

# The short and long run impact of globalisation on income inequality

# Master's thesis

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by

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Abstract

This paper theoretically and empirically investigates the effects of trade liberalisation on

firms' factor input decisions between skilled labour and unskilled labour. The theoretical model

builds on the framework developed in Emami Namini and López (2012) and contributes to

existing literature by extending the framework to a multiple country setup. Additionally, this

paper contributes by testing the theoretical predictions of the model using a novel firm-level

panel dataset covering 284 manufacturing sectors in 27 Eastern European countries and

spanning the years 2002-2009.

The theoretical results suggest that, under the assumption that exporters produce

unskilled labour intensively relative to non-exporters (the empirically observed case in Eastern

Europe), after trade liberalisation and in the short run, the increased demand for unskilled

labour increases its price relative to skilled labour since the stock of skilled labour is assumed

fixed. We find that the increase in the relative factor price becomes larger when the amount of

trading countries increases. The increased price of unskilled labour induces firms to switch their

production process to use skilled labour more intensively. In the long run, households disinvest

into their human capital driven by the increased relative price of unskilled labour. Hence, in

the long run the price of unskilled labour decreases again, which encourages firms to increase

skill intensity in production. Since an increase in the amount of countries that participate in

trade liberalisation aggravates the short run effect on the relative price of unskilled labour, the

sequence of events that follows becomes more pronounced as well.

The results from the empirical analysis seem to strongly support our theoretical

predictions for the short run effects of globalisation. However, no statistical support for long

run effects of trade liberalisation can be found in the examined dataset.

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labour substitution, manufacturing, wage inequalities, Eastern Europe and Central Asia

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# 1 Introduction

Policy makers increasingly recognise the benefits of trade liberalisation, which has led to a sharp increase in the number of trade agreements in the last decade (WTO, 2011). A good example is the recent news on the accession of Russia to the World Trade Organisation (WTO), which makes the presence of all large emerging economies<sup>1</sup> in the global trade-club complete (The Economist, 2012). For the Russian economy this implies that most trade barriers currently protecting its domestic industries will be phased out by 2018. This may hit many of the obsolete and uncompetitive manufacturing industries, but it also provides an excellent opportunity for other existing industries to benefit from larger profit opportunities abroad. However it is believed that these industries, which have mainly been serving the local market, cannot become leading exporters and compete with the world's best without changing their production process to include more managers, engineers and other highly skilled labour (The Economist, 2012). Russian politicians are acting in concert with this belief and aim at creating 25 million high skilled jobs to foster the skill upgrading process in order to reap the benefits from more trade openness.

The case of the accession of Russia to the WTO reveals the potential consequences of an economy opening up to trade. In order to guide governments in designing the policies that should accompany trade liberalisation efforts, academics around the world have been studying the consequences of trade liberalisation. Whereas in the past, research has focused on understanding the gains from trade liberalisation from a country or industry perspective, an increasing awareness that trade should be evaluated at firm level has emerged over the past two decades. Hallak and Levinsohn (2004) phrase it succinctly: "Countries do not produce anything and countries do not trade with one another. Firms and consumers do these things" (p.16). In combination with the emergence of firm-level datasets, a large body of theoretical and empirical research has hence arisen that evaluates gains of trade liberalisation from the perspective that firms differ from one another (the so-called firm heterogeneity literature). In this context, Bernard and Jensen (1995) may be considered the pioneers of this firm heterogeneity literature, but it was not until Melitz (2003) presented his theoretical model on

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<sup>&</sup>lt;sup>1</sup> Brazil, Russia, India, China (BRIC countries).

the productivity gains from trade liberalisation that the body of heterogeneity literature ballooned with extensions and generalisations on the basic models. Recently, Emami Namini & López (2012) have provided an extension by presenting an intra-industry trade model that analyses the effects of trade liberalisation on firms' factor input choice between human capital and labour. The model has two distinct features: (i) firms differ in factor input shares (and not in total factor productivity as assumed by many others in the field, including Melitz, 2003) and (ii) the short and long run effects of trade liberalisation are explicitly modelled by introducing accumulation of human capital.

This paper adds to the literature by extending the theoretical model from Emami Namini and López (2012) to a multiple country setup. This is relevant since it reflects the country context that is by definition examined in empirical studies. Secondly, this paper contributes by empirically testing the short and long run implications of more trade on firms' factor input choices between skilled labour and unskilled labour (the key results of the theoretical model). Hence, the overall research question of this paper is as follows: "What are the short and long run effects of trade liberalisation on firms' factor input ratios and how does the number of countries that participate in trade liberalisation affect the results?"

Firstly, this research question is answered by deriving the effects in a theoretical model. In the second part of the paper, the research question is also tested empirically, thereby building on the derived theoretical predictions, and relevant policy implications are inferred. The empirical analysis uses a novel firm-level dataset covering more than 250 manufacturing sectors, spread over 27 Eastern European countries and covering the period 2002 - 2009<sup>2</sup>. The empirical investigation tests the theoretical predictions in three parts. First, a basic model tests the theoretical predictions for the overall sample. Secondly, a model refinement is introduced to verify that the theoretical results change depending on the assumption regarding the skill intensity of exporters relative to non-exporters by splitting the sample into sectors where exporters produce unskilled labour intensively and sectors where exporters produce skilled labour intensively relative to non-exporters. Third, a model extension is introduced in order to test the presence of Heckscher-Ohlin (H-O) type of trade, which are trade flows originating

 $<sup>^2</sup>$  The dataset is largely based on the Business Environment and Enterprise Performance Survey from the World Bank, available at www.enterprisesurveys.org

from a difference in the relative factor abundance of nations or industries. By evaluating the results of the empirical analysis, this paper elucidates two discussions in the international trade field: (i) whether trade leads to skill biased technology changes at the firm or industry level and (ii) since wage inequalities have often been found to increase after trade liberalisation (see Goldberg & Pavcnik, 2007), whether trade liberalisation expedites wage inequality between skilled labour and unskilled labour in general and whether this is the case in Eastern Europe.

Results from the theoretical model indicate that after trade liberalisation and in the short run, under the assumption that exporting firms produce more unskilled labour intensively relative to non-exporters<sup>3</sup>, the increased demand for unskilled labour increases its price relative to skilled labour since the stock of skilled labour is fixed. We find that the increase in the relative factor price becomes larger when the amount of trading countries increases. In turn, the increased price of unskilled labour induces firms to switch their production process to use skilled labour more intensively. In the long run, households disinvest into their human capital driven by the increased relative price of unskilled labour. Hence, in the long run the price of unskilled labour decreases again, which encourages firms to increase skill intensity in production. Since an increase in the amount of countries that participate in trade liberalisation aggravates the short run effect on the relative price of unskilled labour, the sequence of events that follows becomes more pronounced as well.

The results from the empirical analysis seem to strongly support our theoretical predictions for the short run effects of globalisation. However, no statistical support for long run effects of trade liberalisation are be found in our dataset. The results from the sample-split refinement seem to indicate that trade liberalisation does not always lead to firm level skill upgrading, but that skill upgrading is observed (in the short run) only when exporters produce unskilled labour intensively. In addition, H-O type of trade is found in the sample where exporters produce unskilled labour intensively, which is often believed to be the source of comparative advantage in Eastern Europe (Lankes & Venables, 1996).

<sup>&</sup>lt;sup>3</sup> This assumption is taken because it is the empirically relevant case in our Eastern European dataset. However, the model can also be derived for the assumption that exporters produce skilled labour intensively relative to non-exporters which results in theoretical predictions that are exactly opposite. By means of a sector sample split, the empirical model tests both cases.

The paper proceeds as follows. Section two discusses literature related to this paper. Section three introduces the model and derives theoretical results. Sections four and five introduce the empirical approach and describe the data used, respectively. Section six presents the results, while section seven discusses these and highlights possible limitations to the analysis. Lastly, section eight concludes.

# 2 Related literature

The literature section reviews related literature in the field of international trade and firm heterogeneity. First, the emergence of firm heterogeneity in the international trade literature is discussed by highlighting some key contributions. Second, some generalisations and elaborations on the original models, which serve as basis for more recent work, are discussed. Third, studies covering the effects of trade liberalisation on wage inequality are discussed. Finally, the present paper is put in perspective with existing literature discussed in this section.

The body of literature that examines the effects of trade liberalisation on factor input decisions made by profit maximising firms in an intra-industry trade setting dates back to the contribution from Krugman (1980). Despite (restrictively) assuming that firms produce with identical cost functions and use only one input for production, he explains the emergence of intra-industry trade by means of (i) economies of scale, (ii) the 'love of variety' effect and (iii) the presence of imperfect competition. These three assumptions have proven to be important building blocks for many of the more sophisticated studies in the field. Concurrent with the emergence of firm-level datasets in the late 1990s, a recent body of literature has arisen that extends the earlier (Krugman) models by including firm heterogeneity in either Total Factor Productivity (TFP) (e.g. Melitz, 2003; Bernard, Redding & Schott, 2007; Baldwin & Robert-Nicoud, 2008) or in factor input ratios (e.g. Emami Namini, 2009; Emami Namini & López, 2012; Crozet & Trionfetti, 2011). In this way, inferences about the effects of trade liberalisation on country level can also be used for conclusions on industry level. A significant contribution in this field has been made by Melitz in 2003, who presented a paper that serves as a basis for much of the literature on firm heterogeneity that has been written to date (Melitz, 2003). He proves that trade liberalisation leads to an increase in industry-wide productivity through reallocations of resources to the most productive firms. Hence, by endogenising the firm selection process (drawing on Hopenhayn (1992)), his model shows that exposure to trade forces the least productive firms to exit the market and, by using the released resources, stimulates the most productive firms to self-select into export markets.

Ever since Melitz's (2003) theoretical framework has been presented, numerous studies have found empirical proof for his results. Among others, Pavcnik (2002) posits that trade exposure yields within-plant productivity gains and TFP increases on sector level in Chilean

plants. Aw, Chung & Roberts (2000) attest Melitz' (2003) theoretical findings using a sample of Korean firms and Trefler (2004) finds similar results for Canada after liberalising trade with the U.S. through the signing of the Canada – U.S. free trade agreement. Moreover, Tybout (2003) confirms Melitz' (2003) predications on self-selection into export markets for a number of developing countries. Specifically regarding the market entry and exit behaviour of firms, Melitz's (2003) predicted findings are corroborated by an empirical study on eight European countries by Colantone and Sleuwaegen (2010).

Since the contribution from Krugman in 1980, theoretical and empirical models on intraindustry trade have evolved and are often build on Melitz's (2003) framework. His model on
the productivity enhancing effect of trade liberalisation and the market entry and exit
behaviour of firms has spawned the emergence of a large body of literature that considers
generalisations and extensions from his original setup or complements the international trade
literature by approaching firm heterogeneity from a different perspective. In the following,
some relevant extensions and variations of the Melitz model (2003) are discussed.

Firstly, deviations from the original assumptions have made the original theories more widely applicable. For example, a critical assumption used in many of the models in the field (including Melitz (2003)) is that firms produce using a Constant Elasticity of Substitution (CES) production function, which implies that firms charge a constant mark-up over their marginal costs. This might be considered as a too restrictive assumption, though. Contributions by Melitz & Ottaviano (2003) and Bernard et al. (2003) tackle this issue and show that trade liberalisation can either have a pro-competitive effect by lowering the mark-up of price over marginal costs or induce firms to apply different mark-ups abroad and at home.

Secondly, two extensions that are especially relevant for this paper are the contributions from Bernard et al. (2007) on industry and firm changes in response to trade liberalisations (through the comparative advantage of nations) and Emami Namini (2009). The two papers can be seen as representing two lines of research that both take a different source of firm heterogeneity: TFP (Bernard et al., 2007) and factor input ratios (Emami Namini, 2009). Bernard et al. (2007) depart from the benefits of resource reallocations in a setup of heterogeneous firms, but add resource reallocations between countries and industries through the notion of comparative advantage and establish how both interact in general equilibrium.

The authors prove that the economic reallocations after trade liberalisation generate net employment growth in industries with a comparative advantage and net job destruction in sectors with a comparative disadvantage, while reducing unemployment overall (Bernard et al., 2007). In addition, they find that due to industry-wide productivity increases, the drop in real wages of the not intensively used factor is smaller than classic Stolper-Samuelson theory predicts. Emami Namini (2009), on the other hand, employs a different, but empirically proven, source of heterogeneity: factor input ratios. Next to assuming heterogeneity in factor shares, he goes beyond existing literature by extending the heterogeneous firm setup with a distinction between long and short run impacts of trade liberalisation. He shows that, under the assumption that exporters produce with a higher capital-labour ratio, trade liberalisation leads to an increase in the relative return of capital and a decrease in the share of labour in national income in the short run. In the long run, households' investments (i.e. savings) contribute to the supply of capital. The increase in savings decreases the long run returns on capital while simultaneously increasing the real returns to all factors of production. Moreover, the firm distribution shifts towards the more capital intensive firms in the long run. In order to test these theoretical predictions, Emami Namini and López (2012) complement this theoretical model with an empirical analysis on Chilean firms. The authors find support for Emami Namini's (2009) theoretical predictions and, in addition, are able to draw a direct parallel between the conclusions and the implications for wage inequality in a country: wage inequality increases in the short run, while it declines in the long run (Emami Namini & López (2012)). A different study tests the validity of factor input shares as source of heterogeneity and tests the effects of trade liberalisation on firm survival (Emami Namini, Facchini & López (2011)). Contrary to the literature discussed before that corroborate Melitz's findings, Emami Namini et al. (2011) find an adverse effect of trade openness on exporters, which works through increased factor market competition. Their results posit that non-exporters, instead of exporters, benefit from this intensified factor market competition.

Other generalisations and extensions to the original Melitz (2003) setup have enriched the international trade field with more detailed insights on specific issues and their contributions include, amongst others, country asymmetries (e.g. Arkolakis, Klenow, Demidova, & Rodriguez-Clare, 2008), financial limitations (e.g. Manova, 2012) and firms

exporting more than one product (Eckel & Neary, 2010). Another interesting extension to the basic underlying model is provided by Atolia (2007) who extends the two-production-factor setup that nearly all studies use (including this paper) by introducing a model with three production factors: capital, skilled labour and unskilled labour. His numerical simulations and calibration techniques suggest that wage inequality might, in the long run, rise temporarily due to asymmetries in the speed of adjustment and capital-skill complementarity in production (Atolia, 2007). This finding is partially at odds with H-O theory, which predicts a decline in inequality in the long run.

Lastly, having discussed a variety of generalisations and variations to initial models using firm heterogeneity, we discuss some relevant contributions from the policy perspective. Strongly related to the policy implications of trade liberalisation in an environment of firm heterogeneity is the discussion on inequality and globalisation, which often follows directly from the theoretical predictions using skill intensities as source of heterogeneity. This discussion has received ample attention in the literature, especially for the case of developing countries (e.g. Goldberg & Pavcnik, 2007; Meschi & Vivarelli, 2009). Examining empirical regularities, which show that developing countries have increased exposure to international markets and simultaneously experience inequality levels rising, Goldberg and Pavcnik (2007) investigate whether these findings causally relate to each other. Despite noting that inferences are strictly country and time specific, the authors find that trade adjustments mostly originate from dynamics within industries, rather than between industries since labour is found to be relatively immobile. Hence inequality effects differ strongly across sectors. Another line of research links the emergence of wage inequality after trade liberalisation to the existence of skill premia and skill-biased technology change in different sectors. In their review of literature, Goldin and Katz (2008) argue that the past century brought new and more efficient technologies that require more skilled workers. This explains the existence of skill-biased technology. Harrigan and Reshef (2012) show the existence of skill premia and skill-biased technology change using data from Chile by finding that demand for skilled labour increases after trade liberalisation as exporters produce more skilled labour intensively. As a result, the skill premium increases, despite the fact that all labourers gain from liberalisation in their simulations. Hence we must conclude that, according to their findings, the relative gains for

skilled labour are higher. Fuentes and Gilchrist (2005) confirm the existence of skill-biased technology change as a driver of labour demand and wage inequalities in developing countries. The combined effects of the existence of skill premia and globalisation are not only evidenced in developing countries. For example, Unel (2010) shows that increased trade openness<sup>4</sup> can explain about 15% of the increase in skill premia in the United States. However, again others argue that increasing wage inequalities in developing countries are not a result of (skilled) labour abundance and the existence of skill premia, but are likely caused by their natural resource abundance (e.g. Leamer, Maul, Rodriguez, & Schott, 1999). As mentioned, Emami Namini and López (2012) also draw a parallel between firm-level effects and wage inequalities, but do not require that trade involves skill-biased technology change.

The discussion above has shortly elucidated the field of literature on international trade that uses firm heterogeneity as source of gains from trade liberalisation. The current paper builds on the theoretical model developed in Emami Namini and López (2012), extends the setup to a multiple country framework and tests similar empirical hypotheses with a new dataset. Amidst the body of literature discussed above, this paper both builds on earlier influential contributions by using robust assumptions from these established models (e.g. CES production functions and Dixit Stiglitz (1977) demand preferences) and adds insights into the dynamics of trade liberalisation by modelling the short and long run effects of trade liberalisation in a multiple country setup.

The next section introduces the theoretical framework.

<sup>&</sup>lt;sup>4</sup> Under the (empirically proven) condition that firms in the skill-intensive sector are more exposed to trade than firms in labour intensive sectors.

# 3 Model

In the following section, we derive a dynamic theoretical model that analyses the effects of trade liberalisation on firms' factor input decisions in production in the short and the long run. We largely build on the framework established in Emami Namini and López (2012), but whereas Emami Namini and López assume two countries, we extend the setup to M trading countries in order to provide a more closer match between the empirical estimation and the theoretical framework (in reality, nations have many trading partners). Our results show that the short and long run effects of trade liberalisation become more pronounced in a multiple country framework, as compared to a two country framework.

#### 3.1 Overview

The model examines intra-industry trade between the home country H and its M-itrading partners. Characteristic of the model built by Emami Namini and López (2012) is that firms differ in their factor input ratios. Firms produce using two factors of production, skilled labour (human capital) (S) and unskilled labour (or simply labour) (L). They produce, using a CES production function, a unique variety of an aggregate good Q. Preferences by consumers are characterized by a 'love of variety' property, and they aggregate a continuum of imperfectly substitutable varieties according to a CES function (Dixit & Stiglitz, 1977). Without technically altering the results of the model, market entry and exit of firms will not be modelled since this paper does not aim to provide insights into firm survival or firm dynamics and hence the mass of firms is assumed to be exogenous. Lastly, the following two assumptions are imposed: (i) skilled labour and unskilled labour are perfectly mobile between firms within countries, but not across countries and (ii) all M countries are symmetric in all respects (e.g. consumer preferences)

<sup>&</sup>lt;sup>5</sup> In another paper, Emami Namini explicitly models the entry and exit behaviour of firms and shows that results do not qualitatively differ (Emami Namini, 2009).

#### 3.2 Production

Each firm produces its own unique variety of aggregate good Q according to the following CES production function:

$$q(\phi) = [\phi^{1-\alpha}(A_s s)^{\alpha} + (1-\phi)^{1-\alpha}(A_l l)^{\alpha}]^{\frac{1}{\alpha}}, \qquad 0 \le \phi \le 0, 0 < \alpha < 1, \tag{1}$$

where  $\phi$  is the skilled labour share (human capital share) parameter, s denotes skilled labour input, l (unskilled) labour input and  $A_S$  and  $A_L$  are productivity parameters, such that  $A_S \cdot s$  equals effective input of skilled labour and  $A_L \cdot l$  is effective input of unskilled labour. For simplicity, for the remainder of the analysis we assume that  $A_S = A_L = 1$  and hence the effective input of skilled labour and unskilled labour is given by s and l respectively.

The number of firms is exogenously given by N, which differ with respect to one another in terms of  $\phi$ , the skilled labour share parameter. These N firms are distributed over the interval [0,1] according to a (exogenously) given density  $\mu(\phi)$ . Firms minimize total production costs for their given  $\phi$ , which implies that due to heterogeneity of firms with respect to  $\phi$ , firms produce with different marginal costs (in case factor prices differ). Since no fixed production costs exist, a firm's total production costs per unit output equal its marginal costs to production  $c(\phi)^6$ . Given that  $A_S$  and  $A_L$  are equal to unity, marginal production costs result from minimizing the factor input, under the side constraint that, at least, one unit of output is produced:

$$c(\phi) = [\phi w_s^{1-\sigma} + (1-\phi)w_l^{1-\sigma}]^{\frac{1}{1-\sigma}}, \qquad \sigma = \frac{1}{1-\alpha} > 1,$$
 (2)

where  $\sigma$  denotes the (constant) elasticity of substitution between the effective factor inputs s and l. In addition,  $w_s$  and  $w_l$  represent returns to skilled and unskilled labour respectively (wage for skilled labour and unskilled labour). Equation (2) illustrates that when  $w_s \neq w_l$  firms differ in their marginal production costs according to  $\phi$ .

