Foreign trade barriers and jobs in global supply chains

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Abstract

This paper studies the impact of foreign barriers to goods and services trade on domestic jobs that are directly or indirectly related to affected trade flows. Using the ILO's recently published estimates of the number of jobs in global supply chains, the empirical analysis in this paper largely confirms predictions derived from a theoretical model closely calibrated to actual data from international input-output tables. First, it identifies a sizeable cross-border impact of barriers to manufacturing trade not only on manufacturing jobs, but also on services jobs. Second, service trade barriers affect the number of jobs in both services and manufacturing. Third, spill-over effects of trade policy in one sector to jobs in other sectors have become more important over time. With these findings, the paper provides evidence on the labour market consequences of the increased interconnectedness of countries and sectors through global supply chains, suggesting that trade policy can have significant external effects on foreign labour markets.

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CONTENTS

1 Introduction

The global fragmentation of production has increased the interconnectedness between economic actors in different sectors across borders through global supply chains, where different tasks of a production process are performed in different countries. In such an environment, trade policy does not only have an impact on firms in the sector that is protected from import competition, but also on foreign firms that are targeted by the trade policy, their suppliers, as well as suppliers of these suppliers along the production chain. The trade literature that makes use of Computable General Equilibrium (CGE) models takes these cross-border and cross-sector effects into account, relying on international input-output tables. The information embedded in these tables specifies the inputs that a sector in one country contributes to the outputs of another sector in another country. This allows CGE models to quantify the likely impact of a trade policy applied by one country to trade flows of a particular sector, on all other sectors and countries that form part of the model. However, CGE models are used to quantify the impact of trade policy scenarios in an ex-ante analysis, relying on strong assumptions on the nature and quantification of economic relationships.[1] The actual impact of a trade policy can only be determined through an ex-post empirical analysis.

The recent empirical trade literature has mostly used firm-level data to assess the impact of trade policy, testing the firm-level predictions of the so-called "new" new trade theory whose origins are in the seminal work of Melitz (2003). This literature has traditionally focused very much on the impact of domestic import tariffs on domestic firms, initially focusing on firms in the industry that is protected from import competition. In recent years, an increasing number of studies have also considered the impact of tariffs on downstream firms that import inputs on which tariffs are applied, but still focusing on domestic firms.[2] Only very few studies have investigated the external impact of trade policies on firms located in other countries. For example, Vandenbussche and Zarnic (2008) study the impact of safeguard tariffs applied by the United States to steel imports from Europe, and detect a sizeable negative impact on European steel producers' markups.

[1] For instance, some of the CGE literature builds on the full-employment assumption, restricting the analysis to relative price and employment changes between sectors, with total employment remaining fixed. Such an assumption is popular as unemployment is considered to be a fixable market failure in the neo-classical view. Moreover, the relaxation of the full-employment assumption requires an alternative "closing condition" of the model which could then result in an equally strong assumption.

[2] See, for example, Amiti and Konings (2007), Kasahara and Rodrigue (2008), Halpern et al. (2015), Goldberg et al. (2010) and Vandenbussche and Viegelahn (2016).

Rovegno (2013) studies the impact of foreign antidumping tariffs on South Korean exporters and finds a positive impact on the unit values of targeted exports, suggesting that the tariff is not absorbed by foreign exporters but passed on to consumers.[3] None of these studies investigating the domestic or external impact of trade policy, however, take into account the impact on upstream suppliers of affected firms. Such firm-level studies are lacking mainly due to data constraints, as information on firm-to-firm supplier relationships are not part of most firm-level datasets.

The purpose of this paper is to assess the external impact of one country's trade policy on the number of jobs located in another country. The paper takes into account effects along the entire supply chain. The jobs that we consider are jobs that are directly or indirectly related to the trade flows affected by the trade policy.[4] While the literature that makes use of CGE models considers supply chain linkages, this literature typically only provides evidence on the impact of trade policies on the basis of ex-ante simulations, but does not provide an ex-post empirical analysis. The empirical trade literature provides such an ex-post analysis, but typically does not take into account supply chain linkages between sectors and countries. We contribute to the existing literature by taking into account supply chain linkages between sectors and countries in our empirical analysis.

The jobs that we consider in this paper correspond to the jobs that are included in the ILO's estimates of jobs in global supply chains (ILO, 2015; Kizu et al., 2016), which are macro-level estimates of the number of jobs in one country dependent on global exports to a particular export destination. The empirical analysis that is conducted in this paper relies on these estimates, thereby circumventing the data constraints prevalent at the firm-level. While these estimates are also based on information embedded in international input-output tables, as CGE models are, they can be used in an ex-post empirical analysis, which CGE models do not provide. We conduct our analysis at the bilateral level, by country in which jobs are located and export destination country on which jobs depend. The trade barri-

[3] Brambilla et al. (2012) use labour force survey data to study the impact of one country's trade policy on another country. They show a negative impact of US antidumping duties applied to catfish imported from Viet Nam, on the labour incomes of Vietnamese catfish farmers.

[4] For example, a tariff on the exports of mobile phones will not only affect the mobile phone exporter itself which belongs to the manufacturing sector, but it will also affect firms that supply intermediate inputs for the production of the mobile phone, which may also include services firms. Tariffs that are levied on trade of manufactured goods hence do not necessarily only have an impact on manufacturing jobs, but can also have an impact on jobs in the services sector.

ers that we consider are trade barriers that have been put in place by the export destination country.

This paper aims to contribute to a better understanding of how trade and trade policies shape job creation and destruction across countries in the context of a globally fragmented production. This paper considers separately manufacturing and services jobs. The analysis takes into account not only tariff and non-tariff barriers to goods trade, but also barriers to services trade. This two-sector set-up allows us not only to analyze the impact of barriers to services trade on services jobs and barriers to goods trade on manufacturing jobs ("own-sector effects"). It also allows us to look at the impact of barriers to services trade on manufacturing jobs and barriers to goods trade on services jobs ("cross-sector effects"). These cross-sector effects can in particular be important, when services provide an important share of inputs into manufacturing, or vice-versa. This approach allows the analysis to consider impacts on jobs along the entire supply chain. Moreover, by also studying the impact of services trade restrictiveness, this paper adds to a relatively new literature on trade in services that has become increasingly important over the past years (Kimura and Lee, 2006; Ariu, 2016a,b).

Jobs in global supply chains include all jobs in a country that depend on global exports to a particular export destination. There are three channels through which our measure of jobs in global supply chains can be affected by trade barriers that are put in place by a particular export destination. First, these trade barriers can have an impact on jobs in the sector whose exports have to overcome this barrier in order to reach the export destination. Second, trade barriers can have an impact on jobs in sectors that are suppliers to the sector whose exports have to overcome the trade barrier. Third, trade policy can have an impact on jobs in sectors that contribute as suppliers to third countries' exports to the export destination.

The literature has provided two types of jobs estimates, which could be an alternative to the estimates of the number of jobs in global supply chains that this paper relies on. The first alternative is given by Jiang (2013) who estimates *jobs in global production networks*. These jobs, however, only comprise jobs dependent on *intermediate* goods and services exported to be used in exports of a foreign country. These estimates are not suitable to our context, as we are interested in the impact of trade barriers on all jobs, regardless of whether they depend on intermediates or final goods and services that are traded, given that both can be part of global supply chains. Moreover, trade policy does not distinguish between trade in goods and services that are processed further as intermediate inputs, and trade in goods and services that directly enter consumer demand. Secondly, Timmer et al. (2014) estimate the number of *manufactures global value chain workers* as jobs that are dependent on total final manufacturing demand by all countries. These estimates miss out those jobs that depend on services demand. But these are the jobs that are particularly affected by services trade barriers, which form part of our analysis. Therefore, the paper uses ILO's estimates of the number of jobs in global supply chains (ILO, 2015; Kizu et al., 2016).

Even though the effect on jobs in global supply chains that we identify is not a *net* jobs effect, it is likely to qualitatively correspond to a net effect, at least in the country where these jobs are located. A reduction in trade barriers on goods, for example, will decrease the price of imported goods in the export destination country, which in turn will increase demand, to be met through increasing production and more workers in the country where production is located. However, the effect that we identify does not necessarily correspond to a net jobs effect globally, as jobs in one country may at least partially be created at the expense of jobs located in other countries. The purpose of this paper is hence not to service any normative statement about whether trade policy benefits or harms job creation globally. We rather aim to demonstrate how the impact of a particular trade policy imposed by one country, trickles down through the global production network and has wide-ranging consequences in other countries that go far beyond the sector that is targeted.

The paper proceeds by developing a simple theoretical model of trade in intermediate inputs, consisting of two countries and two sectors, manufacturing and services. Based on the calibration of the model to actual data, we are able to derive several hypotheses that are then tested empirically. First, the theoretical model predicts that a reduction in trade barriers increases the number of jobs in the exporting sector that is targeted with the trade barrier. Second, a reduction in trade barriers produces a cross-sector effect and also increases the number of jobs in sectors supplying inputs to the targeted sector. The empirical model provides evidence in support of these hypotheses. Based on a sample of 40 developed and emerging economies, we use the average goods tariff as a measure for barriers to manufacturing trade, and a services trade restrictiveness index (varying between 0 an 100) for the cross-border supply of services as a measure for barriers to services trade. With regards to the "own-sector effect", we find that, a one percentage point decrease in the average goods tariff in the export destination country increases the number of affected manufacturing jobs in the exporting country by 1.6-3.4 per cent. In analogy, a lower restrictiveness of cross-border services supply by one index point in the export destination country can be associated with 0.6-1.4 per cent more services jobs, specific to the particular country-destination combination, in the exporting country. We also find strong evidence for a "cross-sector effect". A one index point decrease in the export destination's restrictiveness of cross-border services supply, increases affected manufacturing jobs by 0.2-0.5 per cent. In analogy, a decrease of the goods tariff by one percentage point contributes to an increase of 3.2-4.1 per cent of affected services jobs.

