Two-Country Dynamic Model of Trade with Heterogeneous Firms and Comparative Advantage

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Contribution to the Project

The research paper will analyze the dynamic effects of globalization on labor market outcomes. The results will form the basis for the analysis of policy instruments to compensate the losers of globalization.

Two-Country Dynamic Model of Trade with Heterogeneous Firms and Comparative Advantage

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June, 2013

We develop a dynamic trade model with comparative advantage, heterogeneous firms and workers and endogenous firm entry to study wage inequality during the adjustment to trade liberalization. We find that trade liberalization increases wage inequality both in the short run and in the long run. In the short run, wage inequality is mainly driven by inter-sectoral wage inequality, while in the long run, wage inequality is driven by an increase in the skill premium. It is not a good idea to exclude certain sectors from trade liberalization, because that greatly reduces the benefits of trade liberalization, while failing to protect vulnerable workers.

Keywords: trade liberalization; wage inequality; adjustment dynamics

JEL Classification: E24, F11, F16, J62

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1 Introduction

Trade liberalization can lead to higher welfare by allowing firms and workers to be put into more productive uses. However, to take advantage of these benefits both firms and workers need to be reallocated from the sectors with comparative disadvantage to the sectors with comparative advantage. This reallocation costs time and resources and is at the heart of popular concern about trade liberalization. In this paper we present a model with firm and worker heterogeneity and study the transitional dynamics after a reduction in trade barriers, with a special focus on two kinds of wage inequality, the wage inequality between skilled and unskilled workers and the wage inequality across sectors.

The increase in wage inequality in many developed countries over the past decades and its sources have been subject to a lively debate in the economic literature. Until recently the dispute seemed to be settled in favor of skill-biased technological change as being the main contributor to rising wage inequality (see Katz and Autor (1999)). However, while traditionally the trade of a developed country was mainly with other developed countries, the recent enormous rise in trade with low-income countries (most notably China and India) has brought a shift in the structure of trade. This shift in the structure of trade is associated with fears that low-skilled workers from developed countries might lose out from competition with workers from developing countries.

And indeed, Autor et al. (2013) show that increased trade with China goes hand in hand with a decrease in the share of manufacturing employment and that local labor markets that are exposed to Chinese imports suffer higher unemployment and lower wages. In a similar vein, Ebenstein et al. (2009) find wages growing more slowly in sectors exposed to more import penetration, thus giving rise to increased wage inequality. Figure 1 shows that for the EU, too, trade with China has increased enormously while manufacturing employment has decreased.[1]

A comprehensive study of wage inequality should, in our view, contain the following features: i) comparative advantage to study the tension between shrinking, comparative disadvantage sectors and expanding, comparative advantage sectors; ii) skilled and unskilled labor to study changes in the skill premium; iii) adjustment dynamics, because the structure of the economy is unlikely to change over night iv) adjustment costs of labor, because it takes time and resources to switch sectors; v) firm heterogeneity, endogenous firm entry and selection into export markets, because these features have been shown to be important ingredients of international trade.

In this paper we present a model that takes account of each aspect. The model of Bernard et al. (2007) (BRS henceforth) consists of two countries, two factors and two sectors, introducing comparative advantage into the heterogeneous firm model of Melitz (2003). It thus offers a framework that is rich enough to capture points i), ii) and v) above. However, their analysis is restricted to the steady state and thus ignores adjustment problems. To be able to model adjustment dynamics we develop a dynamic version of BRS along the lines of Ghironi and Melitz (2005) (GM henceforth).

In our model, entering firms need to pay a sunk entry cost in order to enter either of two sectors (one skill-intensive, one unskilled-intensive). Upon entering they draw their productivity from a Pareto distribution. In contrast to Melitz (2003), but in line with GM, firms do not have to pay fixed production costs, and therefore

[1] The import penetration ratio is defined as the host country's imports from China divided by the total host country's expenditure on goods, measured as host gross output plus host imports minus host exports. The share of working-age population employed in manufacturing is defined as the number of people employed in manufacturing divided by the number of working-age people employed (16-64 years old). The source of data is Eurostat.

all newly entering firms take up production. However, firms have to pay a fixed cost of exporting if they want to serve the foreign market. This results in selection into export markets, as in Melitz (2003), i.e., only the most productive firms take up exporting. Additionally, each firm is subject to an exogenous rate of exit. This gives rise to non-trivial but tractable adjustment dynamics after trade liberalization, because existing firms keep operating and are stuck in their sector, while newly entering firms are more flexible.[2] Thus, the reallocation of firms from one sector to the other takes place via the death of old firms. They are replaced by newly entering firms which tend to prefer the expanding sector over the shrinking sector.

Workers can be either skilled or unskilled and employed in either of the two sectors. Concerning the mobility of workers we distinguish various scenarios: i) workers retire at an exogenous rate and get replaced by newly entering workers who are more flexible in their occupational choices; ii) workers might or might not be allowed to switch sectors after paying a randomly distributed migration cost; iii) unskilled workers might or might not be allowed to become skilled after paying a randomly distributed training cost. By simulating various combinations of these mobility assumptions we are able to highlight the role of labor adjustment costs.

In our analysis we focus on the effects of trade liberalization on wage inequality in the rich country.[3] We mainly concentrate on two measures of wage inequality, the wage differential between workers who are in the same skill class but in different sectors and the skill premium, i.e., the wage differential between skilled and unskilled workers. We find that income inequality increases following trade liberalization. In the short run, this is driven by a rise in the wage differential between the skill-intensive and the low-skill-intensive sectors. In the medium to long run, inequality rises due to the rising skill premium in the exporting sector.

We also find the two inequality measures to have different dynamics: the skill premium reacts only slowly while wage inequality across sectors jumps on impact and then slowly recedes. Take the extreme example of completely immobile factors in the short run. Then the supply of labor cannot react to the changes in relative demand. Thus, wages in the exporting sector have to go up relative to the importing sector. The skill premium, however, does not change, because the marginal productivity of skilled and unskilled labor cannot change if their composition in production does not change. In the long run, when labor is mobile, the wage differential between both sectors must disappear, while the skill premium increases due to higher demand for the skill-intensive good.

The skill premium in the skill-intensive sector goes up after trade liberalization. What happens to the skill premium in the unskill-intensive sector depends on the mobility assumptions. Assuming lower mobility for skilled workers than for unskilled workers, as might be justified on the grounds of sector-specific human capital, the skill premium in the comparative disadvantage sector will go down temporarily and only rise after a long adjustment period.