#### 3.3 Demand

Consumers aggregate all varieties  $q(\phi)$  according to a CES function (Dixit and Stiglitz, 1977) to give the aggregate consumption good Q:

<sup>&</sup>lt;sup>6</sup> Typically, firms also incur fixed costs to production  $F(\phi)$ , but since market entry and exit is not explicitly modelled, fixed costs are left out for computational convenience since fixed costs do not alter firms' behaviour at the margin.

$$Q = \left[ \int_{0}^{1} q(\phi)^{\frac{\xi-1}{\xi}} \mu(\phi) N d\phi \right]^{\frac{\xi}{\xi-1}}, \qquad \xi > 1,$$
 (3)

where  $\xi$  denotes the elasticity of substitution between the different varieties within Q. Since households consume many varieties that are imperfectly substitutable, firm behaviour is assumed to be driven by large group monopolistic competition. For the remainder of the analysis we impose assumption 1 for computational convenience:

**Assumption 1:**  $\sigma = \xi$ . This implies that the elasticity of substitution between factor inputs and varieties are equal to each other and given by the constant  $\sigma$ .

Assumption 1 will simplify the remainder of the analysis since the marginal cost term  $c(\phi)^{1-\xi}$  will then become linear in  $\phi$ .

Consumers maximize utility, given their budget constraint. Using the Lagrange method to minimize expenditures per unit of the aggregate good Q leads to the following price unit of the aggregate good Q:

$$P = \left[ \int_{0}^{1} p(\phi)^{1-\sigma} \mu(\phi) N d\phi \right]^{\frac{1}{1-\sigma}} = \left[ p(\tilde{\phi})^{1-\sigma} N \right]^{\frac{1}{1-\sigma}}, \tag{4}$$

where the second equation arises when we define the 'average skilled labour share parameter' as given by  $\tilde{\phi} = \int_0^1 \phi \mu(\phi) d\phi$ . In turn,  $\tilde{\phi}$  in equation (4), which is dual to the function in (3), can also be viewed as the skilled labour share parameter of the aggregate good Q. Demand for a single variety  $q(\phi)$  can then be found using Shephard's Lemma<sup>7</sup>:

$$q(\phi) = YP^{\sigma-1}p(\phi)^{-\sigma} \tag{5}$$

where  $Y = w_s \cdot S + w_l \cdot L = PQ$ , with S and L denoting the country's endowments of skilled labour and unskilled labour. Profit maximising firms set their prices at marginal costs plus a mark-up tied to the elasticity of substitution:  $p(\phi) = \frac{\sigma}{\sigma^{-1}}c(\phi)$ .

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<sup>&</sup>lt;sup>7</sup> Shephard's Lemma stipulates that if P (the aggregate price) has been derived through the assumption that consumers minimize the costs to buy one unit of utility, then demand for a single variety ω is given by  $\frac{\partial P}{\partial p(\phi)}$  (Mas-Colell, Whinston and Green, 1995)

# 3.4 Profits and relative factor returns in the steady state

In the remainder, (unskilled) labour l is chosen as numéraire, such that only relative returns to skilled labour  $\frac{w_s}{w_l} = w_s$  matter in the following. In general equilibrium derived later, it will be shown that it is possible that either  $w_s > 1$  or  $w_s < 1$ , which depends on the parameters of the model. Depending on which of the latter two cases holds,  $\phi$  has a positive or negative influence on a firm's profits  $\pi(\phi)$ , which are given by  $\pi(\phi) = \frac{p(\phi)q(\phi)}{\sigma}$ . Filling in  $p(\phi)$  and  $q(\phi)$  from equation (5) and rearranging yields:

$$\pi(\phi) = Y P^{\sigma - 1} \frac{\phi[w_s^{1 - \sigma} - 1] + 1}{\sigma^{\sigma} (\sigma - 1)^{1 - \sigma}},$$
(6)

where Y and P are taken as given for an individual firm due to the large group monopolistic market structure. Since  $\sigma = \frac{1}{1-\alpha} > 1$ , it follows from equation (6) that if  $w_s < 1$  then profits increase with  $\phi$  and if  $w_s > 1$  then profits decrease with  $\phi$ .

A part of household's total consumption in good Q is used for investment into skilled labour. It seems reasonable to assume that this investment is not characterised by the 'love of variety' property that describes consumption of Q and hence investment is not evaluated with aggregate P. Instead, households choose their consumption and investment levels according to the optimum of their lifetime utility V and evaluate investment according to  $p(\tilde{\phi}) = PN^{\frac{1}{\sigma-1}}$ , the price of the average variety of the aggregate good Q. Lifetime utility is given by equation (7):

$$V = \sum_{t=0}^{\infty} \frac{u(Q_t)}{(1+\rho)^t} \tag{7}$$

where  $Q_t$  is the aggregate consumption good as defined in (3),  $\rho$  is the time discount rate and u an instantaneous utility function.

A country's labour endowment L is assumed to be constant over time and hence investments only increase the skilled labour stock and compensate for the 'depreciation' of this human capital, modelled by  $\delta$ . Hence, net investments in skilled labour into a country's skilled labour stock in any period t of the steady state are given by:

$$I_t = S_{t+1} - (1 - \delta)S_t = \delta S \tag{8}$$

where  $I_t$  denotes the amount of aggregate good Q that is invested in period t and  $S_t$  and  $S_{t+1}$  stand for the country's skilled labour stocks at time t and t+1. Note that  $\delta S$  does not contain subscript t since in steady state the amount of skilled labour is constant.

Lastly, important for the derivation of the long run equilibrium is that households own production factors and lend them out to firms for production. Given that they do so in a perfectly competitive manner, the long run steady state of this Ramsey growth setup is characterised by several necessary first order conditions that determine  $w_s$  in the steady state as a function of  $\delta$ ,  $\rho$ ,  $\sigma$  and  $\tilde{\phi}$ . The solution to these FOCs leads to Lemma 1:

**Lemma 1.** The relative return to skilled labour in the steady state is given by:

$$w_{s} = \left[ \frac{(1 - \tilde{\phi})(\rho + \delta)^{1 - \sigma}}{(1 - 1/\sigma)^{1 - \sigma} - \tilde{\phi}(\rho + \delta)^{1 - \sigma}} \right]^{\frac{1}{1 - \sigma}}$$
(9)

**Proof.** See Appendix B, item (I).

Note that index t has disappeared due to the fact that equation (9) describes a steady state relationship. It can now be seen that the parameters  $\delta$ ,  $\rho$ ,  $\sigma$  determine whether  $w_s > 1$  or  $w_s < 1$  in the steady state, which leads to Lemma 2:

**Lemma 2.** If  $\rho + \delta < 1$ , then  $w_s < 1$ . Conversely, if  $\rho + \delta > 1$ , then  $w_s > 1$  in the steady state.

Recall that  $\tilde{\boldsymbol{\phi}}$  is equal to the average skilled labour share parameter over all varieties supplied to the domestic market. Hence, trade liberalisation (discussed later) will alter the level of  $\tilde{\boldsymbol{\phi}}$  in case a fraction ( $\neq$  0) of all firms that serve the domestic market, export as well. Given that  $w_s$  is smaller or larger than 1, we are able to derive the effect of an increase (or decrease) in  $\tilde{\boldsymbol{\phi}}$  on the steady state value of  $w_s$  by means of Lemma 2:

**Lemma 3.** If  $w_s < 1$ , then an increase in  $\tilde{\boldsymbol{\phi}}$  decreases the steady state value of  $w_s$ . Conversely, if  $w_s > 1$ , then an increase in  $\tilde{\boldsymbol{\phi}}$  increases the steady state value of  $w_s$ .

**Proof.** This can be proven by taking the partial derivative of (9) with respect to  $\tilde{\phi}$ :

$$\frac{\partial w_s}{\partial \tilde{\phi}} = \frac{1}{1 - \sigma} w_s^{\sigma} \frac{(\rho + \delta)^{1 - \sigma} [(\rho + \delta)^{1 - \sigma} - (1 - 1/\sigma)^{1 - \sigma}]}{\left[ (1 - 1/\sigma)^{1 - \sigma} - \tilde{\phi}(\rho + \delta)^{1 - \sigma} \right]^2} \tag{10}$$

 $\frac{\partial w_s}{\partial \widetilde{\phi}}$  is negative when the squared bracket (with  $\rho$  and  $\delta$ ) in the numerator is positive, i.e. when  $w_s < 1$ , and  $\frac{\partial w_s}{\partial \widetilde{\phi}}$  is positive when the squared bracket in the numerator is negative, i.e. when  $w_s > 1$  in the steady state.

#### 3.5 Autarkic steady state

Using the above derived building blocks, we are ready to derive the equilibrium in autarky. The autarkic steady state is characterised by three conditions for all M countries:

- (i) Output equals demand for each variety at price  $p(\phi) = \frac{\sigma}{\sigma-1}c(\phi)$  eq. (5)
- (ii)  $w_s = \left[ \frac{(1-\tilde{\phi})(\rho+\delta)^{1-\sigma}}{(1-1/\sigma)^{1-\sigma} \tilde{\phi}(\rho+\delta)^{1-\sigma}} \right]^{\frac{1}{1-\sigma}}$  since countries are in their steady state eq. (9)
- (iii) The factor market clearing conditions<sup>8</sup>

Remember that  $w_s$  is determined by  $\delta$ ,  $\rho$ ,  $\sigma$  and  $\tilde{\phi}$  and that the stock of skilled labour S is such that its demand equals its supply (through households' investments) at price  $w_s$ . Hence, the factor market clearing conditions yield the steady state value of S by substituting in  $w_s$ . The steady state values of S and  $w_s$  can then be used to find the value for  $q(\phi)$ .

# Factor market clearing conditions

The factor market clearing conditions for L and S can be found using Shephard's Lemma applied to the marginal cost function defined in (2) and using demand  $q(\phi)$  for a single variety as given in (5):

$$L = \int_0^1 (1 - \phi)c(\phi)^{\sigma} \frac{Yp(\phi)^{-\sigma}}{P^{1-\sigma}} N\mu(\phi)d\phi + (1 - \tilde{\phi})c(\tilde{\phi})^{\sigma} \delta S$$
 (11)

$$S = w_s^{-\sigma} \int_0^1 \phi c(\phi)^{\sigma} \frac{Y p(\phi)^{-\sigma}}{P^{1-\sigma}} N \mu(\phi) d\phi + \tilde{\phi} w_s^{-\sigma} c(\tilde{\phi})^{\sigma} \delta S$$
 (12)

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 $<sup>^8</sup>$  Supply=demand for skilled S and unskilled labour L markets

where  $\delta S$  denote investments in steady state and  $(1-\tilde{\phi})c(\tilde{\phi})^{\sigma}$  and  $\tilde{\phi}w_s^{-\sigma}c(\tilde{\phi})^{\sigma}$  are the per unit input requirements for the investment good for unskilled labour and skilled labour respectively. Equations (11) and (12) can first be simplified, then divided by each other and in turn be solved for the steady state value of  $S(w_s)$  is given by equation (9)) (see Appendix B II for a derivation):

$$S = L \frac{w_s^{-\sigma} \tilde{\phi}}{1 - \tilde{\phi}} = L \frac{(1 - \tilde{\phi})^{\frac{1}{\sigma - 1}} (\rho + \delta)^{-\sigma} \tilde{\phi}}{\left[1 - \tilde{\phi}(\rho + \delta)^{1 - \sigma}\right]^{\frac{\sigma}{\sigma - 1}}}$$
(13)

Production and revenue

The demand function for a single variety given by equation (5) can now be defined with the steady state values for  $w_s$  and S by inserting equation (9) and (13) in order to obtain the steady state value for  $q(\phi)$ :

$$q(\phi) = \frac{L(1-\tilde{\phi})\frac{\sigma-1}{\sigma}\Omega(\phi)^{\frac{\sigma}{\sigma-1}}}{N[1-\tilde{\phi}(\rho+\delta)^{1-\sigma}]^{\frac{\sigma}{\sigma-1}}}, \text{ where } \Omega(\phi) = (\phi-\tilde{\phi})(\rho+\delta)^{1-\sigma} + 1 - \phi$$
 (14)

Total revenues of an individual firm characterised by skilled labour parameter  $\phi$  then follow by multiplying  $q(\phi)$  and  $p(\phi)$ :

$$q(\phi)p(\phi) = \frac{L(1-\tilde{\phi})^{-1}\Omega(\phi)}{N[1-\tilde{\phi}(\rho+\delta)^{1-\sigma}]},$$
(15)

In order to judge the effect of  $\tilde{\phi}$  on the total revenues of an individual firm, we take the partial derivative of the  $\Omega(\phi)$  term (since the effect of  $\tilde{\phi}$  cannot be seen directly):

$$\frac{\partial \Omega(\phi)}{\partial \phi} = (\rho + \delta)^{1-\sigma} - 1, \qquad (16)$$

which shows that a more skilled labour intensive firm has higher revenues than a labour intensive firm when  $\rho + \delta < 1$  since that implies that  $w_s < 1$ .

#### Properties of the steady state

The previous section has derived steady state values for S,  $w_s$  and  $q(\phi)$ , which combined with the numéraire values for L and  $w_l$ , leads us to Lemma 4:

# **Lemma 4.** A unique and stable autarkic steady state exists.

From equations (9) and (13), we conclude that the country's endowment of skilled labour S/L only determines the *extent* to which  $w_s$  relates to the critical value of 1. This is because only the exogenous parameters  $\rho$  and  $\delta$  determine whether  $w_s < 1$  or  $w_s > 1$  in the steady state. On the other hand, the steady state level of S/L also depends on  $\tilde{\phi}$ . This leads to:

**Lemma 5.** The relative skilled labour stock S/L is defined over interval  $\in [0, \infty)$  depending on the magnitude of  $\tilde{\phi}$ , regardless of whether  $w_s > 1$  or  $w_s < 1$  in the steady state.

**Proof.** See Appendix B part III.

Hence, it is possible that in a relatively skilled labour abundant country, a more skilled labour intensively producing firm earns smaller profits than a more unskilled labour intensively producing firm. It follows that in the scenario of trade liberalisation (derived next), where trade is costly (such that only firms with sufficiently low marginal costs are able to export), it is ex ante ambiguous whether exporting firms produce relatively more or less skilled labour intensively. In case  $w_s < 1$ , a higher value of  $\phi$  results in a lower level of  $c(\phi)$ , and in case  $w_s > 1$ , then a lower value of  $\phi$  results in a lower value of  $c(\phi)$ . Hence if  $w_s < 1$ , exporting firms produce more skilled labour intensive and if  $w_s > 1$ , then exporting firms produce more unskilled labour intensive.

#### 3.6 Trade liberalisation

The trade liberalisation scenario will be approximated by assuming that all import tariffs are initially prohibitively high and that trade liberalisation will reduce all these tariffs to zero<sup>9</sup>. Previously, it was assumed that trade is costly. This costly trade is modelled by introducing the existence of sunk costs for entering the foreign market<sup>10</sup>. Iceberg transport costs are assumed to be zero. Since it is commonly known that not all firms in a sector export after trade liberalisation, it is assumed that sunk export costs are sufficiently large such that only firms with sufficiently low marginal costs can afford to export. As argued before, parameters  $\rho$ 

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<sup>&</sup>lt;sup>9</sup> This assumption might be unrealistically ambitious, but it makes sure that the model is solvable within the scope of this paper.

<sup>&</sup>lt;sup>10</sup> These costs can be thought of as e.g. setting up a distribution channel abroad

and  $\delta$  determine whether skilled labour intensive or unskilled labour intensive firms will export. It is often found that it is an empirical regularity that exporters produce more human capital intensively than non-exporters (see Emami Namini & Lopez (2012) for the same argument). Based on the latter, we define assumption 2 for the remainder of the analysis:

Assumption 2.  $\rho + \delta < 1$ , which implies that  $w_s < 1$ . Hence, firms with larger skilled labour share parameters produce with smaller marginal costs than firms with smaller labour share parameters.

However, note that the general channels through which the results are derived do not depend on whether  $w_s > 1$  or  $w_s < 1$  since both scenarios simply lead to mirror-image, but otherwise identical results. Complementary to much existing literature, when analysing trade liberalisation we will distinguish between the short and the long run and extend the framework to a multiple country setup. In the short run, the stock of skilled labour is assumed to be fixed (at its autarky steady state level). As a result of trade liberalisation, the relative price of skilled labour  $w_s$  will adjust so that factor markets clear. The following three conditions characterise the short run equilibrium after liberalisation:

- (i) Production is equal to demand for all varieties at price  $p(\phi)$
- (ii) A zero cut-off profit condition for exporting
- (iii) The factor market clearing conditions

Jointly, these conditions can be solved for production  $q(\boldsymbol{\phi})$  of each variety, the relative price of skilled labour  $w_s$  and the relative share of exporters in the entire firm distribution. The zero cut-off profit condition will define a critical value for  $\boldsymbol{\phi}$  that defines the division between exporters and non-exporters. In turn, the relative share of exporters can be determined.

In the long run, the stock of skilled labour S is flexible and adjusts such that factor markets will clear. The returns to skilled labour will again be given by  $w_s$  as in equation (9), but the skilled labour capital intensity of the aggregate good Q will change after trade liberalisation if a fraction of all firms will export. Lemma 3 has shown that this affects  $w_s$ . The effects of trade liberalisation will be analysed by first evaluating firms' decision to export, then analysing the short run effects and lastly the long run effects of trade liberalisation.

# 3.7 The export decision

Preferences in all M-1 foreign countries are symmetric and demand for a domestic variety can hence be described by  $q_x(\phi) = YP^{\sigma-1}p(\phi)^{-\sigma}$ , where x is a subscript for exports. Since there are no extra marginal costs (iceberg transport costs are zero), aggregate sales of an exporting firm multiply by a factor M-1 (countries are symmetric):

$$q(\phi) + (M-1)q_x(\phi) = MYP^{\sigma-1}p(\phi)^{-\sigma}$$
 (17)

The sunk costs of entering a foreign market are modelled by  $f_{E_x}$ . Since these are in terms of a firm's own variety, the costs of exporting for a firm with skilled labour parameter  $\phi$  are  $f_{E_x}(\phi) = c(\phi) f_{E_x}$ . With  $f_x = f_{E_x \frac{\rho}{1+\rho}}$ , the per period equivalent of sunk costs for exporting is given by  $c(\phi) f_x$ . In order to define a certain magnitude for  $(\phi) f_x$ , we assume:

**Assumption 3.**  $f_x$  is defined as such that the following two conditions hold, where  $\mathbf{w}_{S_{aut}}$ ,  $S_{aut}$  and  $P_{aut}$  denote steady state autarky values for  $w_s$ , the stock of skilled labour and the aggregate price index:

$$f_x > \frac{(L + w_{s_{aut}} S_{aut}) \left(\frac{\sigma}{\sigma - 1}\right)^{-\sigma}}{\sigma P_{aut}^{1 - \sigma}}$$
 (18)

$$f_{\chi} < \frac{(L + w_{s_{aut}} S_{aut}) \left(\frac{\sigma}{\sigma - 1}\right)^{-\sigma} w_{s_{aut}}^{-\sigma}}{\sigma P_{aut}^{1-\sigma}}$$
(19)

The right hand side of equation (18) shows the supply to the domestic market in case a firm has  $\phi = 0$ . Conversely, the right hand side of (19) is the supply to the domestic market for a firm with  $\phi = 1$ . Hence, the combination of both conditions warrants that the most unskilled labour intensive firms will not export, whereas the most skilled intensive ones will. As a result, there must be a skilled labour share parameter  $\phi_x^*$  that leads to zero profits from exporting. Since  $\phi \in (0,1)$  and  $f_x$  is such that the most skilled labour intensive firms make positive profits from exporting and the most unskilled labour intensive firms make negative profits from exporting (assumption 2), the critical  $\phi$  is found by solving:

$$q(\phi_x^*)[p(\phi_x^*) - c(\phi_x^*)] = c(\phi_x^*)f_x$$
 (20)

which immediately leads to Lemma 6:

**Lemma 6.** If  $\rho + \delta < 1$  and if  $f_x$  is such that conditions (18) and (19) hold, then solely firms with a skilled labour share parameter equal to or larger than  $\phi_x^*$  will export after trade liberalisation.