The theoretical model also allows us to derive hypotheses about the relative strength of the own-sector and the cross-sector effect, as well as the evolution of the magnitude of effects over time. First, the cross-sector effect is smaller than the effect on the targeted sector itself. Second, the cross-sector effect from a decrease in barriers to services trade on manufacturing jobs is smaller than the cross-sector effect from a decrease in barriers to goods trade on services jobs. Finally, the cross-sector effect is predicted to have increased over time. The empirical model also finds evidence in support of these hypotheses. We find a cross-sector effect that is stronger than the own-sector effect only for manufacturing trade barriers. In other words, the average goods tariff is estimated to have a stronger impact on related services jobs than on manufacturing jobs. Also more generally, there is strong empirical evidence for cross-sector effects, which can only arise as a result of supply chains. This has important implications for policy makers who need to take these cross-sector effects into account, when adopting policies to support domestic workers in the case of adverse effects that foreign trade policy changes might have.

The following section introduces the theoretical model and its calibration to actual data, used to derive testable hypotheses. Section 3 describes the data and presents the empirical estimation methodology to estimate the impact of trade barriers on jobs in global supply chains. Section 4 presents the results and provides some robustness checks. Section 5 concludes.

2 THEORETICAL MODEL

This section develops a simple theoretical model that we use to derive hypotheses on the effects of foreign trade policy changes on domestic jobs, which we will test empirically. The specification of international integration in the model is based on the new open macroeconomics literature (see for example Obstfeld and Rogoff, 2000; Corsetti and Pesenti, 2001), whereby trade occurs because of love of variety in demand for domestic and foreign goods. Additionally, the model builds on the literature on sectoral shifts due to structural transformation, in its specification as a two-sector economy using intermediate inputs (as in Uy et al., 2013).

Specifically, the theoretical model focuses on jobs in manufacturing and services within two countries. Production in a sector necessitates intermediate inputs from the same sector and the other sector. For example, to produce more manufacturing output, both more manufacturing as well as more services are required as intermediate inputs, in addition to more labour. These intermediate inputs can either be sourced domestically or externally, giving rise to global supply chain linkages between sectors. Finally, final demand in a sector is composed of domestic and foreign demand.

The theoretical model is used to investigate the impact of a reduction in trade barriers. More specifically, the policy experiment in this paper consists of a reduction in the costs to export output produced by one of the sectors in one country, which lowers the effective price of these exports and raises foreign demand for these exports in the other country. The reduction in trade costs does not affect the exporting sector alone but also induces cross-sector effects due to supply chain relationships modelled through intermediate inputs.

2.1 MODEL SETUP

The partial equilibrium model that we construct, considers two countries, and two sectors $i \in [m, s]$, where m stands for manufacturing and s for services. Each sector's output Y_i is produced with a CES production function, using intermediate inputs $X_{i,i'}$ from sector $i' \in [m, s]$, and labour L_i, which represent the actual value-adding factors of production. The production function of final output for each sector i can be written as

$$Y_i = \left[\alpha_{i,m}^{\frac{1}{\zeta_i}} X_{i,m}^{\frac{\zeta_i - 1}{\zeta_i}} + \alpha_{i,s}^{\frac{1}{\zeta_i}} X_{i,s}^{\frac{\zeta_i - 1}{\zeta_i}} + (1 - \alpha_{m,i} - \alpha_{s,i})^{\frac{1}{\zeta_i}} L_i^{\frac{\zeta_i - 1}{\zeta_i}} \right]^{\frac{\zeta_i}{\zeta_i - 1}}, \tag{1}$$

where $\alpha_{i,m}$ ($\alpha_{i,s}$) represent the share of intermediate manufacturing (services) inputs in the production function, while ζ_i is the elasticity of substitution in production of sector i. Denoting the output price as $P_{y,i}$, the cost of intermediate inputs as $P_{x,i}$, and the wage as W_i, cost minimization implies the following first order conditions:

$$X_{i,m} = \alpha_{i,m} \left(\frac{P_{x,m}}{P_{y,i}} \right)^{-\zeta_i} Y_i \tag{2}$$

$$X_{i,s} = \alpha_{i,s} \left(\frac{P_{x,s}}{P_{y,i}} \right)^{-\zeta_i} Y_i \tag{3}$$

$$L_i = (1 - \alpha_{i,m} - \alpha_{i,s}) \left(\frac{W_i}{P_{y,i}} \right)^{-\zeta_i} Y_i \tag{4}$$

There is no differentiation between intermediate inputs that would depend on whether they are used in manufacturing or services production, such that $X_i = X_{m,i} + X_{s,i}$ holds. Intermediate inputs are a CES composite of domestic and foreign produced intermediates, $M_{i,d}$ and $M_{i,f}$, with prices $P_{m,i,h}$ and $P_{m,i,d}$. The CES function for the production of intermediates and the budget constraint are given by

$$X_i = \left[\beta_i^{\frac{1}{\phi_i}} M_{i,d}^{\frac{\phi_i - 1}{\phi_i}} + (1 - \beta_i)^{\frac{1}{\phi_i}} M_{i,f}^{\frac{\phi_i - 1}{\phi_i}} \right]^{\frac{\phi_i}{\phi_i - 1}} \tag{5}$$

$$P_{x,i} X_i = P_{m,i,d} M_{i,d} + P_{m,i,f} M_{i,f} \tag{6}$$

This gives rise to the following first-order conditions and price index:

$$M_{i,d} = \beta_i \left(\frac{P_{m,i,d}}{P_{x,i}} \right)^{-\phi_i} X_i \tag{7}$$

$$M_{j,i} = (1 - \beta_i) \left(\frac{P_{m,i,f}}{P_{x,i}} \right)^{-\phi_i} X_i \tag{8}$$

$$P_{x,i} = \left[\beta_j P_{m,i,d}^{1-\phi_i} + (1 - \beta_i) P_{m,i,f}^{1-\phi_i} \right]^{\frac{1}{1-\phi_i}} \tag{9}$$

On the consumer side, both domestic and foreign manufactures or services are demanded, where the demand function is once again CES, with the sector-specific share parameter for domestic products γ_i and an elasticity of substitution σ_i. The budget constraint is $p_{c,i} C_i = p_{c,i,d} C_{i,d} + p_{c,i,f} C_{i,f}$ for each sector $i = [m, s]$. The first order conditions and the price index are

$$C_{i,d} = \gamma_i \left(\frac{P_{c,i,d}}{P_{c,i}} \right)^{-\sigma_i} C_i \tag{10}$$

$$C_{i,f} = (1-\gamma_i) \left(\frac{P_{c,i,f}}{P_{c,i}} \right)^{-\sigma_i} C_i \tag{11}$$

$$P_{c,i} = \left[\gamma_i P_{c,i,d}^{1-\sigma_i} + (1-\gamma_i) P_{c,i,f}^{1-\sigma_i} \right]^{\frac{1}{1-\sigma_i}} \tag{12}$$

The same set of equations holds for the foreign country, in which case variables are denoted with a star. Output demanded from a sector of production is made up of domestic and foreign demand for intermediates and consumption, given by

$$Y_i = C_{i,d} + C^*_{i,f} + M_{i,d} + M^*_{i,f} \tag{13}$$

$$Y^*_i = C^*_{i,d} + C_{i,f} + M^*_{i,d} + M_{i,f} \tag{14}$$

The prices of domestically sourced manufactures or services in the CES aggregate are equal to their output price in production. For foreign goods, we assume that there is some gross trade distortion $T \geq 1$, be it a tariff or some other trade cost, that increases its price. Prices are given by

$$P_{c,i,d} = P_{y,i} \tag{15}$$

$$P_{m,i,d} = P_{y,i} \tag{16}$$

$$P_{c,i,f} = P^*_{y,i} T_i \tag{17}$$

$$P_{m,i,f} = P^*_{y,i} T_i \tag{18}$$

We assume a fixed exchange rate of unity, a simplification that does not affect the results of this exercise. Due to the partial equilibrium nature of the model that ignores the household and government side of the economy, the model requires some closing conditions. First, we assume a nominal wage rule that is a direct function of the price level of the respective sector, with wages adjusting at rate ρ_w to changes in prices, implying some degree of rigidity. Second, we assume that total nominal spending on the final output within each sector remains fixed. This allows us to isolate the effect of trading cost reductions from questions related to the distribution of income, which go beyond the scope of this simple model and require more assumptions to be made. Finally, we do not explicitly model capital, which implies that it is allocated efficiently in the economy.

The closing conditions have important repercussions on the overall net job effect predicted by our model. First, imperfect pass through of inflation to nominal wages makes real wages flexible, so that labour supply does not present a constraining factor. Second, fixed nominal demand implies that demand will not be a constraining factor either. Consequently, a reduction in the price markup in a model with fixed nominal demand will raise real overall demand for output and hence jobs. One could argue that fixed nominal demand is unrealistic when jobs and wages change in both countries. The cross-sector effect in the foreign country, however, which is an effect that purely occurs through the supply chain, will if anything be underestimated by the model. This is because the foreign country should benefit from a positive income effect from home country's reduction in trading cost.