This discussion demonstrates that it is crucial to use a dynamic model in order to be able to distinguish between short run and long run effects. In the long run wage differentials between sectors must vanish but in the short run they are the more important source of wage inequality. This short run effect is completely ignored when analyzing

[2] Burstein and Melitz (2012) show that positive fixed costs of domestic production would eliminate all transitional dynamics in GM. This is not the case in our model due to the slow adjustment of workers. We nevertheless prefer to use the GM assumption that fixed costs of domestic production are zero, due to tractability and the numerical problems discussed by Chaney (2005).

[3] A recent literature analyzes the effects of trade liberalization on unemployment (see, e.g., Egger and Kreickemeier (2009), Felbermayr et al. (2010), Helpman and Itskhoki (2010) or Helpman et al. (2010)). Given the already complicated structure of our model we concentrate on wage inequality and leave the analysis of unemployment for future research.

steady state outcomes only, while the effect of the increased skill premium is exaggerated since it takes a long time to manifest.

Labor mobility assumptions are also critical for identifying the winners and losers from trade liberalization. The conventional concern is that unskilled workers in the import-competing sectors are the biggest losers. However, our results suggest that skilled workers in the low-skill intensive sector suffer the most because they are stuck in the noncompetitive sector with relatively low wages while the low-skilled workers can move and get relatively higher wages in the exporting sector. This result is reinforced when the low-skilled workers have the option to train.[4] Low skilled workers in the import-competing sector are happy to suffer relatively lower wages for a while as they can move to the exporting sector and train to become highly paid skilled workers there. This leads to a fast rising supply of skilled workers in the exporting sector and a fast drain of low skilled labor from the import-competing sector. Both of these imply falling relative productivity of skilled labor in the shrinking sector and a sharply falling skill premium in the medium run. Actually, when the unskilled workers have the option to train, trade liberalization can lead to a fall in wage inequality in the medium run.

We also find that it is not a good idea to restrict trade liberalization to specific sectors, because that considerably reduces the benefits of trade liberalization, while hardly protecting workers from foreign competition. Protecting vulnerable sectors not only reduces the gains from trade but also hurts vulnerable workers even more. The reduction in trade in the import-competing sector that comes with a liberalization of the exporting sector considerably hurts high-skilled workers who have invested their skills in the 'wrong' sector.

Although the sluggish adjustment after trade liberalization agreements is at the heart of popular concerns, the trade literature is relatively silent on this topic. There is a developing literature on dynamic general-equilibrium adjustment to trade shocks but the existing studies use frameworks less rich than ours. Their analysis focuses on particular aspects of adjustment after trade liberalization and ignores important channels that could affect adjustment. Our model is particularly suited to analyzing the interaction and importance of different channels that have been shown to be important for trade and labor market adjustment.

Some recent notable papers include Artuç et al. (2010), Dix-Carneiro (2010) and Coşar (2013), who analyze labor market adjustments after trade liberalization. None of these papers, however, considers firm dynamics, heterogeneous firms and comparative advantage in a two-country setting. Their analysis is restricted to asymmetric trade liberalization scenarios in a small-open economy setting which cannot appropriately account for shifts in prices. We show that both comparative advantage in skilled labor as well as the type of trade liberalization (symmetric versus asymmetric) are critical not only for the size of the gains from trade but also for their distribution across different workers over time.

There is also a large literature that extends traditional theories of international trade such as the Heckscher–Ohlin models to analyze dynamic adjustment after trade liberalization. More recently, Baxter (1992), Chen (1992), Backus et al. (1994), Stokey (1996), Ventura (1997), Jensen and Wang (1997), Mountford (1998), Acemoglu et al. (2002), Atkeson and Kehoe (2000), Bond et al. (2003), Ferreira and Trejos (2006), Gaitan and Roe (2007) and Caliendo (2010) have combined versions of the standard Heckscher–Ohlin model with the standard Neoclassical

[4] Much of this resembles the effects discussed in Larch and Lechthaler (2011), who analyze the effects of trade liberalization on unemployment in the BRS-model. However, they use a static model and thus the dynamic perspective, which is at the heart of this paper, is missing.

growth model or an overlapping generations model. These, however, focus mostly on growth issues.

There are some papers that show that inter-industry reallocation entails labor market costs. Kambourov (2009) contends in the presence of regulated labor markets with high firing costs, the inter-sectoral reallocation of labor after a trade reform is slowed down. He builds a dynamic general equilibrium sectoral model of a small open economy with sector-specifc human capital, firing costs, and tariffs in order to understand the effect of labor market regulations on the effectiveness of trade reforms. Calibrating his model to Chile, Kambourov (2009) makes counterfactual simulations and finds that if Chile did not liberalize its labor market at the outset of its trade reform, then the inter-sectoral reallocation of workers would have been 30 percent slower and as much as 30 percent of the gains in real output and labor productivity in the years following the trade reform would have been lost.

In terms of distributional effects, Helpman and Itskhoki (2009) develop a dynamic version of the two-country, two-sector model of international trade of Helpman and Itskhoki (2010) in which one sector produces homogeneous products, "outside sector", and the other produces differentiated products. The main finding is that when the two sectors are symmetric in terms of their labor markets trade unambiguously raises welfare in both countries.

In a similar vein, Ishimaru et al. (2013) analyze the welfare and unemployment consequences of trade liberalization by incorporating search and matching frictions into a two-factor, two-sector, two-country Heckscher–Ohlin framework, and developing a dynamic general equilibrium model with comparative advantage to study the entire dynamic path from the original steady state to the new steady state after trade reform. Their numerical simulations reveal a U-shaped steady state unemployment locus along the trade tariff rates. In the presence of labor market frictions, the flow of workers within sectors and across sectors generates wage fluctuations. When more workers are employed at the comparative advantage sector, the aggregate income is higher. Unless the fluctuation in the aggregate supply is large enough, the employment effect is absorbed through prices. In the long run, prices are also U-shaped, so that income inequality increases, with the unemployed consuming less after the trade reform. However, these, except for Helpman and Itskhoki (2009), ignore the effects of intra-industry trade, firm dynamics, selection into export markets and firm heterogeneity on wage inequality. Even in Helpman and Itskhoki (2009) the firm heterogeneity is limited to one sector while our model incorporates heterogeneous firms in both sectors which allows us to analyze the importance of each channel for adjustment in each sector and study the interactions between these mechanisms. Our results indicate that firm heterogeneity and slow adjustment of firms matter for the dynamics of labor market adjustment following trade liberalization for the import-competing sector in particular. The second sector in Helpman and Itskhoki (2009) is a numeraire sector of homogeneous good which implies that there is not specialization in their model and the role of comparative advantage on wage inequality cannot be analyzed. In addition, none of these papers incorporates both skilled and unskilled workers which is a key feature of our model that allows us to analyze how skill premia evolve after trade liberalization.