The aggregate price index in the open economy follows:

$$P = \left[ \int_{0}^{1} p(\phi)^{1-\sigma} N\mu(\phi) d\phi + (M-1) \int_{\phi_{x}^{*}}^{1} \frac{p(\phi)^{1-\sigma} s_{x} N\mu(\phi)}{1 - G(\phi_{x}^{*})} d\phi \right]^{\frac{1}{1-\sigma}}$$

$$= \left[ N(1 + (M-1)s_{x}) p(\tilde{\phi})^{1-\sigma} \right]^{\frac{1}{1-\sigma}},$$
(21)

with G representing a cumulative density function for  $\phi$  on the interval (0,1),  $\tilde{\phi} = \frac{\tilde{\phi} + (M-1)s_x \tilde{\phi}_x}{1 + (M-1)s_x}$  and  $\tilde{\phi}_x = \int_{\phi_x^*}^1 \phi \frac{\mu(\phi)}{1 - G(\phi_x^*)} d\phi$  and  $s_x = 1 - G(\phi_x^*)$ , which represents the fraction of exporters in the firm distribution (probability that a randomly chosen firm is an exporter). Hence,  $\tilde{\phi}$  denotes the average skilled labour share parameter of the aggregate good Q in the open economy. Since  $\tilde{\phi}_x > \tilde{\phi}$  and  $s_x > 0$ , comparing  $\tilde{\phi}$  with  $\tilde{\phi}$  results in:

**Lemma 7.** Trade liberalisation increases the skilled labour share parameter of the aggregate good Q and increases with M, the amount of trading countries, i.e.  $\tilde{\tilde{\phi}}[M]$  with  $\frac{\partial \tilde{\phi}}{\partial M} > 0 > \tilde{\phi}$ . However, the skilled labour share parameter increases with M at a decreasing rate, i.e.  $\frac{\partial^2 \tilde{\phi}}{\partial^2 M} < 0$ .

**Proof.** See Appendix B, part IV

# 3.8 The impact of trade liberalisation – short run effects

In the short run the returns to skilled labour  $w_s$  will adjust such that factor markets clear since the stock of skilled labour S is assumed to be fixed. The factor market clearing conditions of (11) and (12) can be complemented by the additional factor demands of exporters since they will increase production to also serve the foreign markets:

$$L - L_{f_x} = c(\tilde{\phi})^{\sigma} q(\tilde{\phi}) \left[ N(1 - \tilde{\phi}) + N(M - 1) s_x (1 - \tilde{\phi}_x) + \frac{c(\tilde{\phi})^{\sigma} (1 - \tilde{\phi}) \delta S}{c(\tilde{\phi})^{\sigma} q(\tilde{\phi})} \right], \tag{22}$$

$$S - S_{f_x} = c(\tilde{\phi})^{\sigma} q(\tilde{\phi}) w_s^{-\sigma} \left[ N \tilde{\phi} + N(M - 1) s_x \tilde{\phi}_x + \frac{c(\tilde{\phi})^{\sigma} \tilde{\phi} \delta S}{c(\tilde{\phi})^{\sigma} q(\tilde{\phi})} \right], \tag{23}$$

with 
$$L_{f_x} = N(M-1)s_x f_x \cdot \int_{\phi_x^*}^1 \frac{(1-\phi)c(\phi)^\sigma \mu(\phi)}{1-G(\phi_x^*)} d\phi$$
 and  $S_{f_x} = N(M-1)s_x f_x \cdot \int_{\phi_x^*}^1 \frac{\phi w_s^{-\sigma}c(\phi)^\sigma \mu(\phi)}{1-G(\phi_x^*)} d\phi$ 

which denote the total unskilled labour and skilled labour demand, respectively, for producing sunk export costs<sup>11</sup>. In order to find the effect of trade liberalisation on the factor input choice of firms after trade liberalisation, we derive the new value for  $w_s$  by dividing equations (22) and (23) and solving for  $w_s^{12}$ :

$$w_{s} = \left[ \frac{L - L_{f_{x}}}{S - S_{f_{x}}} \frac{\tilde{\phi} + (M - 1)s_{x}\tilde{\phi}_{x}}{1 + (M - 1)s_{x} - \tilde{\phi} - (M - 1)s_{x}\tilde{\phi}_{x}} \right]^{1/\sigma}$$
 (24)

Equation (24) allows us to compare the returns to skilled labour before (as given by equation (9)) and after trade liberalisation. It can be seen that  $w_s^{trade} > w_s^{aut}$ , which follows  $\text{from }(i)^{13} \tfrac{L-L_{f_X}}{S-S_{f_X}} > \tfrac{L}{S} \text{ and } (ii) \tfrac{\tilde{\phi} + (M-1)s_x(\tilde{\phi}_x)}{1+(M-1)s_x-\tilde{\phi} - (M-1)s_x(\tilde{\phi}_x)} > \tfrac{\tilde{\phi}}{1-\tilde{\phi}} \; .$ 

We are now also ready to derive the effect of a larger number of trading countries M on  $w_s$  in the short run. In order to distinguish the effect of an increasing M on  $w_s$ , we consider the effect of an increase in M on components (i) and (ii) as given before separately. The effect on component (i) can be established using the condition  $\frac{L-L_{f_X}}{S-S_{f_X}} > \frac{L}{S}$ . This is the case because  $\frac{L_{f_X}}{S_{f_Y}} < \frac{L}{S_{f_X}}$  $\frac{L}{s}$ , which in turn holds by definition since we have assumed that  $w_s < 1$ . Hence firms with a higher skilled labour share parameter produce with smaller marginal costs. This implies that exporters will produce relatively more skilled labour intensively since only firms with sufficiently low marginal costs can afford to pay  $f_x$  and hence are able to export. As a result, the relative labour demand for paying the sunk export costs for exporting firms is lower than the aggregate relative labour demand  $\frac{L}{s}$ . The effect of an increase in M on component (ii) is shown by taking the partial derivative of  $\frac{\tilde{\phi} + (M-1)s_x(\tilde{\phi}_x)}{1 + (M-1)s_x - \tilde{\phi} - (M-1)s_x(\tilde{\phi}_x)}$  with respect to M and judging whether the derivative is smaller or larger than zero. Appendix B part VI presents the proof for the result that both components increase when M increases. Hence,  $w_s$  increases more when M increases. This leads to proposition 1:

<sup>12</sup> See Appendix B V for a derivation of equation (24)

<sup>&</sup>lt;sup>11</sup> Which should be subtracted from the available supply of S and L in order to equalise the amount of S and L available and the demand for S and L from the production (domestic and export) of all N firms.

 $<sup>^{13}</sup>$  This holds only when  $L_{\rm fz} \, / \, S_{\rm fz} < L/S$  , which is true in our setting since exporting firms produce more skilled labour intensively.

**Proposition 1.** The relative return to skilled labour  $w_s$  increases in the short run after trade liberalisation and increases with the amount of countries M, i.e.  $\frac{\partial w_s}{\partial M} > 0$ .

Concerning the level of  $w_s$ , we find that  $w_s$  will never increase that strongly that it reaches a level above 1, which leads to Lemma 8:

**Lemma 8.** If  $w_s < 1$  in the autarkic steady state, then  $w_s < 1$  also in the short run equilibrium after trade liberalisation

**Proof.** See Appendix B part VII.

We are also able to directly compare the returns to skilled labour under autarky and under the free trade situation in order to draw an additional inference:

$$\frac{w_s^{trade}}{w_s^{aut}} = \left[ \frac{\left[\frac{L - L_{f_x}}{S - S_{f_x}}\right]^{1/\sigma}}{\left[\frac{L}{S}\right]^{1/\sigma}} \frac{\left[\frac{\tilde{\phi} + (M - 1)S_x(\tilde{\phi}_x)}{1 + (M - 1)S_x - \tilde{\phi} - (M - 1)S_x(\tilde{\phi}_x)}\right]^{1/\sigma}}{\left[\frac{\tilde{\phi}}{1 - \tilde{\phi}}\right]^{1/\sigma}} \right], \tag{25}$$

from which we are able to derive the influence of an increase in L, the amount of labour, on  $w_s$  in order to estimate the effect of a decrease in GDP per capita. It is straightforward to see that since  $L/S > L_{fx}/S_{fx}$  an increase in L (given S stays constant) decreases the entire fraction. Hence, a decrease in GDP per capita, in case  $w_s < 1$ , leads to a decrease in  $w_s^{trade}$  and hence conversely, an increase in GDP per capita aggravates the trade liberalisation effects on  $w_s$ .

The share of skilled labour relative to unskilled labour in a firm's production function (S/L) as a function of skilled labour share parameter  $\phi$  can be found by applying Shephard's Lemma to the marginal cost function in equation (2). This results in  $\frac{S}{L} = \frac{\phi}{1-\phi} w_s^{-\sigma}$ , from which follows (using proposition 1):

**Proposition 2.** The skilled labour-unskilled labour input ratio of every firm in the distribution decreases in the short run after trade liberalisation. Since  $w_s$  increases more when M increases, the skilled labour-unskilled labour input ratio also decreases more when M increases.

# 3.9 The impact of trade liberalisation – long run effects

Since we have  $w_s < 1$ , the combination of Lemma 7 and Lemma 3 immediately leads to the next implication:

**Proposition 3.** The relative return to skilled labour  $w_s$  decreases after trade liberalisation in the long run and decreases more when M becomes larger.

Given proposition 3, the factor input choice of firms in the long run immediately follows from the equality  $\frac{s}{L} = \frac{\phi}{1-\phi} w_s^{-\sigma}$  derived above, which leads to proposition 4:

**Proposition 4.** The skilled labour-unskilled labour input ratio of every firm in the distribution increases in the long run after trade liberalisation. Analogous to proposition 3, when M increases the skilled labour-unskilled labour input ratio increases more when M increases.

The last implication that follows from proposition 3 and 4 implies that the skilled labour stock S will increase in the long run after trade liberalisation:

**Proposition 5.** The skilled labour capital stock S increases in the long run after trade liberalisation.

**Proof.** Appendix B VIII.

In short, the effects of trade liberalisation on firms' factor input mix between skilled labour and unskilled labour in a multiple country setup in the short and the long run can be summarised by propositions (1) to (5).

# 4 Empirical investigation

In the following section, we introduce the empirical strategy in order to test the predictions of the theoretical model (given by propositions (1) to (5)) using recent firm-level data. Prior to discussing the results of the model, descriptive statistics and general patterns in the data will be presented in the next section (Section 5.2).

# 4.1 Empirical approach

The theoretical analysis presented in the previous section derives the effects of trade liberalisation on the factor input mix of firms operating in a market with imperfect competition. The theoretical model is one of intra-industry trade, where differentiated varieties of an aggregate good (Q) are traded, which are produced using two factors of production (skilled labour and unskilled labour) and traded in a multiple country (M different countries) setting. The theoretical model has considered the production factors skilled labour and unskilled labour, but by the same token and without distorting the insights from the model, similar effects of trade liberalisation can be derived for production factors capital and labour. This empirical analysis will focus on the effects of trade liberalisation on the factor input mix of skilled labour relative to unskilled labour, not only to directly test the theoretical predictions made by the model, but also for practical reasons such as the difficulty of measuring the input of physical capital. Also it allows for deriving interesting policy implications, such as the implications for wage earners with different skill levels and the concomitant effect on overall income distribution.

The intuition and mechanisms behind the results, and hence the empirical strategy, depend on which type of capital (human or physical) is considered. We test the relationship between exports and firm level *skill intensity* (in percentages), defined as the number of employees considered as "skilled workers" divided by the total number of employees in a firm. In this way the variable standardises the amount of skilled labour in the production process among small and large firms present in the dataset. As established in the theoretical model, we assume that in the short run the supply of labour is fixed. As Proposition 1 and 2 in the theoretical model predict (in line with the Stolper Samuelson result) an increase in exports in a country where exporters produce with a higher (lower) skill intensity as compared to non-

exporters will increase the relative demand for skilled labour (unskilled labour). This raises the relative price of skilled labour (unskilled labour) and, correspondingly, the relative price for unskilled labour (skilled labour) will decrease, so that firms will transform their production process to use more unskilled labour (skilled labour) relative to skilled (unskilled) labour. In the long run (as posited by Proposition 4), due to the hike in relative returns of skilled labour, households will invest into their human capital, so that the relative stock of skilled labour has increased, its relative price has decreased which causes firms to increase the amount of skilled labour, relative to unskilled labour, in production. The empirical investigation tests these predictions by first establishing the baseline model (Section 4.1.1) and then introducing two refinements, including additional robustness checks (4.1.2 and 4.1.3).

#### 4.1.1 Baseline model

Exports in the current setup are aggregated on 4-digit sector level, whereas skill intensity is examined on firm-level. The reasons for this choice are multiple. Firstly, the assumptions of the model imply that production factors, especially unskilled labour, are mobile across sectors but immobile across countries. Secondly, we can safely assume that skill intensity varies in different sectors (see Appendix A, Figure A. 1) and human capital is typically sector specific. Since the hypothesised effects work through relative prices, the existence of skill premia, generally assumed to differ across sectors (e.g. Asuyama, 2011), and movement of workers across sectors could potentially be very important for the results, at least in the short run. Lastly, the export performance could be very different across sectors. In case export performance of a country is strongly driven by the performance of a few sectors with specifically high or low skill intensity, then the model potentially underestimates the relationship and biases results. Taking exports on country level would forego these important considerations. In addition, in order to standardize the level of exports across sectors and countries, the model considers export intensity, defined as the fraction of direct and indirect exports<sup>14</sup> in a firm's total sales, as the main variable of interest.

 $<sup>^{14}</sup>$  Indirect exports are products sold domestically to third parties that in turn export the end-product (World Bank, 2011)

In order to distinguish between the long versus the short run effects of trade liberalisation, the model includes different lags of the export intensity variable such that the effect of an increase in exports in several periods before on skill intensity now can be estimated. Due to limited length of the panel (see Section 5, Data), this implies matching the *skill intensity* variable with (i) same year export intensity variables (ii) export intensity variables from one period before and (iii) export intensity variables from two periods before. By the theoretical predictions of the model, we expect the sign of the export intensity to change when we go from the short to the long run because the increased relative supply of the factor used intensively reduces its relative price and induces firms to use it more intensively.

In addition, other potentially relevant firm characteristics that could influence the factor input ratio choice by firms (and which are included in the firm-level dataset) and hence need to be introduced as control variables to single out the 'pure' effect of export intensity are included in the model. In order to test the robustness of the results, the control variables will be included gradually. As an initial starting point, the model will include the amount of physical capital/labour (in natural logarithms) in order to control for the demand of skilled labour. It could be expected that a higher ratio of physical capital to labour requires a more skill intensive production process as qualified employees (and managers) are required to operate (complex) machinery. Furthermore, the degree of foreign ownership (in percentages) of the firm could be expected to have an effect on skill intensity since Multinational Enterprises (MNEs) are often thought to relocate production in order to benefit from cheap, unskilled labour. Moreover, our sample of Eastern European countries is often believed to be a destination for multinational activity (Carstensen & Toubal, 2004). A variable for firm level export orientation (measured as exports as a percentage of sales) is also included (labelled exporter) in order to account for heterogeneity in skill levels between the degree of export orientation of exporters and non-exporters. Hence, the first empirical specification is as follows:

Skill intensity<sub>ickt</sub> = 
$$\beta_1 + \beta_2 \cdot (Export\ intensity)_{ckt,\ ckt-1,\ ckt-2} + \beta_3 \cdot \Omega_{ickt} + \delta_t + \delta_{kc} + U_{ickt}$$
 (26)

where subscripts i, c, k, t index a particular firm, country, industry and year, respectively. Export intensity measures sector-wide export intensity. To estimate the short-run impact of trade liberalisation, the time index for the export intensity variable is t. To estimate the longrun impact of trade liberalisation, the time index for the export intensity variable is t-1 or t-2.  $\Omega$  is a vector of control variables including the above described firm-characteristics:  $\log(capital-labour\ ratio)$ , foreign ownership, and exporter, each measured at time t. The variables  $\delta_{kc}$  and  $\delta_t$  are country-sector<sup>15</sup> and time fixed effects in order to capture time-invariant country and sector characteristics and the business cycle respectively. Variable  $\upsilon_{ickt}$  is the error term.

A first robustness check is performed by including country-sector fixed effects dummies in order to control for heterogeneity between different sectors in different countries, which could be present due to varying levels of skill intensity and export openness among sectors. Nowadays, Non-Tariff Measures (NTMs) make it increasingly difficult to judge the openness to trade of individual sectors.

# 4.1.2 First refinement: Sample split

Since the theoretical predictions fully depend on the initial relative skill intensity of exporters (resulting from the relative factor abundance of countries or sectors, exporters could either produce unskilled labour intensively or skilled labour intensively) and could consequently predict opposite signs for the export intensity variable, a first refinement to the original empirical method involves splitting the sample into sectors where exporters produce unskilled labour intensively and sectors where exporters produce skilled labour intensively. We expect the results to show opposite signs for the relation between export intensity and skill intensity both in the short run and the long run. In addition, extra control variables are introduced to further test the robustness of the results. Additional control variables include the size (measured by number of employees, in hundreds) and age (measured by the number of years existing) of the firm in order to capture the 'fixed cost' character of skilled labour<sup>16</sup>. Also, a dummy for the presence of foreign technology licensing in a production plant is included since it could be expected that nature of imported capital is more sophisticated and the use of it

 $<sup>^{15}</sup>$  A dummy included for every sector in different countries, such that sector x in country y receives a different dummy than sector x in country z.

<sup>&</sup>lt;sup>16</sup> It could be expected that the larger a firm is, the less skilled labourers it needs since the managerial staff do not increase proportionally with the firm size and can be used jointly by different entities of firms. On the contrary, it could be thought that when a firm is a start-up, it requires relatively much skilled labour (managerial staff) in order to start production.

requires more skilled labour. Lastly, the full specification also includes the level of *GDP per capita* (in constant 2000 US Dollars) of the country as a proxy for the level of development of a country, which potentially has an effect on supply of skilled labour (through e.g. quality of institutions) and is regarded as a measure for capital in the broadest definition (including human capital).

Secondly, residual diagnostics and specification tests hinted at an improvement of the model by changing the functional form into a level-log specification through the inclusion of the natural logarithm of the sector wide export intensity variable. The logarithmic transformation of the export intensity variable squeezes together larger values in the data and stretches out smaller values, which corrects for outliers and unequal variation. A significant increase in R<sup>2</sup> between the original model and the level-log model and a decrease in the Akaike Information Criterion (which provides a measure for the trade-off between the goodness-of-fit of a model and the number and type of regressors) provide evidence<sup>17</sup> for the improved fit of the level-log specification. Comparing a density plot of export intensity and log(export intensity) (see Appendix A, Figure A. 2) as well as a check of the residuals of the regression<sup>18</sup> favour the refined model. The model specification after the first refinement is:

Skill intensity<sub>ickt</sub> = 
$$\beta_1 + \beta_2 \cdot log(Export\ intensity)_{ckt,\ ckt-1,\ ckt-2} + \beta_3 \cdot \Omega_{ickt} + \delta_t + \delta_{kc} + \upsilon_{ickt}$$
 (27)

where subscripts i, c, k, t index a particular firm, country, industry and year, respectively. Export intensity measures sector-wide export intensity at time t, t-1 and t-2.  $\Omega$  is a vector of control variables including the described firm characteristics from the original model and the newly introduced variables: size, age and a dummy for  $foreign\ technology\ licensing$ . Also the level of  $GDP\ per\ capita$  is included. The variables  $\delta_{kc}$  and  $\delta_t$  are the same as before. Variable  $\upsilon_{ickt}$  is the error term.

 $<sup>^{17}</sup>$  The reader is referred to Appendix A, Table A. 1 for a comparison of the models.

 $<sup>^{18}</sup>$  A check whether the residuals satisfy  $\epsilon \sim N(0, \sigma^2)$ . The normality plot shows a reasonable fit to the Normal distribution and provide support for the specification of the model. See Table A. 3 in the Appendix.