The solution to the non-linear model described in equations (1)-(18) depends on structural parameters that are not easily identifiable from the data. Furthermore, a numerical solution algorithm risks not being able to solve the non-linear model. Therefore we linearise the model, which provides three important advantages. First, parameters of the model can readily be calibrated using empirically observed values. Second, a linear model is easily solved numerically. Third, the model can be solved analytically, to provide interesting insights. However, given the complexity of the model, we resort to a numerical solution. We derive and utilize the linearization of the model for the numerical solution, mainly for the reason of simplified calibration. The linearisation of the model is described in the Appendix.

2.2 Calibration

The linear version of the theoretical model is calibrated for the symmetric two-country case, with manufacturing and services as the two sectors. This requires the calibration of the model parameters $\bar{\alpha}$, $\bar{\beta}$ and $\bar{\gamma}$, which respectively stand for the share of manufacturing and services intermediates in production, the weight of domestic products in the price basket of intermediate inputs, and the weight of domestic products in the overall consumption price basket, as detailed out in the Appendix. To calibrate $\bar{\alpha}$, $\bar{\beta}$ and $\bar{\gamma}$, we rely on average values for 40 developed and emerging economies from the World Input-Output Database (WIOD) referring to manufacturing and business services. The model is calibrated for two different years, 2000 and 2011. Table 1 shows the calibrated parameters.

The manufacturing sector has a larger share of manufacturing intermediate inputs in production than the services sector ($\bar{\alpha}_{mm} > \bar{\alpha}_{sm}$). It is also the case that the manufacturing sector uses relatively more services as intermediate inputs, when compared with services sector's use of intermediate manufacturing inputs in production ($\bar{\alpha}_{ms} > \bar{\alpha}_{sm}$). Demand for intermediate services and manufacturing inputs has a home bias, with a larger share of demand for domestically produced goods and services compared with externally produced goods and services ($\bar{\beta}_m > 0.5$ and $\bar{\beta}_s > 0.5$). There is equally a home bias in the demand for final output ($\bar{\gamma}_m > 0.5$ and $\bar{\gamma}_s > 0.5$). The home bias is larger for services than for manufactured goods ($\bar{\beta}_s > \bar{\beta}_m$ and $\bar{\gamma}_s > \bar{\gamma}_m$).

For the price elasticities of substitution, we assume that the price elasticity of substitution between domestic and foreign intermediates and consumption is larger for manufactured goods than for services ($\phi_m > \phi_s$). The wage adjustment parameter ρ_w is set to 0.5, implying some stickiness of wages.

Table 1: Calibration of parameters

Parameter	**Value 2000**	**Value 2011**
Intermediate input shares in production		
$\bar{\alpha}_{mm}$	0.18	0.44
$\bar{\alpha}_{ms}$	0.084	0.21
$\bar{\alpha}_{sm}$	0.05	0.126
$\bar{\alpha}_{ss}$	0.116	0.334
Domestic share in intermediate input		
$\bar{\beta}_m$	0.65	0.69
$\bar{\beta}_s$	0.85	0.84
Domestic share in consumption input		
$\bar{\gamma}_m$	0.72	0.72
$\bar{\gamma}_s$	0.95	0.96
Elasticity in production function		
ζ_m	1	1
ζ_s	1	1
Elasticity between domestic and foreign intermediates		
ϕ_m	2	2
ϕ_s	1.5	1.5
Elasticity between domestic and foreign finals		
σ_m	1	1
σ_s	1	1

2.3 COMPUTING THE IMPACT ON JOBS IN GLOBAL SUPPLY CHAINS FROM THE MODEL

The theoretical model only includes total employment as a variable. To compute the impact of a trade policy shock on jobs in global supply chains, we use the input-output methodology that has also been used to derive estimates of the number of jobs in global supply chains (ILO, 2015; Kizu et al., 2016). We construct the input-output-matrix from the underlying parameters, calibrated from WIOD, for the baseline case, and then compute the share of jobs in global supply chains.

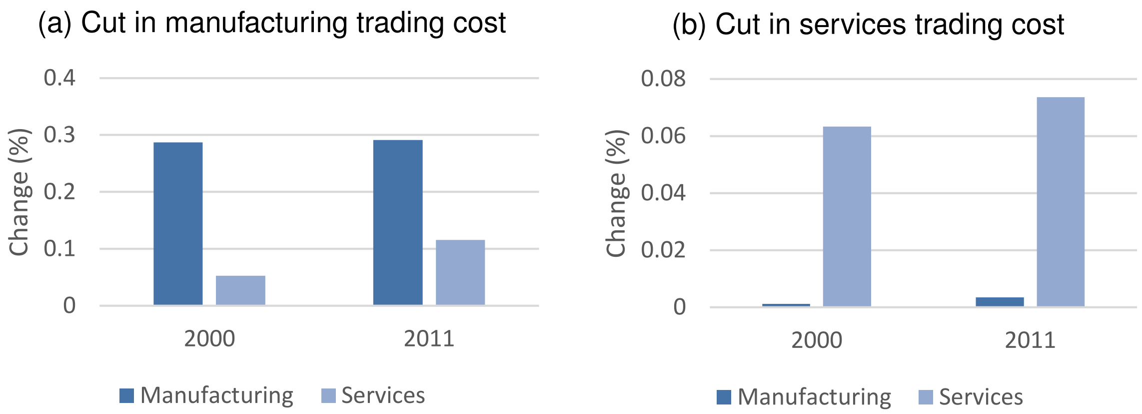
When computing the theoretically predicted impact of the trade policy shock on the number of jobs in global supply chains, we take into account three factors: the adjustment of labour productivity that follows the shock, the adjustment of the Leontief inverse matrix owing to the substitution between production factors and relative price changes, and the adjustment of the demand composition induced by the shock. The resulting post-shock share in global-supply-chain-related jobs along with the model-estimated change in total employment can then be used to derive the theoretically predicted change in the number of global-supply-chain-related jobs.

2.4 THEORETICAL PREDICTIONS

The trade policy shock that we simulate is a one percentage point reduction in trading cost on manufacturing (services) imports. This shock reduces the cost of the imported good (service), which in turn will propagate to all other prices, causing a price decrease as well as a relative re-alignment of prices. The drop in prices raises overall demand given the assumption of constant nominal spending. In contrast, demand for intermediates and final output shifts due to relative price changes along with the elasticities of substitution between different inputs or products.

Figure 1 presents the impact of the trade policy shock on global-supply-chain-related manufacturing and services jobs in the country whose exports are targeted with the tariff, based on the calibrated solution to the model. Panel a (b) shows the resulting impact of a cut in manufacturing (services) trading cost, using the two alternative calibrations based on data from 2000 and 2011 respectively.

Figure 1: Theoretical impact of reduced trading costs on jobs in global supply chains, by sector



*Note: Panel a (b) shows the impact of a reduction in trading cost on manufactured goods (services), on global-supply-chain-related jobs in the manufacturing sector (dark blue) and the services sector (light blue).

Figure 1 consists of different elasticities, each representing the response of global-supply-chain-related jobs in a sector to changes in trading costs in the same or the other sector. Let us denote the number of global-supply-chain-related jobs in manufacturing (services) as Job_m (Job_s) and the manufacturing (services) trading cost as τ_m (τ_s). Then we can define:

$$\varepsilon_{mm} = \frac{\partial Job_m}{\partial \tau_m}\frac{\tau_m}{Job_m}; \quad \varepsilon_{sm} = \frac{\partial Job_s}{\partial \tau_m}\frac{\tau_m}{Job_s};$$

$$\varepsilon_{ms} = \frac{\partial Job_m}{\partial \tau_s}\frac{\tau_s}{Job_m}; \quad \varepsilon_{ss} = \frac{\partial Job_s}{\partial \tau_s}\frac{\tau_s}{Job_s}$$

Based on the results shown in Figure 1, we can derive five testable hypotheses on the relationship between these elasticities:

Hypothesis 1. *A reduction in foreign trading barriers on domestic exports from sector m (s) increases domestic jobs in that same sector m (s), such that $\varepsilon_{mm} < 0$ and $\varepsilon_{ss} < 0$. This effect is referred to as own-sector effect.*

The own-effect in the exporting sector is driven by the drop in the price of the exported good or service, which increases foreign demand and in turn stimulates job creation.

Hypothesis 2. *A reduction in foreign trading barriers on domestic exports from sector m (s) increases domestic jobs also in the other sector s (m), such that $\varepsilon_{ms} < 0$ and $\varepsilon_{sm} < 0$. This effect is referred to as cross-sector effect.*

Hypothesis 3. *The cross-sector effect is smaller than the own-sector effect, such that $\mid \varepsilon_{ms} \mid < \mid \varepsilon_{ss} \mid$ and $\mid \varepsilon_{sm} \mid < \mid \varepsilon_{mm} \mid$.*

The cross-sector effect in the other sector than the exporting sector is mainly driven by two factors. First, the other sector supplies inputs to the directly affected exporting sector. Additionally, substitution effects for intermediate and final output occur as the price of the exported good or service falls.

Hypothesis 4. *The cross-sector effect relative to the own-sector effect is smaller when services trade costs are reduced than when manufacturing trade costs are reduced, such that $\frac{\varepsilon_{ms}}{\varepsilon_{ss}} < \frac{\varepsilon_{sm}}{\varepsilon_{mm}}$.*

The relative importance of the cross-sector effect depends on the extent to which the exporting sector uses intermediate inputs from the other sector in its production. The manufacturing sector uses relatively more services inputs than the other way round, which in turn results in larger cross-effects of services trade liberalization.