The following section describes the theoretical model. Section 3 describes the calibration. In section 4 we describe our simulations of the symmetric trade liberalization scenarios, while section 5 shows the asymmetric trade liberalization scenarios. Section 6 provides some robustness checks and tries to disentangle some of the effects, Finally, section 7 concludes.

2 Theoretical model

The world consists of two countries Home (H) and Foreign (F). Each country produces two goods, good 1 and 2 which can be traded internationally. The production of each good requires two inputs, skilled and unskilled labor. The sector that produces good 1 is skill intensive i.e. the production of good 1 requires relatively more skilled labor than production of good 2. H has a comparative advantage in producing good 1 because it has a higher relative endowment of skilled labor. Similarly, F has a comparative advantage in sector 2 because of its higher relative endowment of non-skilled labor. To generate a positive skill-premium, we assume that unskilled labor is more abundant than skilled labor in both countries. [5] In the long run, factors of production are assumed to be perfectly mobile between sectors but not across countries. In the short run, workers are imperfectly mobile and we will discuss various scenarios with different degrees of short-run mobility.

2.1 Households

Consumers maximize the present discounted value of utility that they derive from consumption:

$$\sum_{i=0}^{\infty} \gamma^i log\left(C_{t+i}\right), \tag{1}$$

where γ is the subjective discount factor.

They maximize utility subject to a budget constraint that equates expenditures to income.

$$\begin{aligned} &B_{t+1} + Q_t B_{*,t+1} + \frac{\eta}{2}\left(B_{t+1}\right)^2 + \frac{\eta}{2} Q_t \left(B_{*,t+1}\right)^2 + \widetilde{v}_{1t} N_{h,1t} x_{1t+1} + \widetilde{v}_{2t} N_{h,2t} x_{2t+1} + C_t = \\ &(1+r_t)B_t + (1+r_t^*)Q_t B_{*,t} + (\tilde{d}_{1t} + \tilde{v}_{1t}) N_{d,1t} x_{1t} + (\tilde{d}_{2t} + \tilde{v}_{2t}) N_{d,2t} x_{2t} + w_{1t}^s S_{1t} + w_{2t}^s S_{2t} + w_{1t}^l L_{1t} + w_{2t}^l L_{2t} + \tau_{h,t} \end{aligned} \tag{2}$$

Households spend their income on purchases of international risk-free real bonds denominated in home currency (B_{t+1}) and in foreign currency ($B_{*,t+1}$), where the foreign bond holdings are adjusted for the consumption-based real exchange rate $Q_t = e_t P_t^*/P_t$ (units of home consumption per unit of foreign consumption; e_t is the nominal exchange rate, units of home currency per unit of foreign) . Households also pay fees for adjusting their holdings of international bonds $\frac{\eta}{2}\left(B_{t+1}\right)^2 + \frac{\eta}{2} Q_t \left(B_{*,t+1}\right)^2$. We assume convex fees for international portfolio adjustment in order to ensure that our model has a unique steady state and is stationary. Households also purchase shares x_{it+1} of ownership in all domestic firms that operate at time t, $N_{h,it}$, at price $\widetilde{v}_{it}$. Note the economy consists of two sectors of production, sector 1 and 2, indexed by i, and households can hold shares simultaneously in both sectors. When deciding how many shares to purchase, households consider all operating firms including incumbents $N_{d,it}$ and new entrants $N_{e,it}$, which implies that $N_{h,it} = N_{d,it} + N_{e,it}$. However, each period a fraction δ of all firms dies. Thus, only $N_{d,it+1} = (1-\delta)N_{h,it}$ will actually produce and generate profits to pay dividends $\tilde{d}_{it}$. The remainder of the household income is spent on aggregate consumption goods C_t.

Consumers obtain income from interest on their holding of home bonds $(1+r_t)B_t$ and foreign bonds $(1+r_t^*)Q_t B_{*,t}$, dividend income $\tilde{d}_{it}$ from owning shares in firms $N_{d,it}$, capital gains if the value of owned firms went up

[5] What matters for comparative advantage are relative endowments, so skilled labor can be scarce in both countries.

in period t, wage income w_{it}^s and w_{it}^l from supplying skilled S_{it} and unskilled L_{it} labor and an international bond fee rebate $\tau_{h,t} = \frac{\eta}{2}\left(B_{t+1}\right)^2 + \frac{\eta}{2} Q_t \left(B_{*,t+1}\right)^2$. The budget constraint is written in aggregate consumption units.

Households choose $C_t, B_{t+1}, B_{*,t+1}, x_{1t+1},$ and x_{2t+1}. The Euler equations for bond and share holdings are:

$$\left(C_t\right)^{-1}\left(1+\eta B_{t+1}\right) = \gamma E_t\left[\left(C_{t+1}\right)^{-1}\left(1+r_t\right)\right] \tag{3}$$

$$\left(C_t\right)^{-1}\left(1+\eta B_{*,t+1}\right) = \gamma E_t\left[\left(1+r_t^*\right)\left(C_{t+1}\right)^{-1}\left(\frac{Q_{t+1}}{Q_t}\right)\right] \tag{4}$$

$$\widetilde{v}_{1t} = \gamma(1-\delta)E_t\left[\left(\frac{C_{t+1}}{C_t}\right)^{-1}\left(\widetilde{v}_{1t+1} + \tilde{d}_{1t+1}\right)\right] \tag{5}$$

$$\widetilde{v}_{2t} = \gamma(1-\delta)E_t\left[\left(\frac{C_{t+1}}{C_t}\right)^{-1}\left(\widetilde{v}_{2t+1} + \tilde{d}_{2t+1}\right)\right]. \tag{6}$$

The economy consists of two sectors of production and households consume a Cobb-Douglass composite of those two traded goods:

$$C_t = C_{1t}^{\alpha} C_{2t}^{1-\alpha}, \tag{7}$$

where α is the share of good 1 in the consumption basket for both H and F. We can obtain relative demand functions for each good from the expenditure minimization problem of the households. They minimize $P_{1t}C_{1t} + P_{2t}C_{2t}$ subject to equation 7. The implied demand functions are:

$$C_{1t} = \alpha\frac{\lambda_t^1}{P_{1t}}C_t \;\; and \;\; C_{2t} = (1-\alpha)\frac{\lambda_t^1}{P_{2t}}C_t, \tag{8}$$

where λ_t^1 is the Lagrangian multiplier associated with equation 7. It can be proved that $\lambda_t^1 = \left(\frac{P_{1t}}{\alpha}\right)^{\alpha}\left(\frac{P_{2t}}{1-\alpha}\right)^{1-\alpha}$. By the envelope theorem $\lambda_t^1 = P_t$, where P_t is the price index that buys one unit of the aggregate consumption basket C_t.