# 4.1.3 Second refinement: Heckscher-Ohlin trade effect

A second refinement to the original model involves testing for a Heckscher-Ohlin (H-O) trade effect in the sample. This implies that we expect countries and sectors to exploit their endowment based comparative advantages, as predicted by the H-O theorem, relative to their main trading partners. This effect is captured by the inclusion of an interaction term between sector-wide exports and the difference in GDP per capita (henceforth GDPpc) levels between the country in which the respective exporter is located and the average GDPpc level of the exporter's sector's top-5 trading partners (further details in the next section). The GDPpc values serve as proxy for the (human) capital over labour ratio, as illustrated by the standard neoclassical growth model (e.g. Solow (1956)). A larger difference between GDPpc levels indicates a larger difference in relative factor abundance and a stronger effect on skill intensity. For practical reasons<sup>19</sup> the H-O effect of trade is only tested for the short-run impact of trade liberalisation on firms' factor intensities. Thus, export intensity values at time t are interacted with the corresponding GDPpc difference terms in t. A suggestion for further research could test for a long run H-O effect. Including this second refinement, the empirical specification is given by:

Skill intensity<sub>ickt</sub> = 
$$\beta_1 + \beta_2 \cdot log(Export\ intensity)_{ckt,\ ckt-1,\ ckt-2} + \beta_3 \cdot (log(Export\ intensity)_{ckt} * GDP$$

$$capita\ difference_{ct}) + \beta_4 \cdot \Omega_{ickt} + \delta_t + \delta_{kc} + \upsilon_{ickt}, \tag{28}$$

where the vector of control variables  $\Omega$  is as before. The interaction term will account for heterogeneity in countries' relative abundance of capital in the broadest definition, which is a proxy for the relative abundance of skilled labour.

The estimation for the (log) linear models specified in equations (26), (27) and (28) is based on the fixed effects estimator, exploiting the within dimension of the data, i.e. the changes in the dependent variable over time within countries and sectors. In this manner, the estimation technique accounts for unobserved heterogeneity across sectors and countries. We

<sup>&</sup>lt;sup>19</sup> Since the analysis selects the top-5 trading partners on *4-digit sector level*, this implies computing the 5 largest trading partners for all these sectors, for 27 different countries, for 4 different years. It goes beyond the scope of this paper to repeat this analysis for two more lags.

prefer a fixed effects estimator over a random effects estimator since we believe that units in the sample are similar in their nature (all are industries or countries) and are not considered as a random pick from the underlying population (Verbeek, 2008). A Hausman test<sup>20</sup> between the random effects and the fixed effects estimators confirms our choice, which implies that we cannot assume that the unit characteristic effects of sectors and countries are uncorrelated with the error term. Hence the fixed effects estimator provides consistent estimates and is the preferred estimator.

 $<sup>^{20}</sup>$  Under the null that FE and RE coefficients are not significantly different, the Chi-Square value equals 42.05, which rejects the null that both RE and FE are consistent. Hence we prefer fixed effects since it is consistent under both hypotheses.

# 5 Data

#### 5.1 Data

By construction, the analysis requires data on firm level, due to firm heterogeneity, and data over a sufficiently long period of time in order to differentiate between the long and the short run impact of trade liberalisation. Panel data are the preferred structure of the data since individual firms can be tracked over time so as to see the changes in their factor input choices.

The data are largely based on a new and large firm-level dataset. The Business Environment and Enterprise Performance Surveys (BEEPS) database from The World Bank<sup>21</sup> collects data from 150-1800 interviews (depending on the size of the country), which constitute a representative sample of an economy's private sector. This panel contains data from surveys conducted in 27 Eastern European countries (for a list of countries included, see Table A. 2 in Appendix A) in the years 2002, 2005, 2007 and 2009. The database includes most variables required for the empirical analysis: number of skilled and unskilled employees, total employment, export intensity (fraction of sales), total sales, 4-digit sector affiliation (ISIC-Rev 3.1), percentage of foreign ownership (in % of equity held by foreign entities), current value of capital holdings, date of establishment and a dummy variable indicating whether the firm uses technology licensed from abroad. The GDP per capita figures on country level (in constant 2000 US Dollars) are sourced from the World Bank's Global Development Indicators.<sup>22</sup> Lastly, in order to calculate the H-O effect of trade, export data is obtained from the UN Comtrade database.<sup>23</sup>

Several data manipulation exercises were required in order to construct the desired dataset. Firstly, only manufacturing sectors were selected (ISIC Rev.3.1 15-37), such that our database includes 284 different sectors. Secondly, the skill intensity variable has been created by dividing the number of employees performing skilled labour through the total number of employees. Crucial for the interpretation of the results is the definition of skilled labour and unskilled labour. The difference between skilled labour and unskilled labour in the dataset is reflected by the requirements of fulfilling the job. Skilled labour is work that requires a degree,

<sup>&</sup>lt;sup>21</sup> http://www.enterprisesurveys.org/

<sup>&</sup>lt;sup>22</sup> http://data.worldbank.org/data-catalog/world-development-indicators

<sup>&</sup>lt;sup>23</sup> http://comtrade.un.org/

training or a specific skill (acquired through work experience) to perform the job, whereas unskilled labour is characterised by performing tasks that do not require any sort of training or work experience. The capital-labour ratio has been computed as a fraction of the current value of the aggregate of machinery, vehicles and equipment (capital) over total employment (labour). The size of a firm is measured by the number of employees (in hundreds). Lastly, 4-digit sector wide export intensity has been computed as a sector-wide average of the export intensity of all firms in a sector, in a given country and a given year and is sourced from the BEEPS. Besides standardisation, taking export intensities also brings the advantage of cancelling out the differing currency units of total sales of a firm, which is measured in local currency units in the Enterprise Survey. The age variable is calculated by subtracting the date of the survey from the year in which a firm has been established. Since the survey years cover data from business activity in the year before, GDP per capita figures of one year earlier are matched with all observations. The first (sample split according to comparative advantage) and second (H-O effect) refinement to the original model explained in the previous section require additional data manipulations which are explained below.

# 5.1.1 Sample split based on comparative advantage

The expected relationship between skill intensity and sector wide export intensity crucially depends on the average skill intensity of exporters relative to non-exporters in the dataset. Since we expect opposite signs for the export intensity variables for a sample where exporters produce skilled labour intensively as compared to non-exporters and a sample where exporters produce unskilled labour intensively as compared to non-exporters, we split the sample based on comparative advantages of 4-digit sectors. From the initial dataset, a further narrowing of the data has been applied in order to only select economic sectors that contain a sufficient amount of reporting firms, so as to avoid situations where sector results or characteristics are driven by only one firm. It is very unlikely that such a single firm behaves as the actual average firm in a given sector. Hence, by removing those sectors, we aim to

achieve a more robust statistical model.<sup>24</sup> Then, we split the sample into sectors where exporters produce skilled labour intensively (labelled 'skilled labour intensive sample' in the remainder of the text) and exporters produce unskilled labour intensively (labelled 'unskilled labour intensive sample') by comparing sector wide average skill intensity of exporters and non-exporters. In order to avoid problems with 'marginal' cases, where the difference in skill intensity between exporters and non-exporters is minimal, the median of the skilled labour intensive sample and the unskilled labour intensive sample is determined. The final sample split is obtained by selecting the sectors where the difference between the skill intensity of exporters and non-exporters is larger than the median. In this manner, we have created two sub-samples: an unskilled labour intensive sample with 1,218 observations and a skilled labour intensive sample of 1,098 observations.

### 5.1.2 Heckscher-Ohlin effect

The H-O effect is based on relative factor endowments across countries. The relative factor abundance (in terms of skilled labour) of a country can be estimated by evaluating the difference in GDP per capita values (serving as proxy for the supply of skilled labour) between the home country of the reporting firm and the average of the country's most important trading partners. We have selected the top-5 export destinations of a 4-digit sector as representing the 'most important trading partners'. Since the most important trading partners can be different for every 4-digit sector, but it is infeasible due to the scope of the paper to calculate the trading partners of all 4-digit sectors in the dataset (284), we proceed in a two-step procedure that determines the most important trading partners of a country. First, in case the top-5 exporting sectors of a country together export more than 70% of a country's total exports in that year, then the most important trading partners are selected for these five 4-digit sectors for all four years in the panel. This gives, at most 100 different trading partners per country (5 sectors\*5 destinations\*4 years). Second, in case the top-5 exporting sectors of a country together do not represent more than 70% of the country's total exports in that year, then the top-5 export destinations of the country as a whole are selected for all sectors in that

.

 $<sup>^{24}</sup>$  Consequently, 66 (4-digit) ISIC sectors that included three observations or less (to account for the fact that at most, firms report three times in the survey) are removed

country. This gives at most 20 different trading partners (5 destinations\*4 years). Table A. 3 in Appendix A presents the top-5 4-digit export sectors per country per year, or indicates that the average of the top-5 trading partners of the country is chosen. A country's export partners per sector, for a given year, can be retrieved from the UN Comtrade database, which reports total trade values valued at Free-On-Board classification including its destination. However, Comtrade reports in HS codes, whereas the dataset has an ISIC Rev. 3.1 sector affiliation. The relevant 4-digit ISIC sectors are matched using UNSTAT's correspondence tables<sup>25</sup> to 2-digit HS sector classification sector. Using the matched sector export data, the top 5 trading partners per sector (or per country) and per year are determined<sup>26</sup>. The average GDP per capita in the corresponding year is determined and subtracted from the GDP per capita of the 'home' country of the sector.

In turn, this difference in GDP per capita values between the firm's home country and the average GDP per capita of the top-5 export destinations of either its sector or its country on a whole is multiplied by the sector-wide export intensity to obtain the interaction effect that captures the impact of H-O type of trade.

### 5.2 Descriptive statistics

Table 2 presents some descriptive statistics of the characteristics of the panel employed in the empirical model. The total number of manufacturing firms present in the dataset equals 10,170, although the extent to which firms consistently report over the years differs (see Appendix A, Table A. 5. Only 352 firms (3.5% of the sample) have completed the survey in three sampling years, whereas the remainder has reported only in one or two years. Hence, panel attrition, i.e. individuals not reporting in all panel sampling years, appears to be large. Important to note is that participation in the survey is not of any kind related to firm survival.

In order to give a detailed overview of the types of firms present in the dataset, Table 2 shows a breakdown of firm size for both exporters and non-exporters (firms with 100% domestic sales). Due to the oversampling of large firms, the Enterprise Surveys contain a

<sup>25</sup> Available as MS Access Database through http://unstats.un.org. The customised matching table for our sample is also available in Appendix A, Table A. 4.

<sup>26</sup> An overview of the top-5 trading partners for the top-5 most important sectors for all countries in every year is too extensive for presentation in the appendix, but is available upon request from the author.

Table 1. Panel data descriptive statistics

	Descriptive s	statistics						
A. Firm size								
	Exporters	Non exporters	Total	%				
Small (<20 workers)	574	3,023	3,597	35.4				
Medium (20-99)	1,243	2,307	3,550	34.9				
Large (100 and over)	1,847	1,167	3,014	29.7				
Total	3,669	6,501	10,170	100				
B. Foreign ownership								
	Exporters	Non exporters	Total	%				
Domestic (<10% foreign)	2,629	5,918	8,560	84.2				
Foreign owned ( $>=10\%$ )	146	85	231	2.3				
Foreign owned (>=50%)	881	498	1,379	13.5				
Total	3,669	6,501	10,170	100				
C. Top-10 most present s	ectors (284 in t	otal)						
Sector	%			%				
1. Wearing apparel	6.3	6. Meat and meat produc	cts	2.7				
2. Structural metal products	4.0	7. Other fabricated meta	l products	2.2				
3. Articles of fur	3.7	8. Food products & beve	rages-2	2.1				
4. Bakery products	3.2	9. Fruit and vegetables		1.8				
5. Food products & beverages-1	2.9	10. Plastics products						

Source: World Bank Enterprise surveys - dataset constructed by the author

balanced mix of small, medium and large sized firms. Still, almost 64% of the firms do not export, which gives rise to an average export intensity of 0.19 in the entire dataset. The figures also show that exporters tend to typically be the larger firms. These findings ('exporting is rare') are consistent with a lot of other empirical work in the field (Bernard, Jensen, Redding & Schott, 2011). The lion's share of all firms is almost exclusively domestically owned (84%), while 13.5% can be considered foreign owned (>=50% of shares are foreign owned). Also, exporting firms tend to be more foreign owned than non-exporting firms. In order to get an overview of the representation per sector, the top-10 of sectors with the highest amount of firm representation is also listed. Clothing (10%), as well as food and beverages (5%) are commonly traded products according to the product classification in the data. The general patterns displayed by the independent variables have been presented in Appendix A, Table A. 6.

Crucial for the interpretation of the model results is the average skill intensity of exporters and non-exporters in the sample, since this reveals their comparative advantage and

Table 2. Average skill intensity between exporters and non-exporters

	Ø Skill intensity	Ø Skill intensity	Ø Skill intensity
	$Entire\ sample$	$Unskilled\ labour$	$Skilled\ labour$
Exporters	55.5	51.9	63.8
Non exporters	57.1	64.0	50.6

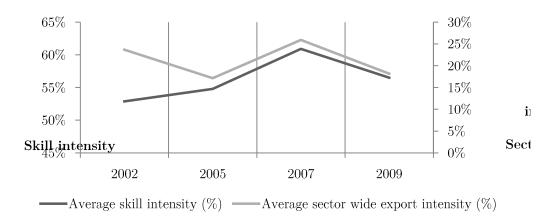
Source: World Bank Enterprise surveys - dataset constructed by the author.

Skill intensity is defined as the number of skilled workers as a percentage of the total amount of workers in a firm 'Unskilled labour' refers to the sub-sample where only those 4-digit sectors are selected in which exporters produce more unskilled labour intensively than non-exporters. 'Skilled labour' refers to the sub-sample where only those 4-digit sectors are selected in which exporters produce more skilled labour intensively than non-exporters.

relative factor abundance. Table 2 shows the average skill intensity for exporters and non-exporters in the entire sample, the unskilled labour intensive sample ('unskilled labour') and the skilled labour intensive sample ('skilled labour'). The table shows that on average, exporters produce more unskilled labour intensively, but that the difference is not very large (1.6). Consequently, results for the sample split will be interesting since the difference between exporters and non-exporters for these estimations is more pronounced. Based on the above average skill intensities, we expect that for the entire sample and the sample where exporters produce unskilled labour intensively, in the short run higher export intensity will lead to an increase in skill intensity and a decrease in skill intensity in the long run (based on Propositions 1 and 2 from the model). For the sample where exporters produce more skilled labour intensively, we expect that an increase in sector wide export intensity leads to a decrease in skill intensity in the short run and an increase in skill intensity in the long run ( Propositions 3 and 4).

The trend of the two variables of particular interest show a relatively stable pattern over the eight years covered in the data (see Figure 1). The data show that, on average, the Eastern European countries suffered from the global economic crisis in the years 2008 and 2009, which is visible by the drop in average sector wide export intensity in 2009. Average skill intensity increased slightly to 61% in 2007 (from 53% in 2002), to decrease again to 56.5% in 2009.

Figure 1. Average skill intensity and export intensity over time (entire sample)



Source: World Bank Enterprise Surveys - Author's calculations

### 6 Results

The following section presents the estimated results for the three models described by equations (26), (27) and (28). The results for the three models will be presented in three separate sections and will be subject to more thorough discussion in the next section (Discussion and implications).

Since the fixed effects model assumes homogeneity within its standard errors, the models have been tested for group-wise heteroscedasticity<sup>27</sup> since it is more likely, due to the structure of the panel, that variances differ across sections than across time. Since the test indicates that between group (countries and sectors) variances are unequal, all fixed effects panel regressions have been performed using panel-robust estimators (Newey-West), which correct for general forms of autocorrelation and heteroscedasticity within the groups. In addition, serial correlation is unlikely to arise due to the limited amount of years in the panel. A repeated groupwise heteroscedasticity test and a general Breusch-Pagan LM test<sup>28</sup> for heteroscedasticity indicate homogeneity of the error term after the adjustment. A final check for multicollinearity between the independent variables should be carried out in order to ensure a sound and valid interpretation of the regression results. A review of the correlation matrix and variance inflation factors (Table A.7 and Table A.8 in Appendix A) of all variables used shows no collinearity problems. Fixed effects are created using manually computed n-t time, country and country-sector dummies as explained in the methodology section.

## 6.1 Overall results entire sample

Table 3 displays the results for the model described by equation (26). Under the gradual inclusion of control variables, it shows the relationship between skill intensity and sector wide export intensity for the entire sample. The previous section has shown that exporters produce slightly more unskilled labour intensively than non-exporters and hence we expect a positive sign for export intensity in the short run and a negative sign for export intensity in the long run. Regression models (1)-(4) regress skill intensity on same year sector wide exports,

<sup>&</sup>lt;sup>27</sup> Resulting outcome for STATA's *xttest3* for groupwise heteroscedasticity with H<sub>0</sub>  $\sigma_i^2 = \sigma^2$  for all i is Prob>Chi<sup>2</sup> = 0.000 and hence suggest a strong rejection of homogeneity of variances.

<sup>&</sup>lt;sup>28</sup> Chi-sq (3) = 3.660862 with corresponding p-value 0.3005.

Table 3. Regression results, for the sample including all sectors (entire sample)

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
4-digit sector-wide exports	7.630*** (1.225)	6.796*** (1.755)	6.379*** (2.374)	-2.181 (9.433)								
4-digit sector-wide exports t-1	, ,	, ,	, ,	, ,	4.313*	3.232	2.313	23.93				
4 digit sector-wide exports t-2					(2.512)	(3.202)	(3.336)	(22.50)	6.771* (3.604)	5.216 (4.166)	4.310 (4.233)	11.93 (17.62)
$Log\ (Capital\ /\ Labour)$		-0.305	-0.272	0.265		-0.148	-0.101	-0.452	(3.33.2)	-0.489	-0.633	0.774
Foreign Ownership		(0.234)	(0.234) $-0.054***$ $(0.015)$	(0.336) $-0.0133$ $(0.022)$		(0.732)	(0.726) -0.088*** (0.031)	(1.120) $-0.052$ $(0.046)$		(0.682)	(0.686) -0.038* (0.046)	(0.958) $-0.077$ $(0.063)$
Exporter			1.712 $(1.662)$	0.412 $(1.982)$			6.075** $(2.718)$	2.504 $(3.951)$			7.460* (3.888)	6.208 $(5.660)$
Constant	51.31*** (0.774)	52.91*** (1.581)	59.79*** (2.364)	57.15*** (3.302)	70.52*** (3.168)	70.14*** (5.641)	69.77*** (5.650)	66.30*** (15.05)	55.17*** (1.409)	53.93*** (4.559)	52.29*** (4.622)	58.85*** (7.096)
Dummies	Country, Year	Country, Year	Country, Year	Country- Sector, Year	Country, Year	Country, Year	Country, Year	Country- Sector, Year	Country, Year	Country, Year	Country, Year	Country- Sector, Year
Observations	8,777	4,580	4,563	4,563	1,979	1,029	1,029	1,029	741	502	498	498
R-squared	0.06	0.08	0.08	0.48	0.08	0.09	0.10	0.41	0.12	0.15	0.15	0.45
AIC	81391.5	42361.7	42195.8	39558.7	18467.2	9550.9	9545.0	9107.2	6754.2	4565.1	4527.1	4310.7

Note: OLS estimates with robust (Newey-West) standard errors in parentheses. Dependent variable in all regressions is skill intensity.

<sup>\*\*\*</sup> denotes significance at the 1% level, \*\* denotes statistical significance at the 5% level and finally \* denotes statistical significance at the 10% level

regression models (5)-(8) regress skill intensity on sector wide exports from one year before and models (9)-(12) use sector wide exports with two lags. Intuitively, it would make sense to include both the export intensity variable and its lag in order to directly distinguish between the short run and long run effects. However, due to a severe loss of observations (caused by strong panel attrition effect described earlier), such a model could not be estimated efficiently and unbiasedly (amount of observations < 100). In addition, the lagged export intensity variables in the full model (including all lags) would, due to the limited number of observations, be collinear with some sector dummies<sup>29</sup> and hence cannot be estimated. Consequently, we decided to split the model into three sets of regressions. The interpretation of all coefficients in this section is based on the *ceteris paribus* assumption, implying that the signs and magnitudes of coefficients are interpreted as implied changes while holding all other variables (characteristics) constant.

Column (1) shows that, taken alone, sector wide export intensity has a statistically significant positive effect on skill intensity (at the 1% level). Using the concept of point elasticities<sup>30</sup> and employing sample averages of the export and skill intensity variable, the coefficient of 7.63 implies that a one percent increase in sector wide export intensity yields an increase of 0.22 percent in the ratio of skilled labour over total employment. This positive effect remains highly significant and positive (despite a slightly smaller magnitude) under the gradual inclusion of extra predictor variables, while controlling for heterogeneity between countries and time in columns (2) and (3) and hence is in line with theoretical predictions. In the full specification (3), we observe that a one percent increase in the degree of foreign ownership lowers the skill intensity ratio by 0.05. The effect of the degree of export intensity of an individual firm (measured by exporter) does not seem to be statistically different from zero. Lastly, regression (4) estimates the full model under the inclusion of (4-digit) country-sector and time fixed effects and shows a statistically insignificant relationship between sector-wide export intensity and skill intensity. Correcting for any heterogeneity across sectors and countries combined, none of the included regressors seem to be significantly different from

<sup>&</sup>lt;sup>29</sup> Since it happens that the only one firm in a sector has a constant export intensity and hence already captures time-invariant fixed effects.

