regards to high-technology firms, only the least productive high-technology firms do not start importing and/or exporting after trade liberalisation, where the decision on whether to import, export, or both, depends on the firm's productivity level, the skill upgrading before and after importing, and on external factors; the level of export and import costs. Skill upgrading in high-technology firms after trade liberalisation takes place only in firms that start importing, or that start engaging in both, importing and exporting.

The model highlights several facts, which would be noteworthy of further empirical testing. One could empirically analyse the following findings of the theoretical model: (i) firms with better skill structure also start importing; (ii) importing firms have a better skill structure than non-importing firms; and (iii) by having an access to cheaper technology and/or to cheaper intermediates, imports serve for increasing the technology level before the start of exporting.

The key contributions of this model are a differentiation between importers and exporters and a thorough analysis of the behaviour of individuals and firms, where the connection between the two has been made by linking fragments of models on the individual's and the firm's behaviour. The possible limitations of the model present additional assumptions, which had to be made when developing the model; e.g. the increase in the wage level of skilled workers after investing in high technology ($\frac{W_h}{W_l} > \gamma$), and after the start of importing ($\frac{W_l^I}{W_l} > \gamma_l^I$), compared to the decrease in the marginal costs in these firms. Furthermore, the model also assumes that the productivity level increase after importing is lower compared to the productivity level increase after investing in high-technology. These additional assumptions to some extent limit the value of the model, as it would be hard to test them empirically. In addition, although the model considers three dynamic phase shifts; i.e. the individual's decision to acquire skills, the firm's decision to opt for high technology, and the firm's decision to start importing and/or exporting, it is limited in discussing only two firm's decisions simultaneously (e.g. high-technology vs. low-technology, no trade vs. importing, etc.). Since nowadays firms face the changing environment which demands complex decision-making on a daily basis, this structure of the model would be limited to transform in everyday environment. Although losing a more static structure of the model would greatly increase its complexity, this limitation would be useful to be taken into account in further studies. Nevertheless, despite the aforementioned shortcomings, I believe the model's conclusions bring contributions to the field of knowledge, since the conclusions are also consistent with previous empirical findings and open several possibilities for further empirical analyses.

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APPENDICES

Appendix A

Claim 2: The gross earnings of rational individuals with the low ability are positive (i.e. $w_U(\Theta_U^*) > 0$).

Proof: Consider rational workers, who maximize their gross earnings and therefore achieve the optimal level of ability:

$$w_U(\Theta_U^*) = \lambda[\ln(\lambda / k_U)] - k_U [(\lambda / k_U) - 1].$$

After simple calculation, one gets the following:

$$w_U(\Theta_U^*) = \lambda[\ln(\lambda) - \ln(k_U) - 1] + k_U.$$

Knowing the following inequality holds: $\lambda > k_U > k_S > 1$, it follows that $w_U(\Theta_U^*) > 0$. ■