Goods 1 and 2 are also consumption baskets defined over a continuum of goods Ω_i:

$$C_i = \left[\int_{\omega\epsilon\Omega_i} c_{it}(\omega)^{\frac{\theta-1}{\theta}} d\omega\right]^{\frac{\theta}{\theta-1}}, \tag{9}$$

where $\theta > 1$ is the elasticity of substitution between goods. At any given time, only a subset of goods $\Omega_{it}\epsilon\Omega_i$ is available in each sector. The consumption based price index for each sector is $P_{it} = \left[\int_{\omega\epsilon\Omega_i} p_{it}(\omega)^{1-\theta} d\omega\right]^{\frac{1}{1-\theta}}$ and the household demand for each variety is $c_{it} = \left(\frac{p_{it}}{P_{it}}\right)^{-\theta} C_{it}$. It is useful to redefine these in terms of aggregate consumption units. Define $\rho_{it} \equiv \frac{p_{it}}{P_t}$ and $\psi_{it} \equiv \frac{P_{it}}{P_t}$ as the relative prices for individual varieties and for sector baskets respectively. Then, we can rewrite the demand functions for varieties and sector baskets as $c_{it} = \rho_{it}^{-\theta} C_{it}$ and $C_{it} = \alpha\psi_{it}^{-1} C_t$, respectively.

F households face identical decision problems. For brevity they are not described.

2.2 Labor supply

We consider two versions of the model. First, we make the assumption that the overall endowments of skilled and unskilled workers are exogenously fixed. In the long run workers are perfectly mobile between sectors. This resembles the case of BRS. In the short run, however, adjustment of workers will be slowed by adjustment costs: each worker has to pay a random, idiosyncratic mobility cost in order to be able to switch sectors. Second, we relax the assumption of perfect immobility across skill classes by allowing unskilled workers to train and become skilled by paying idiosyncratic training costs. In both scenarios, we add a constant turnover of workers. Old workers retire at rate s and are replaced by newly entering workers. First we describe the scenario without training and then we focus on the scenario with training.

2.2.1 Worker mobility without training

Skilled workers are free to move between sectors but doing so implies a positive idiosyncratic movement cost which is represented by an idiosyncratic ε_t^s drawn each period from a random distribution $F(\varepsilon^s)$. Unskilled workers can also move between sectors but they draw their mobility cost ε_t^l from a different distribution $H(\varepsilon^l)$. Since skilled and unskilled workers face symmetric mobility decisions, only the problem of the skilled workers is described.

In deciding whether to switch sector we assume that each worker compares the value of being employed in a specific sector with her cost of moving. Whenever, the gain in value from moving is greater than the cost of moving, then the worker will move. Let V_{it}^s be the value of a skilled worker of being employed in sector i, defined as

$$V_{it}^s = w_{it}^s + \gamma(1-s)\left[(1-\eta_{ijt}^s)V_{it+1}^s + \eta_{ijt}^s V_{jt+1}^s\right] - \int_{\varepsilon_{\min}^s}^{1/\bar{\varepsilon}_t^s} \varepsilon_t^s \partial F\left(\varepsilon_t\right), \tag{10}$$

where η_{ijt}^s is probability of moving from sector i to sector j and s is the probability of retiring. The integral measures the expected movement cost. The value from being employed as a skilled worker V_{it}^s is a function of the real wage that the worker will get and the expected future discounted value, adjusted for the probability of survival and averaged over the cases that the worker will choose to stay in the same sector or switch to the other sector.

The worker will move from sector j to sector i if his relative value from being employed in sector i relative to sector j is higher than the moving cost:

$$\frac{V_{it}^s}{V_{jt}^s} > \varepsilon_t^s. \tag{11}$$

Vice versa, a worker in sector i will move to sector j if $\frac{V_{jt}^s}{V_{it}^s} > \frac{1}{\varepsilon_t^s}$. Since moving costs are non-negative, only one of the two equations can be satisfied, i.e., workers move only in one direction**.** Equation 11 defines a threshold, $\bar{\varepsilon}_t^s$, for which a worker is indifferent between switching and not switching the sector

$$\overline{\varepsilon_t^s} = \frac{V_{it}^s}{V_{jt}^s} \tag{12}$$

and the probability of switching sectors is

$$\begin{aligned}\eta^s_{jit} &= F(\max(\overline{\varepsilon_t}^s, \varepsilon^s_{\min})) \\ \eta^s_{ijt} &= F\left(\max\left(\frac{1}{\overline{\varepsilon_t}^s}, \varepsilon^s_{\min}\right)\right)\end{aligned}$$

where η^s_{jit} is probability to switch from sector j to sector i and vice versa for η^s_{ijt}. Only one of the two rates can be positive, the other has to be zero. $\varepsilon^s_{\min}$ is the minimum moving cost that the worker has to pay in order to switch sectors.

Additionally, each period a constant fraction s of workers retires and is replaced by new entrants, Se_{it}. We assume that newly entering workers are flexible in their choices upon entering the labor force. They can choose the sector in which they prefer to work. The decision of newly entering skilled workers is based on their relative payoffs between sectors 1 and 2. If the value in sector 1 is higher than the value in sector 2, then relatively more workers will enter sector 1, but we avoid the extreme assumption that all entering workers flock to one sector. To assure stationarity in the steady state, we have to 'weigh' the payoffs of each sector with the number of workers in that sector, so that the ratio of workers entering each sector is given by:[6]

$$\frac{Se_{1t}/S_{1t}}{Se_{2t}/S_{2t}} = \frac{V^s_{1t}}{V^s_{2t}}.$$

Having characterized the exit and entry behavior of workers, we can now write the laws of motion for skilled and unskilled workers in sector i. The number of skilled workers in sector i at the end of period t is equal to the fraction of surviving workers from last period, composed of the incumbents who did not switch sector, the workers who moved from sector j to sector i and the new entrants, such that

$$S_{it} = (1-s)\left[(1-\eta^s_{ijt})S_{it-1} + \eta^s_{jit-1}S_{jt-1} + Se_{it-1}\right].$$

Under this scenario, the country supply of skilled workers is fixed so that

$$S = S_{1t} + S_{2t}.$$

Finally, in equilibrium the total number of workers that retires has to equal the number of new entrants that survive:

$$sS = (1-s)(Se_{1t} + Se_{2t}).$$

Remember that in the long run workers are fully mobile between sectors. This implies that for each skill class the values in both sectors need to be the same, which implies that there is full wage equalization across sectors at the steady state. This implies that in the long-run skill premia are equal across sectors ($\frac{w^s_1}{w^l_1} = \frac{w^s_2}{w^l_2}$). Skill premia differ across countries because by assumption country H has a higher relative endowment of skilled labor than country F, so that the skill premium in country H is lower in the long run.