Hypothesis 5. *The cross-sector effect becomes larger over time, relative to the own-sector effect, such that $(\frac{\varepsilon_{ms}}{\varepsilon_{ss}})^{2011} > (\frac{\varepsilon_{ms}}{\varepsilon_{ss}})^{2000}$ and $(\frac{\varepsilon_{sm}}{\varepsilon_{mm}})^{2011} > (\frac{\varepsilon_{sm}}{\varepsilon_{mm}})^{2000}$.*

The increasing importance of the cross-sector effect over time is mainly due to the increased utilization of services inputs in the manufacturing sector, but also due to an increased utilization of manufacturing inputs in services production. In other words, production linkages between sectors have generally increased over time and, in particular, between the two years used for calibration, 2000 and 2011.

The simulation analysis underlines the importance of using jobs in global supply chains as opposed to, for example, gross exports for the analysis in this paper. Gross exports increase enormously in the exporting sector that directly benefits from lower trading costs, thereby largely overstating the actual impact on the economy. In contrast, gross exports in the other sector rise by only a relatively small amount, leading to a severe underestimation of the cross-sector effects in the economy. For illustration purposes, consider the results of the cut in manufacturing trading costs for 2011, shown in panel (a) of Figure 1. If we calculate the ratio of the increase in global-supply-chain-related jobs in manufacturing relative to the increase in global-supply-chain-related jobs in services, we obtain a number that is 2.5. In comparison, the ratio of the increase in gross manufacturing exports relative to the increase in gross services exports, induced by the cut in manufacturing trading costs, reaches a value of almost 10.

3 Data and empirical methodology

This section presents the estimation methodology that we use to test the five hypotheses derived in the previous section from the theoretical model. The empirical model analyses to what extent trade barriers can explain the number of jobs in one country that are dependent on global exports to a particular export destination. To illustrate, the empirical model examines whether trade barriers contribute to explaining, for example, why the number of French jobs that are related to global exports to Germany is different from the number of French jobs related to global exports to Bulgaria, and that these two numbers are yet different from the number of Indian jobs related to global exports to Germany. There is indeed a large variation in the number of global-supply-chain-related jobs across different country-destination pairs (Kizu et al., 2016).

3.1 Estimation methodology

The following equations are estimated with OLS, seperately for global-supply-chain related jobs in manufacturing and in services:

$$\log(Job_{ijt,m}) = \beta_1 \tau_{ijt,m} + \beta_2 \tau_{jt,s} + X'_{it,m}\gamma_1 + X'_{it}\gamma_2 + X'_{jt}\gamma_3 + X'_{ijt}\gamma_4 + \alpha + \epsilon_{ijt} \quad (19)$$

$$\log(Job_{ijt,s}) = \beta_1 \tau_{jt,s} + \beta_2 \tau_{ijt,m} + X'_{it,s}\gamma_1 + X'_{it}\gamma_2 + X'_{jt}\gamma_3 + X'_{ijt}\gamma_4 + \alpha + \epsilon_{ijt} \quad (20)$$

where i stands for the country in which the jobs are located, and j is the export destination on which jobs in country i depend. Subscript m refers to manufacturing, while subscript s refers to services. The model will be estimated using both data pooled over all the sample years, and restricting data to a particular year $t = \bar{t}$.

3.2 Dependent variable

The dependent variables $Job_{ijt,m}$ and $Job_{ijt,s}$ are respectively the total number of manufacturing and services jobs in country i, dependent on global exports to destination j in year t. These jobs have been defined as jobs in global supply chains (ILO, 2015; Kizu et al., 2016). The database that we use, consists of consistent and comparable figures for 40 countries with 40 destinations for the period from 1995 to 2011. These 40 countries and destinations include all EU-27 countries, the United States, Canada, Japan, Australia, Republic of Korea, Taiwan (Province of China), Brazil, Mexico, China, India, Indonesia, the Russian Federation and Turkey. Jobs estimates have been constructed on the basis of production data from WIOD and employment data from the associated Socio-Economic Accounts Database.[5]

For two reasons, the dependent variable corresponds to the absolute number of jobs in a particular country that are dependent on global exports to a particular destination, as opposed to the share of these jobs in total sectoral employment. First, total sectoral employment is country-specific, while the number of jobs in global supply chains is country-destination-specific. The corresponding share hence is not intuitive to interpret, given this difference in dimensions. Second, we would restrict the model unnecessarily if we included total sectoral employment into the denominator of the dependent variable on the left-hand-side of the equation, as we can include total sectoral employment also as explanatory variable on the right-hand-side which is the more flexible set-up.[6]

3.3 Variables of main interest

The main explanatory variables of interest in this regression are $\tau_{ijt,m}$ and $\tau_{jt,s}$, where $\tau_{ijt,m}$ represents barriers to goods trade and $\tau_{jt,s}$ represents barriers to services trade. For each of these variables, we use a set of different measures, without necessarily being exhaustive. The variables that we choose, however, allow us to test the hypotheses we are interested in.

[5] In the empirical analysis of this paper, we only consider estimates for 1995-2011, as estimates available for 2012-13 are produced on the basis of a projection model. In addition, we exclude the estimates for the "rest of the world" as export destination.

[6] $\log \frac{Job}{Tot} = X\beta + \epsilon$ as estimated equation is equivalent to $\log Job = 1 \cdot \log Tot + X\beta + \epsilon$, which is more restrictive than $\log Job = \gamma \cdot \log Tot + X\beta + \epsilon$.

As measures for barriers to goods trade, we include the applied tariff of export destination j against country i, averaged over all goods, into the regression, which we take from the World Bank's WITS Database which was set up in collaboration with UNCTAD. In addition, we also consider the impact of non-tariff barriers to goods trade that are of administrative nature, and include the time needed in country i to export, and the time needed in destination j to import as explanatory variables into the model. These two variables are available from the World Bank's Doing Business Indicators. The time to export and to import refers to the processing time of a shipment, including the time needed for documentary compliance, border compliance and domestic transport.

As measures for barriers to services trade, we use indices of services trade restrictiveness, available from the World Bank, which are specific to export destination j but do not vary by country i. The index is defined on an openness scale from 0, corresponding to openness without any restrictions, to 100, corresponding to complete closure of the market for foreign service providers. As noted in Borchert et al. (2012), the index relies on data collected between 2008 and 2011 and mainly includes policy measures that discriminate against foreign services or service providers. Given the fact that time series information is missing, we only exploit cross-country differences in services trade restrictions. In regressions, where we relate services trade restrictiveness not only to 2011, we assume that services trade restrictions have not changed much over the period of analysis.[7]

Under the General Agreement of Trade in Services (GATS), services trade can occur through the cross-border supply of services (mode 1), the consumption abroad (mode 2), the supply of services through commercial presence (mode 3) and the temporary presence of service-supplying individuals[8] (mode 4). Not only an overall index of services trade restrictiveness is available, but also sub-indices that consider the restrictiveness for each of the modes of services trade separately, except mode 2. We run regressions both on the overall index, as well as on the three available sub-indices. The cross-border supply of services, defined as the supply of a service from one country to another country (mode 1), comes closest to the type of services trade barriers referred to in the theoretical model.

[7] A services trade restrictiveness index for 2014 and 2015 is available from the OECD. Comparing index values for these two years, there is almost no or only very small variation.

[8] A person working for a service provider from and in country A is temporarily present in country B to provide the service. This is unrelated to nationality, i.e. the person could be a national of country B but still be a mode 4 service export from country A to country B when working in country B temporarily.

The coefficients β_1 and β_2 that will be estimated in the manufacturing and services jobs regression are the main coefficients of interest. β_1 captures the "own-sector effect", measuring the impact of barriers to manufactured goods trade on manufacturing jobs and the impact of barriers to services trade on services jobs. β_2 stands for the "cross-sector" effect, measuring the impact of barriers to goods trade on services jobs and the impact of barriers to services trade on manufacturing jobs.

3.4 Control variables

Apart from these main variables of interest, equations (19) and (20) include a range of time-variant or time-invariant control variables. These are in our empirical model country-sector-specific variables, $X'_{it,m}$ and $X'_{it,s}$, country-specific variables, X'_{it}, destination-specific variables, X'_{jt}, or country-destination-specific variables, X_{ijt}.

In order to control for employment trends specific to manufacturing or services, but not necessarily related to global supply chains, we include total sectoral employment in country i where jobs in global supply chains are located, as control variable into the regression. In order to ensure consistency with the estimates of the number of jobs in global supply chains, data are taken from WIOD's Socio-Economic Accounts Database. Moreover, we control for demographics in country i by including the working-age population, available from the UN's Population Division. In countries with a large population, the internal market tends to play a more important role for firms than the export market. For example, the estimates of the number of jobs in global supply chains tends to be relatively small in large countries such as the US or Japan, but relatively large in small countries such as Taiwan (Province of China) or Luxembourg (Kizu et al., 2016).

Similar to standard gravity models of trade, we include a measure of the size of economic activity in both the country in which jobs are located and in the country that serves as the export destination on which jobs depend. As the number of jobs in the country in which jobs are located is sector-specific, we use sectoral value added in country i. Given that these jobs can depend on demand originating from any sector, we also control for the non-sector specific overall GDP in export destination j. Both variables are taken from the World Bank's World Development Indicators database.

The gravity literature suggests further control variables. For one, we include the distance between country i and destination j as control variable. Other variables include dummy variables that indicate contiguity between country i and destination j, and common language, taken from the GeoDist dataset, which in the context of gravity models is a frequently used dataset published by the French research centre CEPII (Mayer and Zignago, 2011). To capture the specificity of the European Union (EU) in production linkages between countries, we moreover construct a dummy variable that indicates whether country i and destination j are both EU member states.