Calculated as  $\eta = \frac{\partial Skill\ intensity_{ickt}}{\partial Export\ intensity_{ckt}} \cdot \frac{Export\ intensity_{ckt}}{Skill\ intensity_{ickt}} = \beta_2 \cdot \frac{Export\ intensity_{ckt}}{Skill\ intensity_{ickt}}$ 

zero. The inclusion of these fixed effects does, however, increase the goodness-of-fit of the model substantially, as indicated by the increased R<sup>2</sup> from 0.1 to 0.5.

Columns (5)-(8) show regressions for skill intensity in year t on export intensity in year t-1, which in our data implies a lag of 2 to 3 years (either from 2007 to 2009, from 2005 to 2007 or from 2002 to 2005). Using country and time fixed effects, the lagged export intensity variable is only statistically different from zero when it is the only independent variable (5). With an estimated coefficient of 4.3, its magnitude and significance level have both decreased as compared to the short run regressions. Using the point elasticity approach, a one percent increase in sector-wide exports at time t-1 implies an increase in skill intensity at time t of 0.12 percent. In the full model (7), it becomes clear that the control variables take over the explanatory power from the export intensity variable and that the positive effect of sector wide export intensity t-1 is not robust to the inclusion of additional control variables. The degree of foreign ownership also enters highly significantly in this model and with a slightly stronger negative effect. The exporter variable is significant at the 5% level and indicates that a one unit increase in export orientation (hence an increase from 0% exports in total sales to 100% exports in total sales) increases skill intensity by 6.1, ceteris paribus. The amount of capital over labour employed in production does not seem to determine skill intensity significantly.

Finally, the long run relationship (i.e. with a lag of 4 to 5 years, so from 2002 to 2005 or from 2005 to 2009) is approximated in regressions (9)-(12). While the lag t-1 can be regarded to be too short for a long run effect, the positive relationship between sector-wide export intensity and skill intensity as shown by lag t-2 is contrary to predications. However, it is only significant (at 10% level) in regression (9). A one-unit increase in sector-wide export intensity two periods ago, leads to an increase of 6.8 in the ratio of skilled labour over total employment, while controlling for firm-level characteristics shows that this effect is not significantly different from zero. Firms that are more foreign owned have lower skill intensity (ceteris paribus) and a one-unit increase in export orientation (hence an increase from 0% export sales to 100% export sales) increases skill intensity by 7.5 points.

### 6.2 Skill intensity sector split

Since the difference between exporters and non-exporters in the entire sample is only marginal (average skill intensity difference of 2.9%), a first robustness check of the results involves splitting the data into sectors where exporters produce relatively unskilled labour intensively and relatively skilled labour intensively compared to non-exporters. Moreover, additional refinements to the model are applied and described by the model as in equation (27). Table 4 presents the results for the unskilled labour intensive sample. Regression equations (1) - (5) estimate the model under country and year fixed effects and regression equations (6) – (10) do so under the inclusion of country-sector and year dummies. The interpretation of the export intensity variable is now in semi-elasticities due to a transformation into natural logarithms. Solely, the effect of an one percent increase in export intensity at time t decreases skill intensity by 1.38 units, ceteris paribus, and is significant at the 5% level (column (1)), which is in contrast to our predictions. However, upon the inclusion of additional control variables (in model 2 and 3), the sign changes and the effect of an (1%) increase in export intensity at time t increases the skill intensity ratio by 1.89 or 1.4 respectively. This shows that the effect is in line with predictions, but the magnitude declines upon the inclusion of extra control variables.

Among the relevant firm characteristics that have a significant influence on skill intensity is foreign ownership, which indicates that higher foreign ownership leads to a less skilled intensive labour production. Also, the exporter variable shows that a firm that exports all its sold goods produces 25 (column 2) to 28 (column 3) units less skilled intensively. Lastly, age shows a statistically significant negative relationship (at the 10% level) with skill intensity, which suggests that older firms produce more unskilled labour intensively. Column (4) shows that the first lag of the export intensity variable is still positive, but insignificant. In turn, the level of GDPpc in the home country positively determines the share of skilled labour in production. In addition, a firm that employs foreign technology in its production process produces, ceteris paribus, with a 34 point higher skill intensity. Variables foreign ownership and age are not significant with the sector wide exports t-1 variable included. Instead, larger firms seem to produce less skilled labour intensively. Column (5) shows that the relationship between skill intensity and sector wide exports reverses upon the inclusion of the

Table 4. Regression results, sub-sample in which exporters produce unskilled labour intensively

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log (4- digit sector-wide exports t)	-1.380**	1.892**	1.400*			-3.053***	1.224	0.135		
	(0.605)	(0.816)	(0.877)			(0.850)	(1.077)	(1.155)		
Log (4- digit sector-wide exports t-1)				4.923					-0.834	
				(3.489)					(3.236)	
Log (4- digit sector-wide exports t-2)					-3.341					-1.242
					(3.880)					(4.361)
Log (Capital / Labour)		-0.610	-0.819	-1.054	-0.473		0.259	0.0589	-0.116	0.0122
		(0.552)	(0.589)	(1.857)	(1.700)		(0.683)	(0.733)	(2.006)	(1.753)
Foreign ownership		-0.111***	-0.109***	-0.0293	0.0949		-0.0855**	-0.0754*	-0.00985	0.132
		(0.0357)	(0.0403)	(0.115)	(0.126)		(0.0355)	(0.0391)	(0.115)	(0.0928)
Exporter		-25.47***	-27.50***	-31.46***	2.985		-28.15***	-30.04***	-37.43***	-8.044
		(3.863)	(4.150)	(9.818)	(14.99)		(3.910)	(4.052)	(10.02)	(14.62)
Size		0.258	-0.061	-3.468*	-0.737		0.454	0.0672	-4.316**	-0.807*
		(0.319)	(0.369)	(1.924)	(0.542)		(0.386)	(0.416)	(2.076)	(0.481)
Age		-11.10**	-10.01*	-5.633	-20.86*		-7.847	-6.156	2.734	-18.46
		(4.699)	(5.620)	(15.63)	(12.50)		(4.876)	(5.548)	(14.74)	(13.56)
Foreign technology			4.558	33.74*	3.235			3.830	22.33	6.633
			(2.913)	(17.89)	(6.873)			(2.854)	(18.46)	(5.927)
GDP per capita			0.003	0.163*	0.057			-0.006	-0.028	
			(0.004)	(0.089)	(0.041)			(0.007)	(0.016)	
Constant	54.70***	58.97***	65.55***	-82.4*	-111.7	59.96***	65.09***	81.56***	74.3**	70.83***
	(2.985)	(5.360)	(16.60)	(169.1)	(178.0)	(3.157)	(5.038)	(25.93)	(15.8)	(72.2)
	C	O	C+	C+	C	Country-	Country-	Country-	Country-	Country-
Dummies	Country, year	Country, year	Country,	Country, vear	Country,	Sector,	Sector,	Sector,	Sector,	Sector,
	year	уеат	year	year	year	year	year	year	year	year
Observations	1,218	837	757	135	101	1,218	837	757	135	101
R-squared (within)	0.07	0.18	0.18	0.27	0.32	0.24	0.36	0.39	0.48	0.39
AIC	11,397.9	7,800.4	7,049.0	$1,\!286.4$	901.1	11,154.4	7,586.9	6,832.4	1,239.2	888.1

Note: OLS estimates with robust (Newey-West) standard errors in parentheses. Dependent variable in all regressions is *skill intensity*.

\*\*\* denotes significance at the 1% level, \*\* denotes statistical significance at the 5% level and finally \* denotes statistical significance at the 10% level

the inclusion of the second lagged export intensity variable. However, also the lag t-2 is insignificant. With the sector-wide exports t-2 included, only age shows a (negative) significant effect on skill intensity. The inclusion of additional country-sector dummies in the model illustrates that the control variables  $foreign\ ownership$  and the degree of export orientation (exporter) have a significant effect on skill intensity with similar signs and coefficients as in columns (2) and (3). The lagged export intensity variables show a reversed sign, but are also insignificant. The goodness-of-fit of the estimated model described by equation (27) improves significantly compared with the results of the entire sample. The  $R^2$ s of the regressions in Table 4 are almost all higher than in Table 3.

In a similar fashion, the results for the sectors in which exporters produce skilled labour intensively are presented in Table 5. Contrary to the results in Table 4, the direct and sole effect of export intensity at time t on skill intensity at time t does not seem to be significantly different from zero in both columns (1) and (6). However, after controlling for relevant firm characteristics in columns (2) and (3), the effect of a 1% increase in 4-digit sector wide exports at time t causes skill intensity to decline by 2.8 and 1.9 points respectively, which are results that have been expected from the theory. Also, the degree of export orientation in this sample increases skill intensity highly significantly in all regressions. In addition, the age of a firm enters highly significantly in all columns (except for the lag t-2 regressions) and shows a robust positive relationship between skill intensity and the amount of years that the firm is in operation. Contrary to the results in Table 4, the sector-wide export intensity at time t is also highly significant after the inclusion of country-sector fixed effects in column (8), but no longer so once controlled for foreign technology and GDP per capita. Whereas in the previous sample, the coefficients of the lagged export intensity variables changed with respect to time t, in the skilled labour intensive sample the coefficients remain the same (negative). The lag of the export intensity variable, export intensity t-1, is negative in both columns (4) and (10), but it is only statistically different from zero while controlling for country-sector heterogeneity. Foreign ownership enters significantly only in the regressions with sector-wide exports t-2 and indicates that an increase in the degree of foreign ownership with one unit, leads to an increase of the skill intensity ratio by 0.25 and 0.29 points respectively while controlling for country and country-sector fixed effects respectively.

Table 5. Regression results, sub-sample in which exporters produce skilled labour intensively

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log (4- digit sector-wide exports t)	0.885	-2.751***	-1.918*			0.774	-3.349***	2.149		
	(0.660)	(0.963)	(1.032)			(0.895)	(1.281)	(1.502)		
Log (4- digit sector-wide exports t-1)				-0.753					-4.308*	
				(2.428)					(2.439)	
Log (4- digit sector-wide exports t-2)					-1.624					-11.73
					(5.548)					(16.15)
Log (Capital / Labour)		-0.093	0.399	1.222	0.564		-0.424	-0.102	-1.914	-0.05
		(0.517)	(0.558)	(1.654)	(1.975)		(0.683)	(0.733)	(2.051)	(3.034)
Foreign ownership		-0.003	0.011	0.023	0.245*		0.025	0.022	-0.021	0.286**
		(0.031)	(0.034)	(0.074)	(0.135)		(0.035)	(0.037)	(0.087)	(0.141)
Exporter		24.78***	25.06***	19.07***	33.63***		25.09***	25.55***	20.06***	33.33***
		(2.953)	(3.016)	(5.686)	(8.155)		(3.263)	(3.395)	(7.454)	(9.596)
Size		0.169	0.237	-0.205	-2.780		0.314	0.386	-0.136	-1.543
		(0.339)	(0.395)	(0.230)	(2.026)		(0.313)	(0.392)	(0.228)	(1.713)
Age		0.874**	0.899***	0.834**	-26.18		0.814*	0.775**	0.943**	-28.94
		(0.365)	(0.337)	(0.387)	(17.29)		(0.458)	(0.389)	(0.449)	(23.02)
Foreign technology			-3.946*	-15.83*	-18.73			-6.971*	-19.20*	-15.54
			(3.075)	(8.132)	(12.29)			(3.859)	(11.46)	(14.47)
GDP per capita			0.007	-0.015	-0.034			-0.000	-0.038	-0.151
			(0.005)	(0.041)	(0.059)			(0.007)	(0.03)	(0.185)
Constant	53.32***	59.78***	35.15**	108.0	156.5	52.18***	59.63***	58.92**	103.5*	120.2
	(2.985)	(5.360)	(16.60)	(169.1)	(178.0)	(3.157)	(5.038)	(25.93)	(15.8)	(72.2)
	C	Ct	C	C	C	Country-	Country-	Country-	Country-	Country-
Dummies	Country, year	Country, year	Country, year	Country, vear	Country, year	Sector,	Sector,	Sector,	Sector,	Sector,
	year	year	year	year	year	year	year	year	year	year
Observations	1,098	759	665	160	86	1,095	757	663	160	86
R-squared (within)	0.09	0.19	0.21	0.28	0.46	0.20	0.32	0.36	0.49	0.55
AIC	$10,\!158.6$	6,931.9	6,057.5	1,441.1	757.8	9,987.8	6,778.4	5,901.1	1,383.0	742.2

Note: OLS estimates with robust (Newey-West) standard errors in parentheses. Dependent variable in all regressions is skill intensity.

<sup>\*\*\*</sup> denotes significance at the 1% level, \*\* denotes statistical significance at the 5% level and finally \* denotes statistical significance at the 10% level

### 6.3 Heckscher-Ohlin trade

Lastly, Table 6 and Table 7 report the estimated results for the model described by equation (28). The models from the sector split refinement in section 6.2 are repeated including an interaction term capturing relative factor endowments of countries. As described in the methodology section earlier, this interaction term is only computed for sector-wide export intensity at time t. Columns (6) and (12) in both tables report the estimated coefficients for the interaction term. In all regressions, the interaction term shows the predicted sign, which indicates that the effect of the export intensity variable is aggravated if the GDPpc difference between the firm's home country and its main trading partners increases. However, only for the sectors where exporters produce unskilled labour intensively and including country-year fixed effects is the interaction term significant (at the 5% level). Additionally, it is interesting to note that in the unskilled labour intensive sample, the sign of the original export intensity variable becomes negative (but insignificant). The remaining variables and their significance do not change with respect to the regressions without the interaction term (columns (3) and (9)).

Table 6. Regression results, sub-sample where exporters produce unskilled labour intensively, consideration of HO-trade

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log (4- digit sector-wide exports t)	-1.380**	1.892**	1.400*			-0.419	-3.053***	1.224	0.135			-0.555
	(0.605)	(0.816)	(0.877)			(1.147)	(0.850)	(1.077)	(1.155)			(1.496)
Log~(4-~digit~sector-wide~exports~t-1)				4.923						-0.834		
				(3.489)						(3.236)		
Log~(4-~digit~sector-wide~exports~t-2)					-3.341						-1.242	
					(3.880)						(4.361)	
Log~(Sector-wide~exports*GDP-difference)						0.175**						0.049
						(0.0773)						(0.086)
Log (Capital / Labour)		-0.610	-0.819	-1.054	-0.473	-0.513		0.259	0.0589	-0.116	0.0122	0.252
		(0.552)	(0.589)	(1.857)	(1.700)	(0.619)		(0.683)	(0.733)	(2.006)	(1.753)	(0.754)
Foreign ownership		-0.111***	-0.109***	-0.0293	0.0949	-0.111***		-0.0855**	-0.0754*	-0.00985	0.132	-0.077*
		(0.0357)	(0.0403)	(0.115)	(0.126)	(0.0409)		(0.0355)	(0.0391)	(0.115)	(0.0928)	(0.04)
Exporter		-25.47***	-27.50***	-31.46***	2.985	-29.91***		-28.15***	-30.04***	-37.43***	-8.044	-29.82***
		(3.863)	(4.150)	(9.818)	(14.99)	(4.363)		(3.910)	(4.052)	(10.02)	(14.62)	(4.279)
Size		0.258	-0.061	-3.468*	-0.737	0.006		0.454	0.0672	-4.316**	-0.807*	0.103
		(0.319)	(0.369)	(1.924)	(0.542)	(0.362)		(0.386)	(0.416)	(2.076)	(0.481)	(0.417)
Age		-11.10**	-10.01*	-5.633	-20.86*	-11.06*		-7.847	-6.156	2.734	-18.46	-7.079
		(4.699)	(5.620)	(15.63)	(12.50)	(5.740)		(4.876)	(5.548)	(14.74)	(13.56)	(5.644)
Foreign technology			4.558	33.74*	3.235	4.694			3.830	22.33	6.633	3.833
			(2.913)	(17.89)	(6.873)	(2.990)			(2.854)	(18.46)	(5.927)	(2.938)
GDP per capita			0.003	0.163*	0.057	0.004			-0.006	-0.028		-0.006
			(0.004)	(0.089)	(0.041)	(0.005)			(0.007)	(0.016)		(0.007)
Constant	54.70***	58.97***	65.55***	-82.4*	-111.7	62.10***	59.96***	65.09***	81.56***	74.3**	70.83***	101.0***
	(2.737)	(3.847)	(17.09)	(47.1)	(142.6)	(18.46)	(2.789)	(8.498)	(22.31)	(14.62)	(11.58)	(27.74)
	C	C	O	O	Ct	Ct	Country-	Country-	Country-	Country-	Country-	Country-
Dummies	Country,	Country,	Country,	Country,	Country,	Country,	Sector,	Sector,	Sector,	Sector,	Sector,	Sector,
	year	year	year	year	year	year	year	year	year	year	year	year
Observations	1,218	837	757	135	101	724	1,218	837	757	135	101	724
R-squared (within)	0.07	0.18	0.18	0.27	0.32	0.18	0.24	0.36	0.39	0.48	0.39	0.39
AIC	11,397.9	7,800.4	7,049.0	$1,\!286.4$	901.1	6,746.7	11,154.4	7,586.9	6,832.4	1,239.2	888.1	6,537.3

Note: OLS estimates with robust (Newey-West) standard errors in parentheses. Dependent variable in all regressions is skill intensity.

<sup>\*\*\*</sup> denotes significance at the 1% level, \*\* denotes statistical significance at the 5% level and finally \* denotes statistical significance at the 10% level

Table 7. Regression results, sub-sample in which exporters produce skilled labour intensively, consideration of HO-trade

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log (4-digit sector-wide exports t)	0.885	-2.751***	-1.918*			-0.902	0.774	-3.349***	-2.149			-2.255
	(0.660)	(0.963)	(1.032)			(1.337)	(0.895)	(1.281)	(1.502)			(2.219)
Log (4-digit sector-wide exports t-1)				-0.753						-4.308*		
				(2.428)						(2.439)		
Log (4-digit sector-wide exports t-2)					-1.624						-11.73	
					(5.548)						(16.15)	
Log(Sector-wide exports*GDP-difference)						-0.708						-0.057
						(0.595)						(0.928)
Log (Capital / Labour)		-0.093	0.399	1.222	0.564	0.335		-0.424	-0.102	-1.914	-0.05	-0.257
- ( - , ,		(0.517)	(0.558)	(1.654)	(1.975)	(0.618)		(0.683)	(0.733)	(2.051)	(3.034)	(0.790)
Foreign ownership		-0.003	0.011	0.023	0.245*	0.006		0.025	0.022	-0.021	0.286**	0.013
-		(0.031)	(0.034)	(0.074)	(0.135)	(0.036)		(0.035)	(0.037)	(0.087)	(0.141)	(0.039)
Exporter		24.78***	25.06***	19.07***	33.63***	26.27***		25.09***	25.55***	20.06***	33.33***	25.64***
•		(2.953)	(3.016)	(5.686)	(8.155)	(3.214)		(3.263)	(3.395)	(7.454)	(9.596)	(3.540)
Size		0.169	0.237	-0.205	-2.780	0.166		0.314	0.386	-0.136	-1.543	0.291
		(0.339)	(0.395)	(0.230)	(2.026)	(0.364)		(0.313)	(0.392)	(0.228)	(1.713)	(0.353)
Age		0.874**	0.899***	0.834**	-26.18	0.888***		0.814*	0.775**	0.943**	-28.94	0.724**
		(0.365)	(0.337)	(0.387)	(17.29)	(0.326)		(0.458)	(0.389)	(0.449)	(23.02)	(0.366)
Foreign technology			-3.946*	-15.83*	-18.73	-3.226			-6.971*	-19.20*	-15.54	-6.852
			(3.075)	(8.132)	(12.29)	(3.483)			(3.859)	(11.46)	(14.47)	(4.368)
GDP per capita			0.007	-0.015	-0.034	0.005			-0.000	-0.038	-0.151	-0.002
			(0.005)	(0.041)	(0.059)	(0.005)			(0.007)	(0.03)	(0.185)	(0.007)
Constant	53.32***	59.78***	35.15**	108.0	156.5	34.38*	52.18***	59.63***	58.92**	103.5*	120.2	66.29**
	(2.985)	(5.360)	(16.60)	(169.1)	(178.0)	(19.29)	(3.157)	(5.038)	(25.93)	(15.8)	(72.2)	(28.30)
	C	O		C	O	O	Country-	Country-	Country-	Country-	Country-	Country-
Dummies	Country,	Country,	Country,	Country,	Country,	Country,	Sector,	Sector,	Sector,	Sector,	Sector,	Sector,
	year	year	year	year	year	year	year	year	year	year	year	year
Observations	1,098	759	665	160	86	621	1,095	757	663	160	86	619
R-squared (within)	0.09	0.19	0.21	0.28	0.46	0.21	0.20	0.32	0.36	0.49	0.55	0.36
AIC	$10,\!158.6$	6,931.9	6,057.5	1,441.1	757.8	$5,\!675.3$	9,987.8	6,778.4	5,901.1	1,383.0	742.2	$5,\!528.2$

Note: OLS estimates with robust (Newey-West) standard errors in parentheses. Dependent variable in all regressions is skill intensity.