[6] If we did not weigh the payoffs, then equalization of payoffs and wages across sectors would only be possible if workers were split equally across sectors.

2.2.2 Worker mobility with training

In this section, we relax the assumption of perfect immobility between skill classes. Unskilled workers of each sector can invest in training to become skilled workers in their sector, but doing so requires paying a positive training cost which is represented by an idiosyncratic ε_t^i drawn each period from a random distribution $\Gamma(\varepsilon^i)$. When deciding whether to invest in training, workers compare their training cost to the relative value of being a skilled worker versus being an unskilled worker in sector i. Unskilled workers in sector i will train if their relative value is higher than their training cost, i.e., if

$$\frac{V_{it}^s}{V_{it}^l} > \varepsilon_t^i. \tag{13}$$

Note that if $\frac{V_{it}^s}{V_{it}^l} < \varepsilon_t^i$, the unskilled worker will prefer not to train. Equation 13 defines a threshold-$\bar{\varepsilon}_t^i$ for which a worker is indifferent between training or not:

$$\bar{\varepsilon}_t^i = \frac{V_{it}^s}{V_{it}^l}, \tag{14}$$

and the probability of training is

$$\eta_{it} = \Gamma\left[\max(\bar{\varepsilon}_t^i), \varepsilon_{\min}^i\right]$$

where $\varepsilon_{\min}^i$ is the minimum training cost that incumbent and newly entering skilled workers have to pay in order to become skilled. Note that these minima are equal across sectors ($\varepsilon_{\min}^1 = \varepsilon_{\min}^2$) and they correspond to the skill premium where each country is initialized ($\varepsilon_{\min}^i = \frac{w_i^s}{w_i^l}$).

Again we assume that each period a constant fraction s of workers retires and is replaced by new entrants. Similar equations as in the previous section apply to govern the entry of new workers. Workers are attracted to the sector with the higher wages, so that relatively more workers will choose the sector with the higher wage. However, since in this section we allow for more mobility, we need more equations that also capture the fact that not only the sector but also the skill class is a matter of choice.

Concerning the comparison of sector per skill class, the same equations as above apply. However, newly entering workers also have to choose their skill class. The decision is analogous to the decision about the sector but we need to take account of the cost of training. Assuming that the minimum cost of training applies to newly entering workers implies:[7]

$$\frac{Se_{it}/S_{it}}{Le_{it}/L_{it}} = \frac{V_{it}^s}{V_{it}^l}\frac{1}{\varepsilon_{\min}^i},$$

Having characterized the exit and entry behavior of workers, we can now write the laws of motion for skilled and unskilled workers. The number of skilled workers in sector i at the end of period t is equal to the fraction of surviving workers from last period, composed of last period incumbents, new entrants and new trainees, such that

$$S_{it} = (1-s)(S_{it-1} + Se_{t-1} + \eta_{it-1}L_{it-1}).$$

The number of unskilled workers in sector i at the end of period t is the fraction of surviving workers from last period, composed of incumbents who did not switch sector or train, workers who switched from sector j and new

[7] Again, this assures stationarity in the steady state.

entrants, such that

$$L_{it} = (1-s)\left[(1-\eta^l_{jit}-\eta_{it})L_{it-1} + \eta_{ijt-1}L_{jt-1} + Le_{it-1}\right].$$

Finally, in equilibrium the total fraction of workers that retires has to equal the fraction of new entrants that survive:

$$sENDOW = (1-s)(Se_{1t} + Le_{1t} + Se_{2t} + Le_{2t}),$$

where $ENDOW = S_t + L_t$ is the total endowment of labor in the H country.

It is important to characterize the new employment payoffs that the different types of workers consider when making their entry and switching decisions. Since skilled workers are not allowed to switch sectors anymore, their employment value from working in sector i in period t is just a function of the real wage that they get and the present discounted value of their future value adjusted for the probability of survival, so that

$$V^s_{it} = w^s_{it} + \gamma(1-s)V^s_{it+1}.$$

The value of unskilled workers has to be adjusted to take account of training:

$$V^l_{it} = w^l_{it} + \gamma(1-s)\left[(1-\eta^l_{ijt}-\eta_{it})V^l_{it+1} + \eta_{ijt}V^l_{jt+1} + \eta_{it}V^s_{it+1}\right] - \int_{\varepsilon^l_{\min}}^{1/\bar{\varepsilon}^l_t} \varepsilon^l_t dH(\varepsilon^l_t) - \int_{\varepsilon^i_{\min}}^{1/\bar{\varepsilon}^i_t} \varepsilon^i_t \partial\Gamma(\varepsilon^i_t).$$

2.2.3 Measures for wage inequality

In order to analyze the effect of trade liberalization on wage inequality, we construct a number in income inequality measures. First we have two measures of wage inequality across sectors. They measure the relative difference in cross sectoral wages for skilled and unskilled workers, so that

$$\begin{aligned} IndexS_t &= \left(\frac{w^s_{1t}}{w^s_{2t}} - 1\right)100, \\ IndexL_t &= \left(\frac{w^l_{1t}}{w^l_{2t}} - 1\right)100. \end{aligned}$$

A rise in either of these indices indicates an increase in cross-sector wage inequality. Note that these indices are zero in steady state but might be different from zero out of the steady state. It is one of the advantages of our dynamic model that it can capture these temporary increases in inequality.