Some of the jobs in global supply chains might be jobs related to production activities that are off-shored by lead firms located in the export destination country. The incentive for firms to engage in off-shoring is likely to depend on the difference in wages between export destination, j, and the country into which jobs are off-shored from the export destination, i. Therefore we calculate a sector-specific relative wage as the ratio of the sectoral wage in country i to the sectoral wage in destination j, which then enters the regression as control variable. The underlying data on wages are taken from WIOD's Socio-Economic Accounts Database.

Some countries may be rather specialized in their global-supply-chain-related activities, while others are more diversified. To take into account the possible impact of the degree of specialization on the number of jobs in global supply chains, we develop a sector-specific Herfindahl concentration index of the number of jobs in global supply chains, specific to each country-destination pair ij. This index is constructed as $\sum_{\sigma \in s} \left(\frac{Jobs_{ijt,\sigma}}{Jobs_{ijt,s}} \right)^2$, where $Jobs_{ijt,\sigma}$ is the country-destination specific number of jobs in global supply chains in subsector σ and $Jobs_{ijt,s}$ is the country-destination specific overall number of jobs in global supply chains in sector s, where s can be manufacturing or services. This Herfindahl concentration index takes on values between $1/N_s$ and 1, where N_s is the number of sub-sectors in sector s. The higher the value of the index, the more concentrated are the jobs in global supply chains, for a given country-destination pair and sector.

Finally, the regressions also include general measures of trade openness from UNCTAD, measured as the sum of exports and imports as a share of GDP, for both country i and destination j. The regressions also control for the level of inward FDI in country i, measured as a share of GDP, from the World Bank's World Development Indicators database.

3.5 Descriptive statistics

Table 2 presents descriptive statistics for all variables that enter the regressions. The number of jobs in global supply chains varies widely, dependent on the country in which jobs are located and the destination on which jobs depend. For example, the minimum value of 2 corresponds to the number of manufacturing workers in Malta whose jobs were dependent on global exports to Latvia in 1995. The maximum value of 19.7 million corresponds to the number of workers in China whose jobs were dependent on global exports to the United States in 2006.

With regards to the trade policy variables, we find that around one third of observations for the goods tariff take the value of zero, which is mainly driven by the country-destination pair combinations within the EU as customs union. The remaining two third of observations has values that are larger than zero, with an average goods tariff of 7.3 per cent. Overall, this results in an average tariff of 4.7 per cent. The average time to import and export is both around 13 days, with maxima in the sample of 41 days in India for importing and 28 days in Romania for exporting. The average index value for services trade restrictiveness is 22.4, on an index defined on the scale between 0 and 100. The average value of the restrictiveness index of mode 1 services trade, which measures restrictions to the cross-border delivery of services, is 25.1, but varies in the sample between 5.4 for Bulgaria as the most liberal country and 70.8 for India as the most restrictive country with regards to mode 1 services trade restrictiveness.

Table 2: Summary statistics for variables that enter regressions

Variable	Level of observation	Mean	Sd.	Min.	Max.	N
Dependent variable						
Number of jobs in GSCs, 000s	$ijst$	69.16	412.4	0.00209	19686	53040
Variables of main interest						
Goods tariff (simple average), per cent	ijt	4.743	5.735	0	62.13	21267
Time to import goods, days	jt	13.34	6.654	5	41	270
Time to export goods, days	it	13.10	5.456	6	28	270
Services trade restrictiveness (Overall), index (0-100)	j	22.40	11.07	11	65.70	32
Services trade restrictiveness (Mode 1), index (0-100)	j	25.12	14.37	5.410	70.75	32
Services trade restrictiveness (Mode 3), index (0-100)	j	21.80	12.59	9.580	69.34	32
Services trade restrictiveness (Mode 4), index (0-100)	j	60.78	12.71	35	95	32
Control variables						
Working-age population, millions	it	77.68	191.8	0.289	1116	680
Sectoral employment, 000s	ist	14127	33671	20.36	290447	1360
Sectoral VA, billion constant 2005 USD	ist	394.1	1081	0.753	9997	1235
GDP, billion constant 2011 international dollar	jt	1422	2517	7.675	15518	663
EU, dummy	ijt	0.271	0.445	0	1	26520
Contiguity, dummy	ij	0.0577	0.233	0	1	1560
Common language, dummy	ij	0.0500	0.218	0	1	1560
Distance, 000 kms	ij	5.158	4.476	0.0596	18.82	1560
GSC jobs concentration, index (0-1)	$ijst$	0.260	0.103	0.115	0.940	53040
Relative wage, ratio	$ijst$	3.038	6.492	0.00999	100.1	37570
Inward FDI, per cent of GDP	it	5.341	12.10	-58.98	173.4	647
Trade openness, per cent of GDP	it/jt	86.85	47.37	14.12	285.3	665

*Notes: For the level of observation, i refers to the country in which jobs are located, j refers to the export destination on which jobs depend, s refers to the sector in which jobs are located and t refers to the year. For example, $ijst$ as level of observation implies that the variable is time-varying at the country-destination-sector level.

4 Empirical results

4.1 Main results on manufacturing jobs

Table 3 shows the impact of foreign trade barriers on domestic manufacturing jobs in global supply chains, using a pooled regression (columns 1-3) as well as a cross-sectional regression for 2011, the latest year for which we have data (columns 4-6). There is strong evidence for an "own-sector effect", where barriers to manufactured goods trade negatively impact manufacturing jobs that are dependent on these trade flows. In all but one specification, we find a statistically significant negative impact of the average goods tariff on related manufacturing jobs. According to the estimates, a one percentage point decrease in the average goods tariff in the export destination country increases the number of related manufacturing jobs by around 1.6-3.4 per cent. These results also hold when including the time to export goods in the country in which jobs are located, and the time to import goods in the destination country (columns 3 and 6), into the regression. The time to export and the time to import goods equally have a negative impact on manufacturing jobs, with one less day corresponding to around 2-3 per cent more jobs.

There is also strong evidence for a "cross-sector effect", where barriers to services trade negatively impact related manufacturing jobs. If the overall services trade restrictiveness in the export destination country is one index point lower, the number of manufacturing jobs in global supply chains increases by 1.4-1.6 per cent (columns 1 and 4). When including sub-indices for the different modes separately, we find a negative impact of services trade restrictiveness for all modes (columns 2, 3, 5 and 6). Mode 1 services trade restrictiveness is the variable that we are particularly interested in, given that this type of services barriers increases costs of the cross-border supply of services, in line with the theoretical model. According to our estimates, a one index point decrease in the export destination's mode 1 services trade restrictiveness increases the number of related manufacturing jobs in global supply chains by 0.2-0.5 per cent.

As for the control variables, results are as expected. The larger the working-age population in a country, the smaller the number of manufacturing jobs in global supply chains. This is because countries with a larger population have a large internal market and extensive internal trade, and are less dependent on exports. The more workers are employed in the manufacturing sector in total, the more global-supply-chain-related jobs are in that sector. Including total manufacturing employment as explanatory variable makes it redundant to include it as part of the dependent variable, which is specified as the logarithm of the absolute number of manufacturing jobs in global supply chains, as opposed to the share of these jobs in total manufacturing employment. Both manufacturing value added in the country in which jobs are located, and GDP in the destination country of exports, have a positive association with the number of manufacturing jobs in global supply chains, in line with results of a standard gravity model of trade.

If the country in which jobs are located and the export destination country are both members of the EU, we find more jobs in global supply chains related to the respective country-destination pair. Also having a common border and a common official language increases the number of related manufacturing jobs in global supply chains. The greater the distance between the country in which jobs are located and the export destination, the smaller the number of manufacturing jobs that depend on this trade relation. General indicators of trade openness in both country and export destination, as well as inward foreign direct investment into the country in which jobs are located, relate positively to the corresponding number of manufacturing jobs in global supply chains.

We also include a measure of the degree to which jobs in global supply chains are concentrated in certain sub-sectors. The concentration measure for manufacturing will, for example, take on relatively low values, in case jobs are distributed more or less equally across different manufacturing sub-sectors. It will take on relatively high values, if most of the manufacturing jobs in global supply chains are in one sub-sector such as garments or chemicals. We find this concentration measure to have a positive impact on the number of jobs in global supply chains, implying that countries with a higher jobs concentration also have a larger number of jobs.

The relative wage, constructed for this regression as the manufacturing wage in the export destination country divided by the manufacturing wage in the country in which jobs in global supply chains are located, has a negative impact on jobs related to the particular country-destination combination. Indeed, some of these jobs might be jobs that are off-shored from the destination country as a result of wage differences, which is expressed in these results.

4.2 Main results on services jobs

Table 4 shows the impact of foreign trade barriers on domestic services jobs in global supply chains, using pooled regressions (columns 1-3) and cross-sectional regressions for 2011 (columns 4-6). We once more find strong evidence for an “own-sector” effect. The estimated impact of overall services trade restrictiveness is negative, where one index point less can be associated with 0.8-1.1 per cent more workers in related services jobs (columns 1 and 4). When including the sub-indices for services trade restrictiveness separately, we only find a negative impact of mode 1 services trade restrictiveness, corresponding to 0.6-1.4 per cent (columns 2-3, 5-6). Restrictions on this type of services trade come closest to the services trade costs modelled in the theoretical part.

Results also hint strongly to the presence of a "cross-sector" effect, when considering the impact of manufactured goods trade barriers on services jobs. The average tariff on manufactured goods has a negative impact on related services jobs in global supply chains in 4 out of the 6 specifications. In the cases in which it is not statistically significant, however, the p-value of the estimated coefficient comes very close to 0.10. The point estimates suggest that a decrease of the goods tariff by one percentage point can be associated with a 3.2-4.1 per cent increase of related services jobs in global supply chains.