<sup>\*\*\*</sup> denotes significance at the 1% level, \*\* denotes statistical significance at the 5% level and finally \* denotes statistical significance at the 10% level

# 7 Discussion and implications

In the following section, the empirical results are subjected to a more thorough discussion and some implications for policy are presented. In addition, possible limitations to the analysis are highlighted. The section is divided into three parts: First, the discussion in section 7.1. Second, a short subsection on policy implications is presented (7.2) and lastly, a section on potential limitations is included, which also incorporates suggestions for further research (7.3).

#### 7.1 Discussion

Since the results of the baseline model and the refinements are presented separately in the results section, the results are discussed separately as well.

### 7.1.1 Entire sample

The empirical results of the overall sample present satisfactory insights into the behaviour of firms in response to trade liberalisation. The increased economic integration of the Eastern European countries, as reflected in the increase in average export intensity from 23% in 2002 to 26% in 2007, provides an indication for the right context to interpret our results<sup>31</sup>.

Since exporters in the entire sample produce slightly more unskilled labour intensively, the short term positive coefficients discussed in the results attest our theoretical predictions. An increase in the sector-wide export intensity variable leads to greater demand for unskilled labour, which drives up the price of unskilled labour and decreases the relative price of skilled labour. The presence of industry factor market competition drives firms to change their production processes to use skilled labour more intensively. This short term prediction seems very robust to the inclusion of a first set of control variables, from which foreign ownership plays a significant role. The decreasing magnitude of the export intensity variable is not a key concern because a decreasing, yet highly significant, coefficient for the export intensity variable

<sup>31</sup> Despite the drop in export intensity to 18% in 2009, which is a likely result of the global economic crisis ('exogenous' event) in which consumer confidence dropped rapidly and global trade slumped.

could be an indication that control variables are well-chosen and 'take over' some explanatory power. Thus, similarly to the empirical analysis in Emami Namini and López (2012), our short run theoretical propositions seem to be backed by statistical support from our panel data analysis. On the other hand, the overall results could speak in favour of the line of research that views skill-biased technology change after trade liberalisation as driver of the skill upgrading process (e.g. Fuentes & Gilchrist, 2005; Bustos, 2011). For example, Bustos (2011) claims that skill upgrading of firms after trade liberalisation is a result of the adoption of skill intensive technology and not from across-sectors factor reallocations. In order to judge which effect is at work in our sample, the first refinement based on comparative advantages should present additional insights into this claim (see section 7.1.2).

The long run theoretical effects of trade liberalisation on skill intensity in production, on the other hand, do not seem to be supported by the data in the overall sample. Whereas the theoretical model predicts a negative sign, the sign for the long run proxies is positive, but only while not including any control variables. Since the full specifications do not indicate a significant relationship, we conclude that there is no statistical support for the long run theoretical predictions using these data. The reasons for our initial inconclusive support of the long run predictions could be multiple. First, the marginal difference between skill intensity of exporters and non exporters could be an indication that the demand for either one of the production factors does not increase significantly compared to the other. Since the exporter variable is not significant in the short run models, which could be an indication that the difference in skill intensity between exporters and non-exporters is not pronounced enough, the need to study the refined results becomes more pressing since the theoretical predictions rely on the assumption that  $w_s > 1$ . This marginal difference in skill intensity could be a reason that we do not find long run results. On the other hand, the robust and significant short run results in line with the predictions do provide evidence for the presence of the right assumptions and hence the validity of this concern should be further test in the first refinement. Secondly, the length of the panel with data lags of maximum three (t-1) or five (t-1)2) could be too short to proxy the long run effect accurately. Thirdly, the panel attrition effect

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<sup>&</sup>lt;sup>32</sup> Exporters produce unskilled labour intensively relative to non-exporters

described in the descriptive statistics (section 5.2) causes that only very few firms constantly report over all years in the panel. Even though this limitation is partially overcome by considering sector-wide averages of the export intensity variable, in case a particular firm, that has a significant influence on sectoral results, drops out of the survey, sectoral figures could be distorted. The first refinement to the model (discussed in the next subsection) will also deal with this problem to a certain extent and hence conclusive inferences should only be drawn after a discussion of those results.

The control variable that shows a robust (negative) influence on skill intensity across all specifications<sup>33</sup> is the degree of foreign ownership that characterises a firm. The result that firms that have higher foreign ownership levels produce more unskilled labour intensively is a phenomenon often observed in Eastern European countries (see Carstensen & Toubal, 2004). This finding provides evidence for potential vertical FDI activity in the region, driven by Multinational Enterprises (MNEs) that relocate part of their production chains to benefit from unskilled labour in the region. Hence their affiliates are likely to produce more unskilled labour intensively. In addition, MNEs tend to be larger and more export oriented than domestically owned firms, as suggested by the descriptive statistics that evidence that exporting firms produce slightly more unskilled labour intensively. This conclusion is also in line with earlier empirical work by Lankes and Venebles (1996) who find that export oriented MNEs regard production cost considerations as their chief motivating factor to locate in the Central Eastern European region.

The inclusion of 4-digit sector dummies in order to capture unobserved heterogeneity between sectors yields insignificant results for both short run and long run approximations of the theoretical predictions. The inclusion of the dummies seems to be intuitively and empirically justified as sectors have differing levels of skill intensity (see Figure A.1). Additionally, Egger and Kreickemeier (2007) find that there are signs of wage dispersion across sectors. They introduce labour market frictions in an intra-industry trade model built on Melitz (2003) and find that wage dispersion within labour market segments (i.e. skilled labour and unskilled labour) increases after trade liberalisation. On top of that, they mention that

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<sup>&</sup>lt;sup>33</sup> Excluding the specifications that include sector dummies. This issue is discussed later in the subsection.

these effects could differ strongly across sectors.. This concern is reinforced with evidence on severe labour market rigidities in Eastern European countries, which makes it harder for firms to change their workforce composition (Selek, 2011). Thus, our model could suffer from labour market imperfections and frictions that could cause employees with similar characteristics are paid different wages by different firms in different sectors. This would justify the use of sector dummies in order to control for the fact that sectors differ. Moreover, the significant increase in R<sup>2</sup> indicates that including the dummies is an important factor in explaining skill intensity. On the other hand, as will be argued later, obatining a maximum goodness-of-fit is not our primary objective and, additionally, there might be some estimation hazards when including 4digit sector dumies that could drive the inconclusive results. Firstly, recall that the marginal difference between exporters and non-exporters could also influence the results while controlling for differences in sectors. Again, this potential shortcoming is be tackled by means of the first refinement. More plausbly, the inclusion of sector dummies at the four-digit level could be too detailed, such that in case only very few firms report in a given sector, the characteristics of this sector could be determined by 'non-average' firms. The sector fixed effects would however consider this sector separately, which in turn could bias the results. Section 7.1.2 takes this issue up further.

#### 7.1.2 Sector split according to skill intensity

Recall that a line of research views the skill upgrading process after trade liberalisation a result of the adoption of skill biased technology (e.g. Bustos (2011) and Harrigan & Reshef (2012)). Hence, according to this literature the positive sign in our overall results could be due to the latter phenomenon. Splitting the overall sample into two samples with opposite predictions for the *export intensity* variable serves as a robustness check for the predictions from the theoretical model since we do not predict a skill upgrading effect in the short run after trade liberalisation in the *skilled labour* sample.

The full specifications in Table 4 and Table 5 show that trade liberalisation in the short run leads to an increase in skill intensity for the *unskilled labour intensive sample* and a decrease in skill intensity for the *skilled labour sample*. Hence, the short run results for the different samples are in accordance with theoretical predictions both in the case that  $w_s > 1$  and  $w_s < 1$ . In addition, these results are in line with findings by Emami Namini and López (2012). Hence, we find proof on the rejection of the hypothesis that skill upgrading after trade liberalisation is a result of skill biased technology change.

However, the results of the regressions without any control variables included suggest a less robust relationship between sector-wide exports at time t and skill intensity at time t, which is an unexpected result and should be discussed shortly. For unskilled labour intensive sectors, the initial effect is significantly negative, but changes to significantly positive when including relevant control variables. This causes a concern for the presence of a multicollinear relationship. However, as identified in the Results section (and shown in Table A. 8), multicollinearity does not seem to be a problem for our regressions. In that case, this phenomenon suggests the presence of a mediating factor. The likely explanation to this factor lies within the construction of the samples. Since the two samples have been selected according to the skill intensity of exporters vs. non exporters there might be an estimation bias when not controlling for the export orientation of a firm since the sample split has been based on the difference in skill intensity between exporters and non-exporters. As a result, the exporter variable enters highly significant in the regressions and is hence important to include since it corrects for the selection criterion of the sample. The same mediating effect is found for the skilled labour sample, although the initial positive effect is not statistically different from zero.

The initially unsupported theoretical prediction for the long run relationship between skill intensity and export intensity in the overall sample is also found in the results of the sample splits. The *skilled labour sample* results suggest a negative relationship after two to three years (t-1) when controlling for differences across sectors, countries and years. However, the result does not seem to be very robust and could be a sign of a 'delayed' short run effect since skilled labour intensive firms might need time to adjust their workforce composition. The unskilled labour intensive sample does show some evidence that points in the right direction, but all coefficients are insignificant. This leads us to conclude that also after model refinements we are not able to empirically prove the theoretical long run predictions with this dataset. A likely reason lies within the nature of the data. First, the relatively short time span of the panel allows for lags of maximum five years, which might be too short for economic long run

effects to take place. Recalling the definition of skilled labour<sup>34</sup>, the construction of the dependent variable could imply that five years might be too short for obtaining a degree or another form of specialized knowledge. As suggested by Bustos (2011), an adequate definition of skill intensity should involve the assumption of perfect substitution between workers within categories and an elasticity of substitution that is higher within than across skill categories. Even though this definition is hard to verify, the way in which the dependent variable has been constructed could potentially affect not only the long run, but also the short run results. Secondly, the panel attrition effect described earlier results in only very few firms (3.5%) reporting in all subsequent survey years. This presents a major limitation of our dataset since the empirical model should approximate (theoretical predictions about) the behaviour of average firms in a sector. In case in the Survey firms, which differ with respect to their skilled labour share parameter  $\phi$ , enter and exit in different survey years, the composition of the sector could differ per survey year and distort the results. In contrast, Emami Namini and López (2012) do find predicted long run effects of trade liberalisation. Their empirical investigation allows for tracking individual firms up to ten years and, in addition, the authors have selected only those firms that have reported over the entire panel. Based on their findings and our short term results, a suggestion for further research hence includes testing the theoretical model using data over a longer period of time in which individual firms report more consistently in all survey periods. Lastly, a possible explanation for inconclusive long run results could be due to imperfections in the model. Recall that the predicted results work through the prices of the respective factors. In the presence of skill wage premia (not an unlikely assumption given results in Unel (2010) and Harrigan and Reshef (2012)), other variables could cause differentials in wages that do not drive a factor substitution effect. An important consideration in this respect is the evidence from Schank, Schnabel and Wagner (2007) on the existence of wage premia for exporting firms with respect to non-exporting firms and even between-firm wage premia due to particular worker characteristics. Hence, it is possible that certain firms pay higher wages to its workers, e.g. to incentivise them or reward them for extraordinary performance, but that this does not drive a factor substitution effect.

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<sup>&</sup>lt;sup>34</sup> Skilled labour is distinguished from unskilled labour by the possession of special knowledge attained at college, university or technical school or gathered as by work experience.

The expressed concern about the assumption that firms should represent the 'average' of the sector are most likely strongly related to the (insignificant) results including 4-digit sector dummies in the model, which exhibit weakened or insignificant relationships in the unskilled labour, skilled labour and the overall sample. Export intensities have been calculated directly from the BEEPS based on sector-wide averages in order to proxy the 'average' firm in the sector. Despite removing the sectors where only one firm reports in all years in order to overcome this problem, it could still be the case that 'non-average' firms dominate a certain 4digit sector, which would distort the results. Especially the regressions with the lagged variables, which have the least amount of observations, could suffer from this problem. A possible solution comes to mind when considering the law of large numbers that states that when the number of observations increases, the average of reporting firms should increasingly represent the 'average' of the sector. Consequently, we have re-estimated the sector split regressions using 2-digit sector dummies, so as to aggregate more firms into one sector. Unfortunately, no significant differences with the initial estimations are observed. Since the results do not improve and potential information on more detailed sector-level is lost (sectors could still strongly differ, even within 2 digit sectors), we believed deeper investigation into this issue does not bear further merits. It is a possibility that the sampled firms by the Enterprise Surveys do not represent the 'average' of the sector, such that the construction of the dataset presents an inherent limitation and, as a result, the calculated sector-wide export intensity variable does not represent the 'average' sector-wide export intensity. Other studies (e.g. Emami Namini & López (2012)) use (trade) data from an external data source<sup>35</sup> to approximate sector performance and obtain more robust results, also for the long run. Hence, it is possible that our results would improve by using more complete data from an external source as well. The author of a different study that uses the same dataset on European firms as this paper does not, however, specifically report a similar problem, but does highlight that the limited length of the panel is a limitation to his study (Seker, 2011).

Concerning the control variables, the *unskilled labour* sample split results are in accordance with the entire sample results on finding that more foreign owned firms produce

 $<sup>^{35}</sup>$  Such as COMTRADE, which includes much more data on country and sector-wide export data and hence can be considered to approximate the average exports in a sector well

more unskilled labour intensively. Hence the earlier presented argument - that the result could be a sign of vertical MNE activity in Eastern Europe - is corroborated by the *unskilled labour intensive* sample results. The *skilled labour sample*, however, does not evidence a different composition of the workforce among domestic or foreign owned firms. This could either be a confirmation of the vertical nature of FDI since we expect more vertical FDI in the unskilled labour sample based on earlier findings or simply indicate that in the sample where exporters produce skilled labour intensively, foreign firms do not employ a significantly different production process.

Coherent across both samples is the conclusion that older firms are more likely to be exporters. The age variable enters significantly in all regressions and exhibits an opposite relationship in both samples: older firms produce more skilled labour intensively in the skilled labour sample and older firms produce more unskilled labour intensively in the unskilled labour sample. Since the sample splits have been made on basis of skill intensity of exporters, older firms seem to be most representative in terms of their workforce composition in both samples. This is an intuitive result since older firms have had more time to adjust their production process to the optimal mode of production according to sector and country characteristics.

Two interesting results remain to be discussed. Robust to the inclusion of sector dummies and the t-I export intensity lag is the finding that the use of foreign technology in a firms' production process reduces skill intensity significantly. Assuming that the nature of the foreign technology is such that it represents sophisticated equipment, one would expect that this requires more skilled labour. A closer look at the definition<sup>36</sup> of the foreign technology license variable explains its unexpected sign, though. Since a license of a foreign company is very likely to be held by affiliates of MNEs, which are by definition a foreign company, this variable could also capture the vertical nature of FDI in the region. Since a foreign technology license is more likely to be used by an MNE affiliate and more foreign ownership in a firm decreases skill intensity in production, the use of foreign technology in production results in a decrease in skill intensity. Secondly, the ratio of physical capital over labour has not shown to be a significant factor driving the workforce structure, which is at odds with what we had

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<sup>&</sup>lt;sup>36</sup> Foreign technology license "measures access to foreign technology" (World Bank, 2011)

expected. A possible explanation to the insignificant results is the measurement problem of physical capital over labour. Our definition relies on an estimate of the current book value of physical capital and proxies labour by the number of employees. Estimation errors in the current book value of capital are likely and the *cost* of the labour force is likely to yield a more precise decision<sup>37</sup> of labour than the amount of employees. However, due to data limitations it has not been possible to construct this variable and hence further research could investigate the relationship using a different definition of capital over labour.

Lastly, we do not find empirical evidence for our theoretical prediction made in equation (25), which derives that an increase in GDP per capita aggravates the trade liberalisation effects on the wage of skilled labour. In the sample where  $w_s < 1^{38}$ , none of the GDPpc coefficients are statistically different from zero and the empirical estimation does not provide conclusive inferences on that particular theoretical result.

### 7.1.3 Heckscher-Ohlin trade

Based on its significant coefficient, we find evidence that the increase in relative demand for skilled labour in the unskilled labour intensive sample arises from Heckscher-Ohlin type of trade: skill upgrading is a result of factor reallocations based on comparative advantages, in this case reallocations of skilled labour towards unskilled labour intensive industries. The result that short term factor shares change more markedly only for the unskilled labour intensive sample is an indication that the effect of trade liberalisation for firms in Eastern Europe is larger in industries with a comparative advantage with respect to their trading partners since Eastern Europe is often believed to have a comparative advantage in unskilled labour and many of the sectors' trading partners in the dataset are skilled labour abundant Western European countries. This finding is in line with what we could expect from theoretical predictions since factor reallocations could speed up the adjustment process: Eastern European exporters specialise in producing goods that require unskilled labour relatively intensively, whereas they import more capital intensive goods, leaving both sides of the trade better off.

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<sup>&</sup>lt;sup>37</sup> However, we have not been able to use this definition since the data on cost of labour were very scarce.

<sup>&</sup>lt;sup>38</sup> The sample where exporters produce skilled labour intensively (*skilled labour sample*)

<sup>&</sup>lt;sup>39</sup> See Bohle & Greskovits (2006) and (Carstensen & Toubal, 2004)

This finding is, however, at odds with some other empirical work in the field. As mentioned, Bustos (2011) documents that increased skill demand after trade liberalisation is a result of within firm technology and skill upgrading and argues against the presence of H-O type of trype in her sample. She is able to distuinguish between the traditional type of H-O trade effect that this paper finds and within firm technology upgrading by emprically employing several measures of firm-level spending on technology. Although the Enterprise Survey does not contain this detailed type of information and hence additional testing for this effect could not be done, future research could attempt to distinguish between H-O type of trade and firm-level skillupgrading in Eastern European firms in order to elucidate the disucssion in this field even more.

Our results also advance that evidence on skill upgrading has not been found in the *skilled labour intensive* sample, which could be used as an argument against the effect of skill upgrading. Since Eastern Europe is not consdered to be abundant with skilled labour, H-O type of factor reallocations are less likely to take place. Hence due to a lack of evidence in favor of the skill upgrading behaviour of firms, we do not reject our finding that there is a H-O type of trade effect in our sample of Eastern European firms.

## 7.2 Policy implications

Both the theoretical model and the empirical results lead to immediate implications of trade liberalisation on wage inequality and industrial policy in Eastern Europe. Our theoretical model sets out that in countries where exporters produce unskilled labour intensively (the empirically observed case, see Section 5.2), in the short run after trade liberalisation the rewards to unskilled labour increase relatively faster than rewards to skilled labour, which reduces wage inequality between both groups. However in the long run, when households have been able to disinvest into skilled labour, wages of unskilled labour will come under pressure and relative wage inequality will increase in favour of skilled labour. The empirical investigation in this paper has only proven the short run effects of globalisation and hence could be a suggestion that that there are signs of decreasing wage inequality in Eastern Europe. However, other research in the field has highlighted that conclusions about wage inequalities should involve more considerations. A matched employer-employee data study

conducted by Schank, Schnabel and Wagner (2007) contends that a very large share of the wage premium paid by exporters (compared to non-exporters) can be attributed to differences in workforce structure across firms and observable employee characteristics. Hence, a large share of wage inequalities arises from differences within employees. Secondly, a contribution by Seker (2011) on the importance of Eastern European countries' investment climate for the realisation of the gains of trade liberalisation documents that labour market rigidities (i.e. stringent labour market regulations) significantly impair firms' firing and hiring policies. Consequently, these higher cost of employment lead to a higher productivity threshold of exporting  $(\phi_x^*)$  in our model) and could reduce the share of exporters in the firm distribution, which would damage the firms' adjustment processes as described in our theoretical model. This could also be the reason for the inconclusive long run results. Policy makers should hence focus on making the adjustment process after trade liberalisation as efficient as possible. Additionally, since exporter wage premia are documented and the positive effects of trade liberalisation will result in a decrease in wage inequality and in increase in sector wide productivity<sup>40</sup>, trade liberalisation efforts should be promoted by Eastern European governments.