We are also interested in measuring inequality for classes of workers, namely the skill premia per sector and as a country average. The skill premium for sector i is defined as the percentage difference between the wage of skilled and unskilled workers, i.e.,

$$Skill_{it} = \left(\frac{w^s_{it}}{w^l_{it}} - 1\right)100.$$

Before constructing the average skill premium for each country, we define the average wages for skilled workers as $w^s_t = \frac{S_{1t}}{S_t}w^s_{1t} + \frac{S_{2t}}{S_t}w^s_{2t}$, and for unskilled workers as $w^l_t = \frac{L_{1t}}{L_t}w^l_{1t} + \frac{L_{2t}}{L_t}w^l_{2t}$. Then, the aggregate skill premium

for country H is

$$Skill_t = \left(\frac{w_t^s}{w_t^l} - 1\right) 100.$$

Finally, we measure aggregate wage inequality for each country by constructing a theoretical Gini index, which is a standard measure of inequality used in economics. The Gini index measures the extent to which the distribution of wages among the different groups of workers within each country deviates from a perfectly equal distribution. A Gini index of 0 represents perfect equality, while an index of 1 implies perfect inequality. The Gini coefficient is defined as half the relative mean difference of a wage distribution. Before constructing the Gini index, however, we define the average wage income for country H as $w_t = \frac{S_{1t}}{S_t+L_t} w_{1t}^s + \frac{S_{2t}}{S_t+L_t} w_{2t}^s + \frac{L_{1t}}{S_t+L_t} w_{1t}^l + \frac{L_{2t}}{S_t+L_t} w_{2t}^l$. Then, the Gini coefficient for country H is

$$Gini_t = \frac{1}{2w_t}\left(\frac{S_{1t}}{S_t+L_t}\left|w_{1t}^s - w_t\right| + \frac{S_{2t}}{S_t+L_t}\left|w_{2t}^s - w_t\right| + \frac{L_{1t}}{S_t+L_t}\left|w_{1t}^l - w_t\right| + \frac{L_{2t}}{S_t+L_t}\left|w_{2t}^l - w_t\right|\right).$$

The term in the parentheses is a measure of dispersion which calculates the absolute deviations from the average income and weights those by the population shares.

2.3 Production

There are two sectors of production in each country. The production technology is assumed to be Cobb-Douglass in the two inputs of production:

$$Y_{it} = z_i Z S_{it}^{\beta_i} L_{it}^{(1-\beta_i)}, \tag{15}$$

where z_i is firm specific productivity, Z is aggregate productivity, S_{it} and L_{it} are the amount of skilled and unskilled labor used in the production of output in sector i. β_i is the share of skilled labor required to produce one unit of output Y_i in sector i. Sector 1 is assumed to be skill intensive and sector 2 non-skill intensive which implies that $1 > \beta_1 > \beta_2 > 0$. The labor market is assumed to be perfectly competitive which means that the real wages for both skilled and non-skilled labor are equal to the values of their marginal products of labor. Relative labor demand can be described by the following condition:

$$\frac{w_{it}^s}{w_{it}^l} = \frac{\beta_i}{(1-\beta_i)} \frac{L_{it}}{S_{it}}, \tag{16}$$

which says that the ratio of the skilled wage w_{it}^s to the unskilled wage w_{it}^l for sector i is equal to the ratio of the marginal contribution of each factor into producing one more unit of sectoral output. This condition is valid for both sectors.

Firms in each sector are heterogeneous as they produce with different technologies indexed by relative productivity z. Productivity differences across firms translate into differences in the unit cost of production. This cost measured in the units of aggregate consumption C_t is $\frac{(w_{it}^s)^{\beta_i}\left(w_{it}^l\right)^{1-\beta_i}}{zZ_t}$,where $w_{it}^s \equiv \frac{W_{it}^s}{P_t}$ and $w_{it}^l \equiv \frac{W_{it}^l}{P_t}$ are the real wages as described above.

Prior to entry, firms are identical and face a sunk entry cost f_{et} effective units of skilled and unskilled labor equal to $\frac{f_{et}(w_{it}^s)^{\beta_i}\left(w_{it}^l\right)^{1-\beta_i}}{Z_t}$ units of aggregate H consumption. Note that entry costs can differ between sectors due

to different factor intensities and to sectoral wage differentials. Upon entry some firms draw their productivity level z from a common distribution $G(z)$ with support on $[z_{min}, \infty)$. This firm productivity remains fixed thereafter. Since there are no fixed costs of production, all firms produce every period, until they are hit with a death shock, which occurs with probability $\delta\epsilon(0,1)$ in every period. This exit-generating shock is independent of the firm's productivity level, so $G(z)$ also represents the productivity distribution of all producing firms.

Some firms can serve both H and F markets. Exporting goods to F, however, is costly and involves both a melting-iceberg trade cost $\tau_t \geq 1$ as well as a fixed cost f_{xt} (again measured in units of effective skilled and non-skilled labor).[8] We assume that firms hire workers only from their domestic markets to cover these fixed costs. These costs, in real terms, are $\frac{f_{xt}(w_{it}^s)^{\beta_i}\left(w_{it}^l\right)^{1-\beta_i}}{Z_t}$.

All firms face a residual demand curve with constant elasticity in both H and F markets. They are monopolistically competitive and set flexible prices that reflect the proportional markup $\frac{\theta}{\theta-1}$ over marginal cost. Let $p_{d,it}(z)$ and $p_{x,it}(z)$ denote the nominal domestic and export prices of a H firm in sector i. We assume that the export prices are denominated in the currency of the export market. Prices in real terms, relative to the price index in the destination market are then given by:

$$\rho_{d,it}(z) = \frac{p_{d,it}(z)}{P_t} = \frac{\theta}{\theta-1}\frac{(w_{it}^s)^{\beta_i}\left(w_{it}^l\right)^{1-\beta_i}}{zZ_t}, \rho_{x,it}(z) = \frac{p_{x,it}(z)}{P_t^*} = \frac{1}{Q_t}\tau_t\rho_{d,it}(z). \tag{17}$$

The equations for F are similar except for the position of the real exchange rate $\rho_{d,it}^*(z) = \frac{p_{d,it}^*(z)}{P_t^*} = \frac{\theta}{\theta-1}\frac{(w_{it}^{s*})^{\beta_i}\left(w_{it}^{l*}\right)^{1-\beta_i}}{zZ_t^*}$, $\rho_{x,it}^*(z) = \frac{p_{x,it}^*(z)}{P_t} = Q_t\tau_t^*\rho_{d,it}^*(z)$.

Due to the fixed export cost, firms with low productivity levels z may decide no to export in any given period. When making this decision, a firm decomposes its total profit $d_{it}(z)$ (which is returned to households as dividend as specified in the budget constraint) into portions earned from domestic sales $d_{d,it}(z)$ and export sales $d_{x,it}(z)$. All of these profits are expressed in real terms in units of aggregate consumption in the firm's location. Therefore, H firms measure their profits in H consumption C_t units. For an H firm total profits are $d_{it}(z) = d_{d,it}(z) + d_{x,it}(z)$, where

$$d_{d,it}(z) = \frac{1}{\theta}\left(\frac{\rho_{d,it}(z)}{\psi_{it}}\right)^{1-\theta}\alpha_i C_t \tag{18}$$

$$d_{x,it}(z) = \begin{cases} \frac{Q_t}{\theta}\left(\frac{\rho_{x,it}(z)}{\psi_{it}}\right)^{1-\theta}\alpha_i C_t^* - \frac{f_{xt}(w_{it}^s)^{\beta_i}\left(w_{it}^l\right)^{1-\beta_i}}{Z_t}, & \text{if firm z exports} \\ 0 & \text{otherwise.} \end{cases} \tag{19}$$

Note that α_i is the share of good i in the aggregate consumption basket where $\alpha_1 = \alpha$ and $\alpha_2 = 1-\alpha$.