The control variables enter the regressions with the expected sign and the interpretation of estimated coefficients is in analogy to the results obtained earlier for manufacturing jobs in global supply chains. Only for sectoral value added, there are now some specifications, where services value added enters the regression with a statistically significant negative coefficient. However, given that the regression also controls for total services employment, the negative coefficient on services value added reflects a negative impact of higher labour productivity in services on the number of services jobs in global supply chains. While this result holds for the regressions that are run on the full sample, it does not prevail when restricting the sample to 2011.

Table 3: Trade barriers and their impact on manufacturing jobs in global supply chains, pooled sample and 2011 sample

Dependent variable: Log(GSC jobs)	(1) Pooled	(2) Pooled	(3) Pooled	(4) 2011	(5) 2011	(6) 2011
Goods tariff (simple average) (ijt)	-0.034***	-0.031***	-0.016***	-0.027***	-0.025***	-0.009
	(0.002)	(0.002)	(0.003)	(0.007)	(0.008)	(0.008)
Time to import goods (jt)			-0.032***			-0.022***
			(0.001)			(0.004)
Time to export goods (it)			-0.018***			-0.030***
			(0.002)			(0.007)
Services trade restrictiveness (Overall) (j)	-0.016***			-0.014***		
	(0.001)			(0.003)		
Services trade restrictiveness (Mode 1) (j)		-0.005***	-0.002***		-0.004**	-0.004**
		(0.000)	(0.001)		(0.002)	(0.002)
Services trade restrictiveness (Mode 3) (j)		-0.011***	-0.007***		-0.010***	-0.007***
		(0.001)	(0.001)		(0.002)	(0.002)
Services trade restrictiveness (Mode 4) (j)		-0.003***	-0.002***		-0.004***	-0.004**
		(0.000)	(0.001)		(0.001)	(0.001)
Log(Working-age population) (it)	-0.547***	-0.548***	-0.512***	-0.327***	-0.329***	-0.551***
	(0.024)	(0.023)	(0.032)	(0.088)	(0.088)	(0.099)
Log(Manufacturing employment) (ist)	1.412***	1.413***	1.461***	1.161***	1.161***	1.449***
	(0.023)	(0.023)	(0.034)	(0.081)	(0.081)	(0.101)
Log(Manufacturing VA) (ist)	0.201***	0.201***	0.122***	0.216***	0.218***	0.147***
	(0.007)	(0.007)	(0.011)	(0.026)	(0.026)	(0.028)
log(GDP) (jt)	0.968***	0.987***	0.927***	0.964***	0.976***	0.955***
	(0.006)	(0.006)	(0.009)	(0.024)	(0.024)	(0.024)
EU (ijt)	0.385***	0.392***	0.290***	0.296***	0.273***	0.342***
	(0.017)	(0.017)	(0.026)	(0.072)	(0.075)	(0.072)
Contiguity (ij)	0.412***	0.398***	0.369***	0.358***	0.337***	0.367***
	(0.028)	(0.028)	(0.039)	(0.108)	(0.108)	(0.109)
Common language (ij)	0.501***	0.487***	0.332***	0.445***	0.435***	0.338***
	(0.026)	(0.026)	(0.041)	(0.108)	(0.108)	(0.113)
Log(Distance) (ij)	-0.588***	-0.596***	-0.688***	-0.671***	-0.686***	-0.708***
	(0.009)	(0.009)	(0.013)	(0.037)	(0.038)	(0.037)
GSC jobs concentration (ijst)	1.619***	1.676***	2.151***	2.048***	2.094***	2.251***
	(0.086)	(0.087)	(0.138)	(0.361)	(0.378)	(0.350)
Relative wage (ijst)	-0.007***	-0.007***	-0.002	-0.017***	-0.017***	-0.012***
	(0.001)	(0.001)	(0.001)	(0.004)	(0.004)	(0.003)
Inward FDI (it)	0.001*	0.001*	-0.000	0.004	0.004	0.005*
	(0.000)	(0.000)	(0.001)	(0.003)	(0.003)	(0.003)
Trade openness (it)	0.002***	0.002***	0.002***	0.002***	0.002***	0.001*
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Trade openness (jt)	0.002***	0.002***	0.000	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	No	No	No
R2	0.91	0.91	0.91	0.91	0.91	0.92
Number of observations	14471	14471	7253	1060	1060	1060

*Notes: ***, ** and * indicate a significance level of 1, 5 and 10 per cent, respectively. Given that the Cook-Weisberg test and the White test strongly reject homoskedasticity in all specifications, robust standard errors are reported in brackets. Explanatory variables marked with (i) are specific to the country in which the jobs are located. Explanatory variables that are marked with (j) are specific to the export desination. Explanatory variables that are marked with (ij) are country-destination specific.

Table 4: Trade barriers and their impact on services jobs in global supply chains, pooled sample and 2011 sample

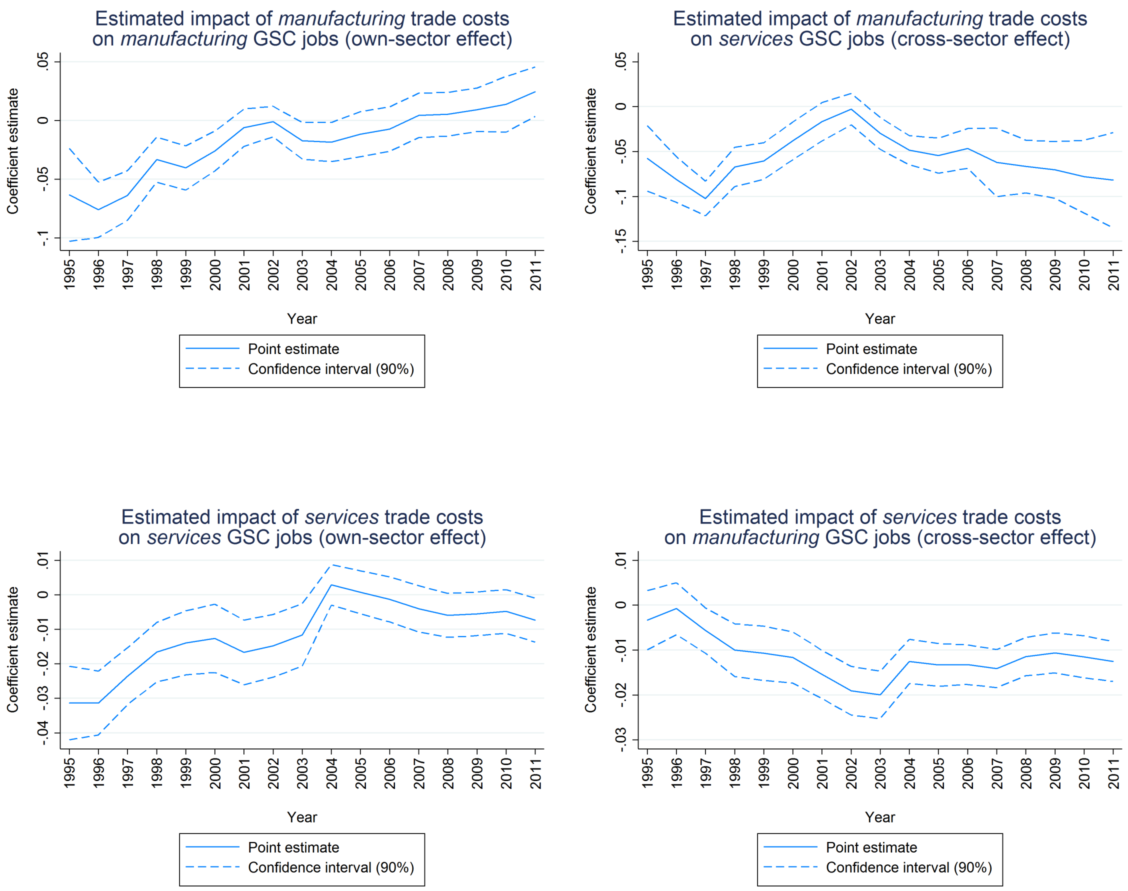
Dependent variable: Log(GSC jobs)						
	(1)	(2)	(3)	(4)	(5)	(6)
	Pooled	Pooled	Pooled	2011	2011	2011
Goods tariff (simple average) (ijt)	-0.032***	-0.033***	-0.033***	-0.035	-0.036	-0.041*
	(0.003)	(0.002)	(0.006)	(0.024)	(0.023)	(0.023)
Time to import goods (jt)			-0.030***			-0.024***
			(0.002)			(0.007)
Time to export goods (it)			-0.024***			-0.024***
			(0.003)			(0.008)
Services trade restrictiveness (Overall) (j)	-0.011***			-0.008*		
	(0.001)			(0.005)		
Services trade restrictiveness (Mode 1) (j)		-0.014***	-0.006***		-0.014***	-0.010***
		(0.001)	(0.001)		(0.004)	(0.004)
Services trade restrictiveness (Mode 3) (j)		0.001	0.002		0.004	0.003
		(0.001)	(0.002)		(0.005)	(0.005)
Services trade restrictiveness (Mode 4) (j)		-0.001	0.001		0.000	0.000
		(0.001)	(0.001)		(0.002)	(0.002)
Log(Working-age population) (it)	0.157***	0.162***	0.534***	0.466***	0.496***	0.662***
	(0.045)	(0.044)	(0.070)	(0.162)	(0.160)	(0.174)
Log(Services employment) (ist)	0.966***	0.983***	0.679***	0.586***	0.576***	0.448**
	(0.057)	(0.057)	(0.087)	(0.200)	(0.196)	(0.209)
Log(Services VA) (ist)	-0.011	-0.029*	-0.071***	0.124*	0.112*	0.078
	(0.018)	(0.018)	(0.026)	(0.065)	(0.064)	(0.064)
log(GDP) (jt)	0.968***	0.975***	0.929***	0.930***	0.941***	0.917***
	(0.008)	(0.009)	(0.013)	(0.034)	(0.034)	(0.035)
EU (ijt)	0.557***	0.608***	0.557***	0.171*	0.251**	0.302***
	(0.023)	(0.023)	(0.039)	(0.097)	(0.105)	(0.108)
Contiguity (ij)	0.199***	0.193***	0.183***	0.103	0.099	0.135
	(0.030)	(0.030)	(0.041)	(0.119)	(0.117)	(0.121)
Common language (ij)	0.449***	0.399***	0.408***	0.513***	0.471***	0.415***
	(0.032)	(0.033)	(0.050)	(0.133)	(0.138)	(0.141)
Log(Distance) (ij)	-0.431***	-0.438***	-0.488***	-0.574***	-0.569***	-0.564***
	(0.013)	(0.013)	(0.020)	(0.061)	(0.060)	(0.059)
GSC jobs concentration (ijst)	0.312***	0.428***	0.693***	0.993*	1.191**	1.424***
	(0.118)	(0.117)	(0.173)	(0.542)	(0.523)	(0.537)
Relative wage (ijst)	-0.018***	-0.004	-0.008	-0.055***	-0.040**	-0.024
	(0.004)	(0.004)	(0.006)	(0.016)	(0.017)	(0.017)
Inward FDI (it)	0.002***	0.002***	0.000	-0.001	-0.001	-0.004
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.004)
Trade openness (it)	0.008***	0.008***	0.008***	0.008***	0.008***	0.009***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Trade openness (jt)	0.005***	0.005***	0.003***	0.003***	0.003***	0.002*
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	No	No	No
R2	0.91	0.92	0.92	0.92	0.92	0.92
Number of observations	6756	6756	3157	463	463	463