### 7.3 Limitations and suggestions for further research

The reader should be aware of the limitations of this paper that arise from the theoretical framework, the underlying data and the employed methodology. The theoretical model is based upon a set of assumptions that are crucial for the derivation of the results and hence a violation in either one of them could invalidate our predictions.

The theoretical model could be tested in a variety of empirical approaches, each with their own set of limitations. Our empirical model suffers foremost from a short time span and, on top of that, covers an era of global economic instability, which potentially has violated the predicted long run relationship. The nature of the panel only allowed lags of maximum five years, which might be considered too short for a long run effect. In addition, the sectoral classification used in the empirical analysis should approximate 'average' firms in a sector and

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<sup>&</sup>lt;sup>40</sup> Assuming no labour market frictions

it is possible that a potentially small amount of firms in the current 4-digit sector setup do not reflect a representative sample of a sector. In combination with a strong panel attrition effect, the longitudinal strength of the dataset is a reason for concern.

Future research could test the theoretical predictions in a number of alternative ways. It should go without saying that larger databases with more observations within sectors and longer time horizons are preferred. Related to this suggestion is the likely improvement that the result would obtain by using (trade) data from an external source to approximate 'average' export intensity of sectors since the selection of firms from the BEEPS could together not represent the 'average' firm in a sector. In addition, since the theoretical predictions channel through factor prices, an appealing research agenda would be to include *prices* of different varieties of labour and capital. In this way also another dependent variable (physical capital/labour) could be tested for similar theoretical predictions as derived in this paper.

Due to the scope of this paper, the test of the H-O component of trade could only be executed for the contemporaneous relation with export intensity and not with its lags. To elucidate the discussion on the actual presence of H-O type of trade in relation to, for example, skill upgrading theory, firm-level evidence on this phenomenon could be added to the current setup. Lastly, other empirical work on labour market frictions (e.g. Egger & Kreickemeier, 2007) serve as an indication that labour market dynamics could be relevant additions to the model.

## 8 Conclusions

Since countries nowadays become increasingly interdependent and the rate of globalisation is increasing, the need for understanding the effects of trade liberalisation becomes ever more pressing for policymakers. The increasing number of bilateral trade agreements in the last decade is a sign that governments are also actively pursuing trade liberalisation efforts (WTO, 2011). Meaningful questions to consider in this context are to what extent opening up to trade affects wage distributions and to what extent overall welfare changes. Ever since the realisation that heterogeneity between firms plays a crucial rule in explaining the effects of trade liberalisation (Bernard & Jensen (1995)), a large body of empirical and theoretical literature using firm heterogeneity has emerged that is able to address these (and other related) questions. This paper contributes to this literature by theoretically and empirically investigating the effects of trade liberalisation on firm-level factor input decisions between skilled labour and unskilled labour in a multiple country setup. The outcomes of the model hence give rise to intriguing insights into the effects of trade liberalisation on wage inequalities. This paper adds to the rising body of firm heterogeneity literature by extending the theoretical model from Emami Namini and López (2012) to a multiple country setup. Secondly, this paper contributes by empirically testing the short and long run implications of increasing trade openness on firms' factor input choices between skilled labour and unskilled labour (the key results of the theoretical model). Our analysis has aimed at answering the following overall research question: "What are the short and long run effects of trade liberalisation on firms' factor input ratios and how does the number of countries that participate in trade liberalisation affect the results?"

The answer to this question comes from two distinct parts of the paper: a theoretical model and an empirical investigation of the derived results. The theoretical model uses CES production functions, Dixit and Stiglitz consumer preferences (Dixit & Stiglitz, 1977) and monopolistic competition among firms to arrive at lucid predictions for the short and long run effects of trade liberalisation: After trade liberalisation and in the short run, under the assumption that exporting firms produce slightly more unskilled labour intensively relative to

non-exporters<sup>41</sup>, the increased demand for unskilled labour increases its price relative to skilled labour since the stock of skilled labour is assumed fixed. We find that the increase in the relative price becomes larger when the amount of trading countries increases. The increased price of unskilled labour induces firms to switch their production process to use skilled labour more intensively. In the long run, households disinvest into their human capital, driven by the increased relative price of unskilled labour. Consequently, the price of unskilled labour decreases, which encourages firms to increase skill intensity. Since an increase in the amount of countries that participate in trade liberalisation aggravates the short run effect on the relative price of unskilled labour, the sequence of events that follows becomes more pronounced as well. On the aggregate, this implies that according to theory wage inequality (measured by the returns to both factors) declines in the short run, but increases in the long run.

The main aim of the empirical investigation has been to verify the latter theoretical predictions using recent firm-level data. We mainly used the Business Environment and Enterprise Performance Surveys from the World Bank for the years 2002 until 2009, covering 284 four-digit disaggregated manufacturing sectors in 27 Eastern European and Central Asian countries to construct our dataset. The empirical methodology examines a baseline model and introduces two refinements for additional (robustness) testing. First, the sample is split based on the relative skill intensity of exporters relative to non-exporters in order to verify the opposite predictions for both the cases where sectors have exporters that produce unskilled labour intensively and sectors where exporters produce unskilled labour intensively relative to non-exporters. In this way, the analysis elucidates the discussion on skill biased technology change within firms and sectors after trade liberalisation. Second, the empirical model tests the presence of Heckscher-Ohlin (H-O) type of trade in the data.

Our empirical results seem to strongly support the short run theoretical predictions about the effect of trade liberalisation on skill intensity in production. The overall results show a skill upgrading effect after trade liberalisation, in line with our theory. Moreover, in the sample where exporters produce skilled labour intensively, an increase in sector wide export intensity leads to a *decrease* in skill intensity in the short run. These findings are an argument

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<sup>&</sup>lt;sup>41</sup> The empirically relevant case for the sample of Eastern European countries considered in this paper.

in favour of our model and contradict skill biased technology change after trade liberalisation in Eastern Europe as found by other studies in the field (e.g. Bustos (2011)). Based on the average skill intensity of exporters relative to non-exporters in the overall sample, we have reason to believe that Eastern Europe is relatively unskilled labour abundant (also in line with Carstensen & Toubal, 2004). In accordance with the latter, evidence for H-O type of trade is found for sectors where exporters produce unskilled labour intensively. Our results are also serve as an indication that multinational activity in Eastern Europe is of the vertical type since Multinational Enterprises (MNEs) are found to produce significantly more unskilled labour intensively relative to domestically owned firms.

On the other hand, empirical evidence for the support of the predicted long run results are not found in our data. Hence, even though based on the overall data wage inequalities are expected to decrease in the short run and increase in the long run, the latter (long run) effect is not proven empirically. Hence, we have provided theoretical and empirical evidence for a decrease in wage inequalities after trade liberalisation in Eastern European countries.

It should be noted however that despite our suspicion on certain measurement errors the short run results are not entirely robust to the inclusion of heterogeneity between sectors. The latter, together with the inconclusive long run results are two shortcomings of the analysis are a likely result of the limitations imposed by the dataset, which might have a too short time span to capture long run effects and might include too few firms in every sector to approximate 'average' sector results. Hence, future research could include (trade) data from an external source (other than the BEEPS) to approximate 'average' sector export performance.

Nevertheless, this paper provides lucid insights into the discussion on the effects of trade lbieralisation on wage inequalities and skill upgrading behaviour of firms. Recent advancements in the field include labour market frictions in intra-industry trade models (e.g. Egger & Kreickemeier, 2007) and stress the importance of labour market rigities in Eastern Europe (Seker, 2011). These advancements in trade modelling, combined with the inconclusive evidence for the predicted long run effects presented in this paper, provide the motivation for insightful further resarch in the field that could refine and extend the current model and test its implications using larger firm-level datasets.

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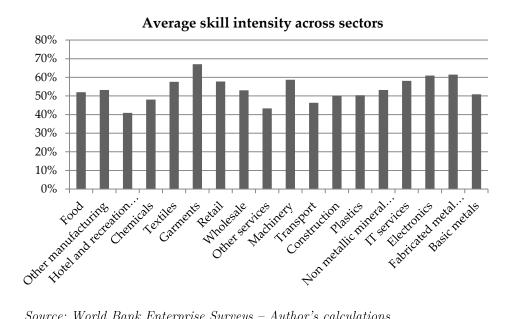
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#### Appendix 10

#### Appendix A 10.1

Figure A. 1



 $Source:\ World\ Bank\ Enterprise\ Surveys-Author's\ calculations$ 

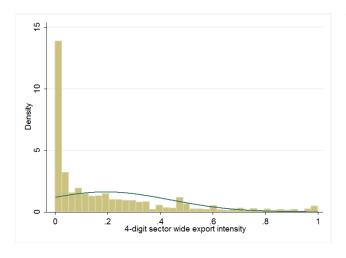
Table A. 1

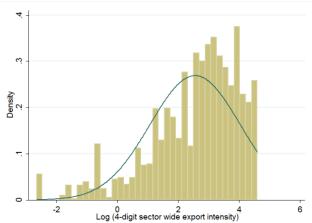
Variable	(1)	(2)
4-digit sector-wide exports t	15.646**	
	(7.502)	
Log~(4-digit~sector-wide~exports~t)		1.340*
		(0.876)
Log~(Capital~/~Labour)	- 0.616	- 0.819
	(0.564)	(0.589)
Foreign Ownership	-0.113**	-0.102***
	(0.038)	(0.040)
Exporter	-29.820***	-27.505***
	(4.367)	(4.15)
Size	-0.201	-0.06
	(0.353)	(0.369)
Age	-9.052	-10.008*
	(5.470)	(5.612)
Foreign technology	4.310	4.558
	(2.866)	(2.913)
GDP per capita	0.005	0.003
	(0.004)	(0.004)
Constant	56.687***	65.553***
	(16.16)	(17.09)
Observations	823	757
R-squared	0.172	0.182
AIC	7,658	7,051

Note: OLS estimates with robust (Newey-West) standard errors in parentheses.

Dependent variable in all regressions is skill intensity.

Figure A. 2





<sup>\*\*\*</sup> denotes significance at the 1% level, \*\* denotes significance at the 5% level \* denotes significance at the 10% level

Figure A. 3

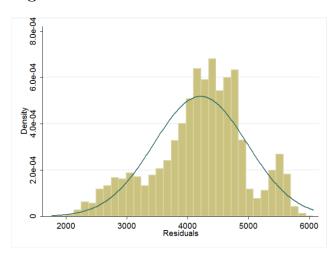


Table A. 2

Countries present in the dataset		
Albania	Georgia	Russia
Armenia	Hungary	Serbia
Azerbaijan	Kazakhstan	Slovakia
Belarus	Kyrgyz	Slovenia
Bosnia	Latvia	Tajikistan
Bulgaria	Lithuania	Ukraine
Croatia	Moldova	Uzbekistan
Czech Republic	Montenegro	
Estonia	Poland	
Macedonia	Romania	

## Table A. 3

The table below lists the top-5 exporting sectors in a country per year or indicates that the top-5 performing sectors do not represent more than 70% of total trade in a country (labelled "country"), in which case the top-5 export destinations of the country are selected.

Country	2009	2007	2005	2002
Albania	3610	1920	2320	1930
	1920	1511	2710	1822
	2211	1810	1822	2030
	0	2811	3612	2742
	0	2720	1542	2441
Armenia	Country		Country	3130
				1822
				3150
				2956
				2670
Azerbaijan	2429		0	2952
	1711		0	2971
	1531		0	1596
	2924		0	2441
	1543		0	3002
Belarus	1520		1822	2811
	1810		3550	1822
	2929		3614	3650
	3610		3663	2812
	2022		2852	1532
Bosnia	Country		2020	1822
			2875	1598
			1561	2811
			2441	3614
			1600	2670
Bulgaria	2411	Country	2415	2415
	1810		1593	2811
	2925		2651	1584
	2520		2413	2613
	1511		1730	1740
Croatia	2610	Country	3511	2922
	3220		2613	1730
	3610		2020	1823
	1531		3220	3162
	2423		3110	1822
Czech				
Republic	2731		3430	3110
	2429		1920	2940
	1729		2441	2122
	2520		2742	2722
	3190		2710	2442
Estonia	Country		3430	1772
			1520	3614
			3162	3310
			3130	3110
			1821	3161
Macedonia	2710		2721	2710
	2720		2971	1822
	1810		2640	1711
	2732		3614	2051
	1729		1930	2051

Georgia	1542		1593	2415
Country	2009	2007	2005	2002
	1513		1533	3520
	2610		2710	1593
	1552		1596	1930
	2694		1760	1532
Hungary	Country		3410	Country
			3430	
			2742	
			2956	
			2875	
Kazakhstan	1531		1561	2951
	3110		2442	2442
	2423		2956	2626
	1543		1821	1754
	1514		2924	2682
Kyrgyz	2320		2615	1711
	1543		3110	3430
	3430		1723	1715
	1711		3430	3110
	1520		1598	2466
Latvia	1512		2020	2614
	2021		2030	3614
	2010		1822	2010
	1810		3614	1596
	1554		1583	1822
Lithuania	Country		3614	3611
			2112	2112
			3110	3420
			1724	1822
			2320	1725
Moldova	1552		1822	1593
	2811		2871	1717
	1810		1593	1830
	1600		1551	2931
	3190		2621	2666
Montenegro	2811		0	0
	3511		0	0
	2010		0	0
	2696		0	0
	3610		0	0
Poland	Country		Country	Country
Romania	3000		Country	2752
	1511			1740
	1712			2951
	1721			3550
	2811			2811
Russia	Country		2924	2932
			2451	2754
			3002	2523
			3220	1810
			1520	2466
Serbia	Country		Country	1740
				2320
				2524
				3150
				1551

Slovakia	2413		3663	3663
Country	2009	2007	2005	2002
	3520		2466	1824
	2102		2971	2413
	3110		2871	2415
	2811		2911	2852
Slovenia	Country		Country	Country
 Tajikistan	1810		2415	1711
	3130		1533	1589
	1711		1711	2875
	1712		1822	2954
	2412		2513	2722
Ukraine	2899		2811	Country
	2913		1715	
	1810		2466	
	2929		1910	
	2912		1754	
Uzbekistan	1552		3110	1711
	3410		1533	2412
	1711		1593	2615
	1531		2415	2912
	1513		3430	1753

Table A. 4

ISIC 4-digit	HS	1996											
1511	2	5	15	16	23	41	51						
1511	2	5	15	16	23	41	51						
1512	3	5	16	23									
1513	7	8	11	12	20								
1514	12	14	15	23									
1520	4	17	21	35									
1520	4	17	21	35									
1531	10	11	19										
1532	11	15	17	19	35								
1533	12	23											
1542	17												
1542	17												
1543	17	18	20										
1551	22												
1551	22												
1552	22												
1554	22												
1561	2	3	4	11	15	16	17	18	19	20	21	22	23
1583	2	3	4	11	15	16	17	18	19	20	21	22	23
1584	2	3	4	11	15	16	17	18	19	20	21	22	23
1589	2	3	4	11	15	16	17	18	19	20	21	22	23
1593	2	3	4	11	15	16	17	18	19	20	21	22	23
1593	2	3	4	11	15	16	17	18	19	20	21	22	23
1596	2	3 3	4	11	15	16	17	18	19	20	21	22	23
1596	2		4	11	15	16	17	18	19	20	21	22	23
1598	2	3 3	4	11	15	16	17	18	19	20	21	22	23
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Table A. 5

Descriptive statistics								
			$\mathbf{Y}\mathbf{ear}$					
	2002	2005	2007	2009	Total			
Panel ID can't be matched	0	3	0	0	3			
Only in 2002	1,186	0	0	0	1,186			
Only in 2002, 2005	235	247	0	0	482			
Only in 2002, 2005, 2009	113	119	0	120	352			
Only in 2005	0	2,549	0	0	2,549			
Only in 2005, 2009	0	682	0	633	1,315			
Only in 2007	0	0	1,161	0	1,161			
Only in 2009	0	0	0	3,122	3,122			
Total	1,534	3,600	1,161	3,875	10,170			

Table A. 6

Descriptive statistics					
Variable	Min.	Max.	$\mathbf{Mean}$	Std. Dev.	Obs.
Skill intensity	0	100	55.7	25.79	9,417
Sector-wide exports	0	1	.193	.2449	9,501
Sector-wide exports t-1	0	1	.189	.2607	2,039
Sector wide exports t-2	0	1	.188	.2752	863
$\mathrm{K}/\mathrm{L}$	0	13,325.5	44.902	1946.399	4,764
Foreign Ownership	0	100	11.007	28.5875	10,004
Exporter	0	100	.189	.3193	10,153
Size	0.01	99	1.4309	4.0544	10,137
Age	1	205	18.3717	34.5767	10090
Foreign technology	0	1	.12806	.33417	8,098
GDP per capita	152	13,836	2,972	2,420	10,170

Table A. 7

Correlation							
	Skill intensity	Sector exports	Sector exports t-1	$\begin{array}{c} {\rm Sector} \\ {\rm exports} \\ {\rm t-2} \end{array}$	m K/L	Foreign ownership	Exporter
Skill intensity	1						
Sector exports	0.2064	1					
Sector exports t-1	0.1953	0.3282	1				
Sector exports t-2	0.1734	0.2623	-0.1405	1			
K/L	-0.1171	-0.0821	-0.0572	0.0339	1		
Foreign ownership	-0.0207	0.214	0.4893	-0.1078	-0.1112	1	
Exporter	0.2321	0.6718	0.2746	0.1115	-0.0644	0.3371	1
Size	0.1636	0.2831	-0.0735	-0.1996	0.0019	0.0524	0.2376
$\mathbf{Age}$	0.0149	0.0967	0.1441	-0.0505	-0.0465	0.3483	0.1287
Foreign Tech.	0.0432	0.2039	0.1804	-0.195	-0.0083	0.1898	0.3148
GDP per capita	0.2120	-0.4951	-0.0316	-0.5013	-0.0788	0.2059	-0.2813

$\alpha$		-1-		
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	Size	$\mathbf{Age}$	$ \begin{array}{c} {\bf Foreign} \\ {\bf tech.} \end{array} $	GDP per capita	
Size	1				
$\mathbf{Age}$	0.3658	1			
Foreign tech.	0.002	-0.1087	1		
GDP per capita	0.5594	0.5384	0.1611	1	

Table A. 8

Collinearity diagnostics							
SQRT Variable	R-VIF	VIF	Tolerance	Squared			
Skill intensity	1.25	1.12	0.8015	0.1985			
Sector exports	2.44	1.56	0.41	0.59			
Sector exports t-1	1.76	1.33	0.5686	0.4314			
Sector exports t-2	1.54	1.24	0.6503	0.3497			
K/L	1.05	1.02	0.9567	0.0433			
Foreign ownership	1.66	1.29	0.6011	0.3989			
Exporter	2.14	1.46	0.4682	0.5318			
Size	1.65	1.29	0.6049	0.3951			
$\mathbf{Age}$	1.4	1.18	0.7161	0.2839			
Foreign Tech.	1.26	1.12	0.7963	0.2037			
GDP per capita	1.07	1.03	0.9362	0.0638			

Table A. 9 Regression results, sub-sample in which exporters produce unskilled labour intensively (larger sector dummies)

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log (4-digit sector-wide exports t)	-1.380**	1.892**	1.400*			-1.261	-5.458	0.927		
	(0.605)	(0.816)	(0.877)			(2.799)	(3.902)	(5.142)		
Log (4-digit sector-wide exports t-1)				4.923					-43.57***	
				(3.489)					(9.459)	
Log (4-digit sector-wide exports t-2)					-3.341					-1.451
					(3.880)					(1.740)
$Log\ (Capital\ /\ Labour)$		-0.610	-0.819	-1.054	-0.473		-0.659	-0.507	-0.802	-0.001
		(0.552)	(0.589)	(1.857)	(1.700)		(0.730)	(0.785)	(2.249)	(2.142)
Foreign ownership		-0.111***	-0.109***	-0.0293	0.0949		-0.0264	0.0252	-0.0253	0.287*
		(0.0357)	(0.0403)	(0.115)	(0.126)		(0.038)	(0.041)	(0.098)	(0.156)
Exporter		-25.47***	-27.50***	-31.46***	2.985		28.51***	26.23***	21.72***	23.42***
		(3.863)	(4.150)	(9.818)	(14.99)		(3.536)	(3.613)	(7.418)	(7.921)
Size		0.258	-0.061	-3.468*	-0.737		0.232	0.201	-0.233	-2.895
		(0.319)	(0.369)	(1.924)	(0.542)		(0.433)	(0.443)	(0.241)	(2.134)
Age		-11.10**	-10.01*	-5.633	-20.86*		1.003**	0.938**	0.801**	-33.74*
		(4.699)	(5.620)	(15.63)	(12.50)		(0.467)	(0.406)	(0.311)	(19.48)
Foreign technology			4.558	33.74*	3.235			-5.157	-19.69*	-21.20
			(2.913)	(17.89)	(6.873)			(4.322)	(11.08)	(14.86)
GDP per capita			0.003	0.163*	0.057			-0.0148	-0.083***	-0.028
			(0.004)	(0.089)	(0.041)			(0.017)	(0.028)	(0.041)
Constant	54.70***	58.97***	65.55***	-82.4*	-111.7	64.57***	63.54***	89.81*	86.5***	141.6
	(2.985)	(5.360)	(16.60)	(169.1)	(178.0)	(11.89)	(11.59)	(47.69)	(21.6)	(119.6)
Dummies	Countre	Countrie	Country Country	Country,	Country,	Country-	Country-	Country-	Country-	Country-
	Country,	Country,	Country,			Sector,	Sector,	Sector,	Sector,	Sector,
	year	year	year	year	year	year	year	year	year	year
Observations	1,098	759	665	160	86	1,095	757	663	160	86
R-squared (within)	0.09	0.19	0.21	0.28	0.46	0.28	0.42	0.43	0.41	0.45

Note: OLS estimates with robust (Newey-West) standard errors in parentheses. Dependent variable in all regressions is skill intensity.