A firm will export if and only if it would earn non-negative profits from doing so. For H firms, this will be the case if their productivity draw z is above some cutoff level $z_{x,it} = \inf\{z : d_{x,it} > 0\}$. We assume that the lower bound productivity z_{min} identical for both sectors and low enough relative to export costs that $z_{x,it}$ is above z_{min}. Firms with productivity between z_{min} and $z_{x,it}$, serve only their domestic market and form a non-traded sector.

[8] The Iceberg trade costs are proportional to the value of the exported product and represent a number of different barriers to trade. These include trade barriers which can be influenced by policy, like restrictive product standards or slow processing of imports at the boarder, and which cannot be influenced by policy, like the costs of transportation. We follow the standard in the literature of modeling trade liberalization as a decrease in the Iceberg trade cost.

2.3.1 Firm Averages

In every period a mass $N_{d,it}$ of firms produces in sector i of country H. These firms have a distribution of productivity levels over $[z_{min}, \infty)$ given by $G(z)$. We assume that those distributions are identical across countries and sectors. Among these firms there are $N_{x,it} = [1 - G(z_{x,it})] N_{d,it}$ exporters. It is useful to define two average productivity levels, an average $\tilde{z}_{d,it}$ for all producing firms in sector i country H and an average $\tilde{z}_{x,it}$ for all H exporters in sector i:

$$\tilde{z}_{d,it} = \left[\int_{z_{min}}^{\infty} z^{\theta-1} dG(z)\right]^{\frac{1}{(\theta-1)}}, \tilde{z}_{x,it} = \left[\int_{z_{x,it}}^{\infty} z^{\theta-1} dG(z)\right]^{\frac{1}{(\theta-1)}}.$$

These productivity averages summarize all the information on the productivity distributions of firms for a given sector and country.

We can redefine all the prices and profits in terms of these average productivity levels. The average nominal price of H firms in the domestic market is $\tilde{p}_{d,it} = p_{d,it}(\tilde{z}_{d,it})$ and for the export market to F $\tilde{p}_{x,it} = p_{x,it}(\tilde{z}_{x,it})$. The price index for sector i at H reflects prices for the $N_{d,it}$ home firms (with average price $\tilde{p}_{d,it}$) and the F exporters to the H market (with average price $\tilde{p}^*_{x,it}$). Then, the price index for sector i in H can be written as $P_{it} = \left[N_{d,it} \left(\tilde{p}_{d,it}\right)^{1-\theta} + N^*_{x,it} \left(\tilde{p}^*_{x,it}\right)^{1-\theta}\right]$. When written in real terms of aggregate consumption units, this expression becomes $\psi_{it} = \left[N_{d,it} \left(\tilde{\rho}_{d,it}\right)^{1-\theta} + N^*_{x,it} \left(\tilde{\rho}^*_{x,it}\right)^{1-\theta}\right]$, where $\tilde{\rho}_{d,it} = \rho_{d,it}(\tilde{z}_{d,it})$ and $\tilde{\rho}^*_{x,it} = \rho^*_{x,it}(\tilde{z}^*_{x,it})$ are the average relative prices of H producers and F exporters in the H market.

We can similarly define $\tilde{d}_{d,it} = d_{d,it}(\tilde{z}_{d,it})$ and $\tilde{d}_{x,it} = d_{x,it}(\tilde{z}_{x,it})$ such that $\tilde{d}_{it} = \tilde{d}_{d,it} + [1 - G(z_{x,it})] \tilde{d}_{x,it}$ is total profits of H firms in sector i adjusted for the share $1 - G(z_{x,it})$ of firms that export.

2.3.2 Firm Entry and Exit

In every period there is an unbounded mass of prospective entrants in both sectors and countries. These entrants are forward looking and correctly anticipate their future expected profits in every period. We assume that entrants at time t only start producing at time t+1 which introduces a one-period time-to-build lag in the model. The exogenous exit shock occurs at the end of the time period after entry and production. Thus, a proportion δ of new entrants will never produce. Prospective entrants in sector i in H in period t compute their expected post-entry value given by the present discounted value of their expected stream of profits $\{\tilde{d}_{is}\}_{s=t+1}^{\infty}$,

$$\tilde{v}_{it} = E_t \sum_{s=t+1}^{\infty} \left[\gamma^{s-t} (1-\delta)^{s-t} \left(\frac{C_s}{C_t}\right)^{-1} \tilde{d}_{is}\right]. \tag{20}$$

This also corresponds to the average value of incumbent firms after production has occurred. Firms discount future profits using the household stochastic discount factor, adjusted for the probability of firm survival $1 - \delta$. Entry occurs until the average firm value is equalized to the entry cost

$$\tilde{v}_{it} = \frac{f_{et} \left(w^s_{it}\right)^{\beta_i} \left(w^l_{it}\right)^{1-\beta_i}}{Z_t}. \tag{21}$$

Finally, we have an accumulation equation for the number of firms:

$$N_{d,it} = (1-\delta)(N_{d,it-1} + N_{e,t-1}). \tag{22}$$

2.3.3 Parametrization and productivity draws

The productivity z is assumed to be distributed Pareto with lower bound z_{min} and shape parameter $k > \theta - 1$: $G(z) = 1 - \left(\frac{z_{min}}{z}\right)^k$. Let $\nu = \left\{\frac{k}{[k-(\theta-1)]}\right\}^{\frac{1}{\theta-1}}$,then average productivities are

$$\tilde{z}_{d,it} = \nu z_{min} \text{ and } \tilde{z}_{x,it} = \nu z_{x,it}. \tag{23}$$

The share of exporting firms in sector i in H is

$$\frac{N_{x,it}}{N_{d,it}} = 1 - G(z_{x,it}) = 1 - \left(\frac{\nu z_{min}}{\tilde{z}_{x,it}}\right)^k. \tag{24}$$

This together with the zero export profit condition for the cutoff firm $\tilde{d}_{x,it} = 0$ imply that average export profits must satisfy

$$\tilde{d}_{x,it} = (\theta - 1)\left(\frac{\nu^{\theta-1}}{k}\right)\frac{f_{xt}\left(w_{it}^s\right)^{\beta_i}\left(w_{it}^l\right)^{1-\beta_i}}{Z_t}. \tag{25}$$