*Notes: ***, ** and * indicate a significance level of 1, 5 and 10 per cent, respectively. Given that the Cook-Weisberg test and the White test strongly reject homoskedasticity in all specifications, robust standard errors are reported in brackets. Explanatory variables marked with (i) are specific to the country in which the jobs are located. Explanatory variables that are marked with (j) are specific to the export desination. Explanatory variables that are marked with (ij) are country-destination specific.

4.3 Results over time

We also estimate equations (19) and (20) consecutively for every year that forms part of the sample. This serves on the one hand as a robustness check and allows us to verify whether results obtained are specific to the sample used, or also hold for every year individually. On the other hand, running the regressions by year allows us to obtain year-specific estimates of the coefficients that are part of the model. Based on this information, we can investigate whether own-sector effects and cross-sector effects have become more or less important over time.

Figure 2: Own effects and cross-effects, restricted sample



*Notes: Coefficients are shown with 90-per-cent confidence intervals and are produced with a regression specified as in column 5 of Tables 3 and Tables 4 and run for each year in 1995-2011 separately. Given that the Cook-Weisberg test and the White test strongly reject homoskedasticity in all specifications, confidence intervals are based on robust standard errors.

Figure 2 shows the estimated coefficients over time, obtained for the "own-sector" and the "cross-sector" effects on manufacturing and services jobs. As we would like to compare the evolution of estimated coefficients over time, we restrict the estimation sample of country-destination pairs to those observations for which data are available for the full time period from 1995 to 2011.[9] The overall patterns indicate that cross-sector effects have become less important over time, as suggested by the upward sloping trend in coefficients. In contrast, cross-sector effects have become more important over time, as indicated by the downward sloping trend in coefficients.

4.4 Are the theoretical predictions confirmed empirically?

On the basis of the results obtained, we can verify whether the hypothesis from the theoretical model are confirmed in the empirical analysis. We take as a benchmark the specifications shown in columns 3 and 6 of the regression tables 3 and 4, where the measure for manufacturing trade barriers is the simple average of the goods tariff and the measure for services trade barriers is the mode 1 services trade restrictiveness index. Table 5 reports the relevant coefficients.

Table 5: Estimated "own-sector" and "cross-sector" effects of trade barriers

Symbol	Description	Point estimate: pooled sample	Point estimate: 2011
Effects of manufactured goods trade barriers			
ϵ_{mm}	Effect of manufactured goods trade barriers on manufacturing jobs	-0.016***	-0.009
ϵ_{sm}	Effect of manufactured goods trade barriers on services jobs	-0.033***	-0.041*
$\frac{\epsilon_{sm}}{\epsilon_{mm}}$	Cross-effect relative to own-effect, manufactured goods trade barriers	2.06	4.56
Effects of services trade barriers			
ϵ_{ms}	Effect of services trade barriers on manufacturing jobs	-0.002***	-0.004***
ϵ_{ss}	Effect of services trade barriers on services jobs	-0.006***	-0.010***
$\frac{\epsilon_{ms}}{\epsilon_{ss}}$	Cross-effect relative to own-effect, services trade barriers	0.33	0.40

[9] For this reason, the coefficients for 2011 that are shown in Figure 2 differ from the coefficients for 2011 shown in Tables 3 and 4.

As indicated in the table, we find strong evidence in favour of hypotheses 1 and 2 that state that there are own- and cross-sector effects, which related more (less) trade barriers to less (more) jobs. We find hypothesis 3 to only be confirmed for services trade barriers, while for manufactured goods trade barriers, the cross-sector effect on services jobs is larger than the own-sector effect on manufacturing jobs. The cross-sector effects estimated from the data are hence larger than predicted by the theoretical model, suggesting that supply chain linkages in the real world are more complex than modelled in the theory. For hypothesis 4, we find empirical support, given that the cross-sector effect relative to the own-sector effect is smaller when services trade costs are reduced than when manufacturing trade costs are reduced. When considering the results over time, we find that the cross-sector effect has become more important over time, relative to the own-sector effect, as was shown earlier in Figure 2, which confirms hypothesis 5.

5 Conclusion

The global fragmentation of supply chains implies that changes in production in any sector somewhere in the world can have repercussions on other sectors in the same or in other countries, which would not be directly evident from observing trade flows. This also implies that changes to trade barriers, as long as they cause shifts in demand, also have repercussions on demand and jobs in sectors that are not directly affected by the trade barrier. This paper shows that these cross-sector effects are in fact important and sizeable.

The literature that makes use of CGE models typically provides evidence on the impact of trade policies on the basis of ex-ante simulations rather than on the basis of an ex-post empirical analysis. The literature that provides ex-post empirical evidence on the impact of trade policies typically does not take into account supply chain linkages between different sectors and countries. This paper aims to fill the existing gap in the literature and provides empirical evidence on the impact of trade policies on jobs, taking into account supply chain linkages.

This paper finds that foreign trade barriers imposed on exports of a certain sector have an impact on the number of jobs in that sector that are affected by the barriers ("own-sector effect"). Foreign trade barriers imposed on exports of a certain sector also have an impact on the number of jobs in other sectors, which is driven by supply chain linkages ("cross-sector effect"). Indeed, a decrease in the average goods tariff in the export destination country increases the number of affected manufacturing and services jobs in the exporting country. Similarly, a less restricted cross-border services supply in the export destination country increases the number of affected manufacturing and services jobs in the exporting country. Moreover, we find that the cross-sector effect from a decrease in barriers to services trade on manufacturing jobs is smaller than the cross-sector effect from a decrease in barriers to goods trade on services jobs. Also, the cross-sector effect towards the sector that is not directly targeted is predicted to have become larger over time.

The empirical analysis also reveals some surprising effects. For example, the cross-sector effects estimated from the data are much larger than predicted by the theoretical model. This is especially the case for manufacturing trade barriers, where the cross-sector effect on services jobs is even larger than the own-sector effect on manufacturing jobs. This suggests that the supply chain linkages in the real world are more complex than in a two-sector model. Additionally, changes in trade barriers might have income and distribution effects that imply that the closing conditions used in the model underestimate the cross-sectoral effect. Future research could expand the theoretical model to make its quantitative predictions more in line with the empirical analysis.

By providing evidence on the impact of foreign trade barriers on the domestic labour market, this paper contributes to an informed decision making of policy makers. Viegelahn (2016) points to the importance of labour market institutions and policies for the mitigation of adverse effects that trade policies can have on workers in the context of global supply chains. Such policies can be better targeted if knowledge about the sectors affected by trade policy is improved. Also, policy makers may have a better indication of how their labour market is affected by trade and trade policies, when engaging in trade negotiations.

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Appendix

Linearisation of the theoretical model

The ultimate aim is to identify how a change in trade barriers in one sector by one country affects the output of both sectors in the other country. We therefore solve the model using a first order Taylor approximation around the model solution, where we denote lower-case variables as the percentage deviation of a variable from that solution, i.e. $y = \frac{dY}{Y}$.