<sup>\*\*\*</sup> denotes significance at the 1% level, \*\* denotes statistical significance at the 5% level and finally \* denotes statistical significance at the 10% level

Table A. 10 Regression results, sub-sample in which exporters produce skilled labour intensively (larger sector dummies)

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log (4-digit sector-wide exports t)	0.885	-2.751***	-1.918*			-5.744***	-1.687	-0.644		
	(0.660)	(0.963)	(1.032)			(2.046)	(2.073)	(2.839)		
Log~(4-digit~sector-wide~exports~t-1)				-0.753					-1.241	
				(2.428)					(7.758)	
$Log~(4 ext{-}digit~sector ext{-}wide~exports~t ext{-}2)$					-1.624					-1.310
					(5.548)					(2.558)
Log~(Capital~/~Labour)		-0.093	0.399	1.222	0.564		-0.228	-0.318	-0.687	0.145
		(0.517)	(0.558)	(1.654)	(1.975)		(0.811)	(0.855)	(2.300)	(1.761)
Foreign ownership		-0.003	0.011	0.023	0.245*		-0.0867**	-0.0813*	0.121	0.136
		(0.031)	(0.034)	(0.074)	(0.135)		(0.043)	(0.047)	(0.129)	(0.094)
Exporter		24.78***	25.06***	19.07***	33.63***		-29.93***	-8.99***	-8.56***	-9.030
		(2.953)	(3.016)	(5.686)	(8.155)		(4.311)	(4.529)	(11.84)	(14.93)
Size		0.169	0.237	-0.205	-2.780		0.367	-0.0122	-3.290	-0.810
		(0.339)	(0.395)	(0.230)	(2.026)		(0.473)	(0.531)	(2.532)	(0.489)
$oldsymbol{Age}$		0.874**	0.899***	0.834**	-26.18		-12.27**	-11.47*	-8.519	-19.89
		(0.365)	(0.337)	(0.387)	(17.29)		(5.144)	(6.297)	(14.84)	(13.62)
Foreign technology			-3.946*	-15.83*	-18.73			3.086	16.72	5.631
			(3.075)	(8.132)	(12.29)			(3.129)	(19.41)	(6.039)
GDP per capita			0.007	-0.015	-0.034			0.002	0.131***	
			(0.005)	(0.041)	(0.059)			(0.015)	(0.0400)	
Constant	53.32***	59.78***	35.15**	108.0	156.5	69.32***	75.47***	57.05	-47.7***	67.97***
	(2.985)	(5.360)	(16.60)	(169.1)	(178.0)	(7.813)	(8.499)	(59.19)	(68.0)	(3.072)
	Country,	Country,	Country,	Country,	Country,	Country-	Country-	Country-	Country-	Country-
Dummies	year	year	year	year	year	Sector,	Sector,	Sector,	Sector,	Sector,
	ycui	· ·			Ü	year	year	year	year	year
Observations	1,098	759	665	160	86	1,095	757	663	160	86
R-squared (within)	0.09	0.19	0.21	0.28	0.46	0.31	0.45	0.43	0.50	0.38

Note: OLS estimates with robust (Newey-West) standard errors in parentheses. Dependent variable in all regressions is skill intensity.

<sup>\*\*\*</sup> denotes significance at the 1% level, \*\* denotes statistical significance at the 5% level and finally \* denotes statistical significance at the 10% level

## 10.2 Appendix B

(I) The four first order conditions (originally taken from Baxter (1992)) that characterise the steady state of a Ramsey growth model are given by:

$$w_s + (1 - \delta)p(\tilde{\phi}_t) = p_t^s \tag{29}$$

$$w_{s_t} = p(\tilde{\phi}_t) \left[ \tilde{\phi}_t^{1-\alpha} + (1 - \tilde{\phi}_t)^{1-\alpha} \left( \frac{l_t}{s_t} \right)^{\alpha} \right]^{(1-\alpha)/\alpha} \tilde{\phi}_t^{1-\alpha}$$
 (30)

$$w_{l_t} = p(\tilde{\phi}_t) \left[ \tilde{\phi}_t^{1-\alpha} \left( \frac{s_t}{l_t} \right)^{\alpha} + (1 - \tilde{\phi}_t)^{1-\alpha} \right]^{(1-\alpha)/\alpha} (1 - \tilde{\phi}_t)^{1-\alpha} \tag{31}$$

$$p_{t+1}^{S} = (1+\rho)p(\tilde{\phi}_t) \tag{32}$$

where  $p_t^s$  is the price per unit of skilled labour in period t and  $w_{s_t}$  and  $w_{l_t}$  the wage ratios for skilled labour and unskilled labour in period t respectively. Equation (29) is a zero profit condition for households' skilled labour lending behaviour. Equations (30) and (31) give the necessary conditions for equilibrium in factor markets such that the value of the marginal product of skilled labour and unskilled labour is equal to the respective wages. Equation (32) is the Euler equation. By inserting (32) and (30) into the first equation and rearranging, we are able to find an expression for l/s:

$$\frac{l}{s} = \left\{ \frac{\left[\frac{\rho + \delta}{\tilde{\phi}^{1-\alpha}}\right]^{\alpha/(1-\alpha)} - \tilde{\phi}^{1-\alpha}}{(1 - \tilde{\phi})^{1-\alpha}} \right\}^{1/\alpha} \tag{33}$$

Equation (36) can then be inserted into equation (31)

$$\frac{w_l}{p(\tilde{\phi})} = \left\{ \frac{\left[1 - \tilde{\phi}\right]^{\alpha/(1-\alpha)} (\rho + \delta)^{\alpha/(1-\alpha)}}{(\rho + \delta)^{\alpha/(1-\alpha)} - \tilde{\phi}^{\alpha/(1-\alpha)}} \right\}^{(1-\alpha)/\alpha}$$
(34)

In turn, we consider the combination of equations (29) and (32) separately:

$$\frac{w_s}{n(\tilde{\phi})} = (\rho + \delta) \frac{\sigma - 1}{\sigma} \tag{35}$$

Then using equations (35) and (34) and dividing each other and remembering that  $\sigma = \frac{1}{1-\alpha}$ , we can rearrange to arrive at equation (9).

(II) Given that  $c(\phi)^{\sigma}p(\phi)^{-\sigma} = (\frac{\sigma^{-1}}{\sigma})^{\sigma} = \left[\frac{c(\tilde{\phi})}{p(\tilde{\phi})}\right]^{\sigma}$ , equations (11) and (12) can be simplified to:

$$c(\tilde{\phi})^{\sigma}q(\tilde{\phi})(1-\tilde{\phi})\left[N+\frac{\delta S}{q(\tilde{\phi})}\right]=L \tag{36}$$

$$c(\tilde{\phi})^{\sigma}q(\tilde{\phi})w_s^{-\sigma}\tilde{\phi}\left[N+\frac{\delta S}{q(\tilde{\phi})}\right]=S \tag{37}$$

Dividing equation (36) by (37) yields:

$$\frac{1 - \tilde{\phi}}{\tilde{\phi}} w_s^{\sigma} = \frac{L}{S} \tag{38}$$

Solving (38) for S yields (13) and solving (38) for  $w_s$  yields (9).

(III) Lemma 5 can be proven using a hypothetical numerical example using  $\sigma = 2$ . Using equation (13) and dividing by L, it follows that relative skilled labour endowment S/L is:

$$\frac{S}{L} = \frac{(1 - \tilde{\phi})^{\frac{1}{2-1}} (\rho + \delta)^{-2} \tilde{\phi}}{\left[1 - \tilde{\phi} (\rho + \delta)^{1-2}\right]^{\frac{2}{2-1}}} = \frac{(1 - \tilde{\phi}) \tilde{\phi}}{(\rho + \delta - \tilde{\phi})^{2}},$$
(39)

By assumption,  $\rho + \delta - \tilde{\phi} > 0$ , but at the same time  $\rho + \delta$  can be smaller or larger than 1. Hence, from the above it follows that if  $\tilde{\phi}$  goes to zero, then S/L goes to zero. However if  $\tilde{\phi}$  approaches  $\rho + \delta$ , then  $S/L \to \infty$ .

(IV) Taking the partial derivative of  $\frac{\tilde{\phi} + (M-1)s_{\chi}\tilde{\phi}_{\chi}}{1 + (M-1)s_{\chi}}$  with respect to M, yields:

$$\frac{\partial \left[\frac{\tilde{\phi} + (M-1)s_x \tilde{\phi}_x}{1 + (M-1)s_x}\right]}{\partial M} = \frac{\left\{\left[s_x \tilde{\phi}_x\right] \left[1 + Ms_x - s_x\right]\right\} - \left\{\left[s_x\right] \left[\tilde{\phi} + (M-1)s_x \tilde{\phi}_x\right]\right\}}{\left[1 + (M-1)s_x\right]^2},\tag{40}$$

After simplification and rearranging, yields:

$$\frac{\partial \left[\frac{\widetilde{\phi} + (M-1)s_x\widetilde{\phi}_x}{1 + (M-1)s_x}\right]}{\partial M} = \frac{S_x[\widetilde{\phi}_x - \widetilde{\phi}]}{[1 + (M-1)S_x]^2} > 0 \text{ since } \widetilde{\phi}_x > \widetilde{\phi}$$
(41)

The second order partial derivative follows:

$$\frac{\partial^{2} \left[ \frac{\widetilde{\phi} + (M-1)s_{x}\widetilde{\phi}_{x}}{1 + (M-1)s_{x}} \right]}{\partial^{2} M} = \frac{-2S_{x}^{2} \left[ \widetilde{\phi}_{x} - \widetilde{\phi} \right]}{\left[ 1 + (M-1)S_{x} \right]^{3}} < 0$$
 (42)

(V) Given that  $\tilde{\tilde{\phi}} = \frac{\tilde{\phi} + s_x \tilde{\phi}_x}{1 + s_x}$ , equations (22) and (23) can be simplified by factoring out and replacing the previous:

$$L - L_{f_x} = c(\tilde{\phi})^{\sigma} q(\tilde{\phi}) (1 + (M - 1)S_x - \tilde{\phi} - (M - 1)s_x \tilde{\phi}_x) \left[ N + \frac{c(\tilde{\phi})^{\sigma} \frac{1}{1 + S_x} \delta S}{c(\tilde{\phi})^{\sigma} q(\tilde{\phi})} \right]$$
(43)

$$S - S_{f_x} = c(\tilde{\phi})^{\sigma} q(\tilde{\phi}) w_s^{-\sigma} (\tilde{\phi} + (M - 1) s_x \tilde{\phi}_x) \left[ N + \frac{c(\tilde{\phi})^{\sigma} \frac{1}{1 + S_x} \delta S}{c(\tilde{\phi})^{\sigma} q(\tilde{\phi})} \right]$$
(44)

In turn, dividing equations (43) and (44) by each other yields:

$$\frac{L - L_{f_x}}{S - S_{f_x}} = \frac{1}{w_s^{-\sigma}} \frac{1 + (M - 1)s_x - \tilde{\phi} - (M - 1)s_x \tilde{\phi}_x}{\tilde{\phi} + (M - 1)s_x \tilde{\phi}_x}$$
(45)

Which can then be solved for  $w_s$  as in equation (24).

(VI) In order to prove that  $w_s$  increases faster when the amount of trading countries M increases, we split the expression for  $w_s$  into two separate components presented earlier in the main text: (i)  $\frac{L-L_{f_X}}{s-S_{f_X}}$  and (ii)  $\frac{\tilde{\phi}+(M-1)s_X\tilde{\phi}_X}{1+(M-1)s_X-\tilde{\phi}-(M-1)s_X\tilde{\phi}_X}$ .

In order to show that component (i) becomes larger when the amount of trading countries M increases we use the argument that  $\frac{L-L_{f_X}}{s-s_{f_X}} > \frac{L}{s}$ . This is the case because  $\frac{L_{f_X}}{s_{f_X}} < \frac{L}{s}$ , which in turn intuitively holds since we have assumed that  $w_s < 1$  and hence firms with a higher skilled labour share parameter produce with smaller marginal costs. This implies that exporters will produce relatively more skilled labour intensively since only firms with sufficiently low marginal costs can afford to pay  $f_x$  and hence are able to export. As a result, the relative labour demand for paying the sunk export costs for exporting firms is lower than the aggregate relative labour demand  $\frac{L}{s}$ .

Consequently, in order to show that  $\frac{L-L_{fx}}{s-s_{fx}}$  increases when M increases, we need to prove that the following condition holds, given that  $M_{\tilde{z}} > M_I$  for any M:

$$\frac{L - L_{f_x} \cdot M_2}{S - S_{f_x} \cdot M_2} > \frac{L - L_{f_x} \cdot M_1}{S - S_{f_x} \cdot M_1} \tag{46}$$

This inequality can be proven to hold by cross-multiplication and further simplification:

$$\left[L - L_{f_x} \cdot M_2\right] \cdot \left[S - S_{f_x} \cdot M_1\right] > \left[L - L_{f_x} \cdot M_1\right] \left[S - S_{f_x} \cdot M_2\right] \tag{47}$$

$$L \cdot S - (L \cdot S_{f_{x}} \cdot M_{1}) - (L_{f_{x}} \cdot M_{2} \cdot S) + (L_{f_{x}} \cdot M_{2} \cdot S_{f_{x}} \cdot M_{1})$$

$$> L \cdot S - (L \cdot S_{f_{x}} \cdot M_{2}) - (L_{f_{x}} \cdot M_{1} \cdot S) + (L_{f_{x}} \cdot M_{1} \cdot S_{f_{x}} \cdot M_{2})$$

$$(48)$$

$$L \cdot S_{f_x} \cdot [M_2 - M_1] > L_{f_x} \cdot S \cdot [M_2 - M_1] \tag{49}$$

$$\frac{L}{S} > \frac{L_{f_x}}{S_{f_x}},\tag{50}$$

Expression (54) holds, because the relative labour demand for paying the sunk market export costs for exporters is lower than aggregate labour demand as argued at the start of this paragraph.

We prove that component (ii) increases with M by taking the partial derivative with respect to M:

$$\frac{\partial \left[\frac{\tilde{\phi} + (M-1)s_{x}\tilde{\phi}_{x}}{1 + (M-1)s_{x} - \tilde{\phi} - (M-1)s_{x}\tilde{\phi}_{x}}\right]}{\partial M} \\
= \frac{\left\{\left[s_{x}\tilde{\phi}_{x}\right]\left[1 + (M-1)s_{x} - \tilde{\phi} - (M-1)s_{x}\tilde{\phi}_{x}\right]\right\} - \left\{\left[s_{x} - s_{x}\tilde{\phi}_{x}\right]\left[\tilde{\phi} + (M-1)s_{x}\tilde{\phi}_{x}\right]\right\}}{\left[1 + (M-1)s_{x} - \tilde{\phi} - (M-1)s_{x}\tilde{\phi}_{x}\right]^{2}}, \tag{51}$$

Further simplification leads to:

$$\frac{\partial \left[\frac{\tilde{\phi} + (M-1)s_x \tilde{\phi}_x}{1 + (M-1)s_x - \tilde{\phi} - (M-1)s_x \tilde{\phi}_x}\right]}{\partial M} = \frac{s_x (\tilde{\phi}_x - \tilde{\phi})}{\left[1 + (M-1)s_x - \tilde{\phi} - (M-1)s_x \tilde{\phi}_x\right]^2} > 0, \tag{52}$$

The second order partial derivative follows:

$$\frac{\partial^{2} \left[ \frac{\tilde{\phi} + (M-1)s_{x}\tilde{\phi}_{x}}{1 + (M-1)S_{x} - \tilde{\phi} - (M-1)S_{x}\tilde{\phi}_{x}} \right]}{\partial^{2} M} = \frac{-2 \left[ s_{x} (\tilde{\phi}_{x} - \tilde{\phi}) \right] \left[ s_{x} - s_{x}\tilde{\phi} \right]}{\left[ 1 + (M-1)s_{x} - \tilde{\phi} - (M-1)s_{x}\tilde{\phi}_{x} \right]^{3}} < 0 \tag{53}$$

(VII) Lemma 8 is proven by imposing a contradiction. First of all, it is necessary that  $w_s < 1$  in order for  $w_s$  to increase in the short run as this condition causes exporters to produce more skilled labour intensively than non-exporters. Moreover, when  $w_s$  approaches 1 then it is ambiguous whether all firms will export or no firm would export as the skilled labour share parameter does not influence profits from serving the foreign market any longer. But in case all firms export,  $S_x = 1$  and  $\tilde{\phi} = \tilde{\phi}_x$  in which case  $w_s$  in equation (24) is equal to its autarkic level (as in equation (9)). When no firm exports,  $S_x = 0$ , then  $w_s$  also approaches its autarkic level. Hence, even though  $w_s$  will increase after trade liberalisation in the short run, it will stay smaller than 1.

(VIII) Taking equation (24) and solving it for  $\frac{L-L_{f_x}}{s-s_{f_x}}$  in the open economy steady state yields:

$$\frac{S_{trade} - S_{f_x}}{L - L_{f_x}} = \frac{w_{s_{trade}}^{-\sigma}(\tilde{\phi} + (M - 1)s_x\tilde{\phi}_x)}{1 + (M - 1)s_x - \tilde{\phi} - (M - 1)s_x\tilde{\phi}_x},$$
 (54)

which implies that, relative to the steady state in autarky, relative skilled labour demand has increased as  $\frac{w_{s_{trade}}^{\sigma}(M-1)(\tilde{\phi}+s_{x}\tilde{\phi}_{x})}{1+(M-1)s_{x}-\tilde{\phi}-(M-1)s_{x}\tilde{\phi}_{x}} > \frac{w_{s_{aut}}^{\sigma}\tilde{\phi}}{1-\tilde{\phi}}$ , where the latter fraction denotes (relative) skilled labour demand in autarky. Given this information, we know that relative skilled labour supply (after paying sunk export costs) must be larger than  $S_{aut}/L$ . Hence:

$$\frac{S_{trade} - S_{f_x}}{L - L_{f_x}} > \frac{S_{aut}}{L} \rightarrow S_{trade} - S_{aut} > S_{f_x} - \frac{S_{aut}L_{f_x}}{L},$$

We also know that  $\frac{S_{f_x}}{L_{f_x}} > \frac{S_{aut}}{L}$ , which can be used to arrive at the right hand side of the equation above and hence:

$$S_{f_x} > \frac{S_{aut}L_{f_x}}{L} \rightarrow S_{f_x} - \frac{S_{aut}L_{f_x}}{L} > 0 \rightarrow S_{trade} - S_{aut} > 0 \rightarrow S_{trade} > S_{aut}$$