The production equation yields

$$
\begin{aligned}
Y_i^{-\frac{1}{\zeta_i}} dY_i &= \alpha_{i,m}^{\frac{1}{\zeta_i}} X_{i,m}^{-\frac{1}{\zeta_i}} dX_{i,m} + \alpha_{i,s}^{\frac{1}{\zeta_i}} X_{i,s}^{-\frac{1}{\zeta_i}} dX_{i,s} + (1 - \alpha_{m,i} - \alpha_{s,i})^{\frac{1}{\zeta_i}} L_i^{-\frac{1}{\zeta_i}} dL_i \\
\Leftrightarrow y_i &= \bar{\alpha}_{m,i} x_{i,m} + \bar{\alpha}_{m,i} x_{i,s} + (1 - \bar{\alpha}_{m,i} - \bar{\alpha}_{s,i}) l_i \qquad (21)
\end{aligned}
$$

where $\bar{\alpha}_{i,m} = \left(\alpha_{i,m} \frac{Y_i}{X_{i,m}}\right)^{\frac{1}{\zeta_i}} \frac{X_{i,m}}{Y_i}$ is the share of manufacturing intermediates in production, and $\bar{\alpha}_{i,s} = \left(\alpha_{i,s} \frac{Y_i}{X_{i,s}}\right)^{\frac{1}{\zeta_i}} \frac{X_{i,s}}{Y_i}$ is the share of services intermediates.

Optimality conditions for firms are

$$x_{i,m} = -\zeta_i p_{x,m} + \zeta_i p_{y,i} + y_i \qquad (22)$$

$$x_{i,s} = -\zeta_i p_{x,s} + \zeta_i p_{y,i} + y_i \qquad (23)$$

$$l_i = -\zeta_i w_i + \zeta_i p_{y,i} + y_i \qquad (24)$$

For intermediates, we obtain

$$m_{i,d} = -\phi_i p_{m,i,d} + \phi_i p_{x,i} + x_i \qquad (25)$$

$$m_{i,f} = -\phi_i p_{m,i,f} + \phi_i p_{x,i} + x_i \qquad (26)$$

$$p_{x,i} = \bar{\beta}_i p_{m,i,d} + (1 - \bar{\beta}_i) p_{m,i,f} \qquad (27)$$

where $\bar{\beta}_i = \beta_i \left(\frac{P_{m,i,d}}{P_{x,i}}\right)^{1-\phi_i}$ is the weight of domestic products in the price basket of intermediate inputs.

For consumption, we obtain

$$c_{i,d} = -\sigma_i p_{c,i,d} + \sigma_i p_{c,i} + c_i \qquad (28)$$

$$c_{i,f} = -\sigma_i p_{c,i,f} + \sigma_i p_{c,i} + c_i \qquad (29)$$

$$p_{c,i} = \bar{\gamma}_i p_{c,i,d} + (1 - \bar{\gamma}_i) p_{c,i,f} \qquad (30)$$

where $\bar{\gamma}_i = \gamma_i \left(\frac{P_{c,i,d}}{P_{c,i}}\right)^{1-\sigma_i}$ is the weight of domestic products in the overall consumption price basket.

The price equalities are

$$p_{c,i,d} = p_{y,i} \tag{31}$$

$$p_{m,i,d} = p_{y,i} \tag{32}$$

$$p_{c,i,f} = p^*_{y,i} + \tau_i \tag{33}$$

$$p_{m,i,f} = p^*_{y,i} + \tau_i \tag{34}$$

The resource constraints imply

$$y_i = \frac{C_{i,d}}{Y_i} c_{i,d} + \frac{C^*_{i,f}}{Y_i} c^*_{i,f} + \frac{M_{i,d}}{Y_i} m_{i,d} + \frac{M^*_{i,d}}{Y_i} m^*_{i,f} \tag{35}$$

$$y^*_i = \frac{C^*_{i,d}}{Y^*_i} c^*_{i,d} + \frac{C_{i,f}}{Y^*_i} c_{i,f} + \frac{M^*_{i,d}}{Y^*_i} m^*_{i,d} + \frac{M_{i,d}}{Y^*_i} m_{i,f} \tag{36}$$

$$x_i = \frac{X_{m,i}}{X_i} x_{m,i} + \frac{X_{s,i}}{X_i} x_{s,i} \tag{37}$$

The first closing assumptions assumes that total spending on consumption of both manufactures and services remains constant, meaning that $\Delta P_{c,i} C_i = 0$ for both $i = [m, s]$. This implies

$$p_{c,i,d} + c_{i,d} = - r_{f,i}(p_{c,i,f} + c_{i,f}) \tag{38}$$

where we define $r_{f,i} = \frac{P_{c,i,f} C_{i,f}}{P_{c,i,d} C_{i,d}}$ as the ratio of nominal spending on foreign over domestic products. Using above relationship, the price equalities and combining (28) and (29), we derive the functions of the response of consumption of domestic and foreign products as a function of the price of output:

$$c_{i,d} = - \frac{\sigma_i + \frac{1}{r_{f,i}}}{1 + \frac{1}{r_{f,i}}} p_{y,i} - \frac{1 - \sigma_i}{1 + \frac{1}{r_{f,i}}} (p^*_{y,i} + \tau_i) \tag{39}$$

$$c_{i,f} = - \frac{1 - \sigma_i}{1 + r_{f,i}} p_{y,i} - \frac{\sigma_i + r_{f,i}}{1 + r_{f,i}} (p^*_{y,i} + \tau_i) \tag{40}$$

Demand for intermediates of each type is given by

$$x_m = \frac{X_{m,m}}{X_m} \left(-\zeta_m p_{x,m} + \zeta_m p_{y,m} + y_m\right) + \frac{X_{s,m}}{X_m} \left(-\zeta_s p_{x,m} + \zeta_s p_{y,s} + y_s\right) \tag{41}$$

$$x_s = \frac{X_{m,s}}{X_s} \left(-\zeta_s p_{x,s} + \zeta_s p_{y,s} + y_s\right) + \frac{X_{s,s}}{X_s} \left(-\zeta_m p_{x,s} + \zeta_m p_{y,m} + y_m\right) \tag{42}$$

These equations are used in (25) and (26) to determine $m_{i,d}$ and $m_{i,f}$ as a function of prices and sectoral output. Using $p_{x,i} = \bar{\beta}_i p_{y,i} + (1-\bar{\beta}_i)(p^*_{y,i} + \tau_i)$, we can derive

$$\begin{aligned} m_{m,d} = &- \phi_m p_{y,m} + \phi_m \left(\bar{\beta}_m p_{y,m} + (1-\bar{\beta}_m)(p^*_{y,m} + \tau_m)\right) \\ &+ \frac{X_{m,m}}{X_m}\left(-\zeta_m \left(\bar{\beta}_m p_{y,m} + (1-\bar{\beta}_m)(p^*_{y,m}\right) + \zeta_m p_{y,m} + y_m\right) \\ &+ \frac{X_{s,m}}{X_m}\left(-\zeta_s \left(\bar{\beta}_m p_{y,m} + (1-\bar{\beta}_m)(p^*_{y,m}\right) + \zeta_s p_{y,s} + y_s\right) \end{aligned} \quad (43)$$

$$\begin{aligned} m_{m,f} = &- \phi_m (p^*_{y,m} + \tau_m) + \phi_m \left(\bar{\beta}_m p_{y,m} + (1-\bar{\beta}_m)(p^*_{y,m} + \tau_m)\right) \\ &+ \frac{X_{m,m}}{X_m}\left(-\zeta_m \left(\bar{\beta}_m p_{y,m} + (1-\bar{\beta}_m)(p^*_{y,m}\right) + \zeta_m p_{y,m} + y_m\right) \\ &+ \frac{X_{s,m}}{X_m}\left(-\zeta_s \left(\bar{\beta}_m p_{y,m} + (1-\bar{\beta}_m)(p^*_{y,m}\right) + \zeta_s p_{y,s} + y_s\right) \end{aligned} \quad (44)$$

$$\begin{aligned} m_{s,d} = &- \phi_s p_{y,s} + \phi_s \left(\bar{\beta}_s p_{y,s} + (1-\bar{\beta}_s)(p^*_{y,s} + \tau_s)\right) \\ &+ \frac{X_{m,s}}{X_s}\left(-\zeta_s \left(\bar{\beta}_s p_{y,s} + (1-\bar{\beta}_s)(p^*_{y,s}\right) + \zeta_s p_{y,s} + y_s\right) \\ &+ \frac{X_{s,s}}{X_s}\left(-\zeta_m \left(\bar{\beta}_s p_{y,s} + (1-\bar{\beta}_s)(p^*_{y,s}\right) + \zeta_m p_{y,m} + y_m\right) \end{aligned} \quad (45)$$

$$\begin{aligned} m_{s,f} = &- \phi_s (p^*_{y,s} + \tau_s) + \phi_s \left(\bar{\beta}_s p_{y,s} + (1-\bar{\beta}_s)(p^*_{y,s} + \tau_s)\right) \\ &+ \frac{X_{m,s}}{X_s}\left(-\zeta_s \left(\bar{\beta}_s p_{y,s} + (1-\bar{\beta}_s)(p^*_{y,s}\right) + \zeta_s p_{y,s} + y_s\right) \\ &+ \frac{X_{s,s}}{X_s}\left(-\zeta_m \left(\bar{\beta}_s p_{y,s} + (1-\bar{\beta}_s)(p^*_{y,s}\right) + \zeta_m p_{y,m} + y_m\right) \end{aligned} \quad (46)$$

This set of equations, combined with the consumption equations (39) and (40), can be inserted into the resource constraints (35) and (36) to obtain a sytem of 4 equations with the variables y_mm y_s, y^*_m and y^*_s as functions of the prices p_m, p_s, p^*_m and p^*_s as well as the exogenous trade costs τ_i. We combine these with the production function (21) as well as the first order condition for labour, (4). Furthermore, the simple wage rule implies

$$w_i = \rho_w p_{y,i}. \quad (47)$$