2.4 Market Clearing Conditions, Aggregate Accounting and Trade

Equilibrium conditions require that net supply of home and foreign bonds muse equal zero worldwide, so that $B_{t+1} + B_{t+1}^* = 0$ and $B_{*,t+1} + B_{*,t+1}^* = 0$. Shares in firms cannot be traded internationally which implies that $x_{it+1} = x_{it} = 1$. Imposing these equilibrium conditions and aggregating the home and foreign household budget constraints, implies the following expression for the accumulation of net foreign assets,

$$\begin{aligned} B_{t+1} + Q_t B_{*,t+1} + C_t = (1+r_t)B_t + (1+r_t^*)Q_t B_{*t} + \frac{1}{2}\left(\widetilde{d}_{1t}N_{1t}^d + -Q_t\widetilde{d}_{1t}^* N_{1t}^{*d}\right) + \frac{1}{2}\left(\widetilde{d}_{2t}N_{2t}^d - Q_t\widetilde{d}_{2t}^* N_{2t}^{*d}\right) \\ + \frac{1}{2}(w_{1t}^s S_{1t} - Q_t w_{1t}^{*s} S_{1t}^*) + \frac{1}{2}(w_{2t}^s S_{2t} - Q_t w_{2t}^{*s} S_{2t}^*) + \frac{1}{2}(w_{1t}^l L_{1t} - Q_t w_{1t}^{*l} L_{1t}^*) + \frac{1}{2}(w_{2t}^l L_{2t} - Q_t w_{2t}^{*l} L_{2t}^*) \qquad (26) \\ - \frac{1}{2}\left(\widetilde{v}_{1t}N_{1t}^e + -Q_t\widetilde{v}_{1t}^* N_{1t}^{*e}\right) - \frac{1}{2}\left(\widetilde{v}_{2t}N_{2t}^e - Q_t\widetilde{v}_{2t}^* N_{2t}^{*e}\right) - \frac{1}{2}(C_t - Q_t C_t^*). \qquad (27) \end{aligned}$$

Note that the current account of the Home country is defined as

$$CA_t \equiv B_{t+1} - B_t + Q_t(B_{*,t+1} - B_{*,t})$$

Finally, total revenue in each sector must equal total expenditure on labor:

$$N_{d,it}\left(\frac{\tilde{\rho}_{d,it}}{\tilde{\psi}_{it}}\right)^{1-\theta}\alpha_i C_t + Q_t N_{x,it}\left(\frac{\tilde{\rho}_{x,it}}{\tilde{\psi}_{it}}\right)^{1-\theta}\alpha_i C_t^* + \tilde{v}_{it}N_{e,it} - \tilde{d}_{it}N_{d,it} = w_i^s S_{it} + w_{it}^l L_{it} \tag{28}$$

$$N^*_{d,it}\left(\frac{\tilde{\rho}^*_{d,it}}{\tilde{\psi}^*_{it}}\right)^{1-\theta}\alpha_i C^*_t + \frac{N_{x,it}}{Q_t}\left(\frac{\tilde{\rho}^*_{x,it}}{\tilde{\psi}^*_{it}}\right)^{1-\theta}\alpha_i C_t + \tilde{v}^*_{it}N^*_{e,it} - \tilde{d}^*_{it}N^*_{d,it} = w^{s*}_{it}S^*_{it} + w^{s*}_{it}S^*_{it}, \tag{29}$$

at H and F respectively.

3 Calibration

We interpret periods as quarters and set the household discount rate γ at 0.99 and the inverse of the intertemporal elasticity of substitution at 1 in accordance with log utility in consumption—both standard choices for quarterly business cycle models. We set the elasticity of substitution $\theta = 3.8$ based on the estimates using plant-level U.S. manufacturing data in Bernard et al. (2003). We set the Pareto shape parameter $k = 3.4$ for productivity draws, which ensures that the variance of log productivity is finite: $k > \theta - 1$.

Changing the sunk cost of entry, f_{ei} re-scales the mass of firms in an industry, and, without loss of generality we set $f^i_e = f_e = 1$. We set the minimum value of productivity draws $z_{\min} = 1$. We set the steady-state fixed export cost f_x to equal 23.5 percent of the per-period, amortized flow value of the sunk entry costs, $[1-\gamma(1-\delta)]/[\gamma(1-\delta)]f_e$. This leads to a steady state share of exporting firms of 21 percent. These choices of parameter values are based on GM.

Exit in the model is completely exogenous. We set the size of the exogenous firm exit probability $\delta = 0.025$ to match the U. S. empirical level of 10 percent job destruction per year

To focus on comparative advantage, we assume that all industry parameters except factor intensity (β_i) are the same across industries and countries. We consider symmetric differences in industry factor intensities ($\beta_1 = 0.6, \beta_2 = 0.4$). However, differently from BRS we set country endowments to be asymmetric for the case without training. The reason behind this parametrization choice is that we are interested in analyzing wage inequality and in order to give rise to a long-run skill premium in each country, we need to assume that both H and F are endowed with relatively more unskilled than skilled labor. However, a key contribution of our analysis is the presence of comparative advantage. Therefore, we assume that the H country is endowed with relatively more skilled workers than the F country, so that $S = 900$ and $L = 1100$ for H and $S^* = 500$ and $L^* = 1500$ for F. Note that, in the case where training is allowed the country supply-specific supplies of skilled and unskilled labor become endogenous and only the total labor endowment is fixed where we have $ENDOW = S_t + L_t = 2000$ and $ENDOW^* = S^*_t + L^*_t = 2000$. In order to avoid asymmetry due to demand effects, we set the share of each good in consumer expenditure to equal a half ($\alpha_1 = \alpha_2 = 0.5$).

Our focus of analysis on cross-sectoral mobility are developed countries. Artuç et al. (2010) find that average cross-industry mobility costs are large and very dispersed. Without loss of generality, we set the scale parameter for cross industry mobility costs to be equal across countries such that $\varepsilon^s_{\min} = \varepsilon^{*s}_{\min}$ and $\varepsilon^l_{\min} = \varepsilon^{*l}_{\min}$ but we consider three different scenarios where we increase the degree of cross-sectoral mobility. The first scenario is with the largest mobility costs where $\varepsilon^s_{\min} = \varepsilon^l_{\min} = 5$. In the second scenario, we assume that unskilled workers are more mobile than skilled workers $\varepsilon^s_{\min} = 5$ and $\varepsilon^l_{\min} = 1$. This is the most realistic case since Artuç et al. (2010) find that on average in the US workers with a college degree face higher mobility costs than workers without one. Finally, we

analyze a third case where the cross-industry mobility costs are low for both skilled and unskilled workers such that $\varepsilon^s_{\min} = \varepsilon^l_{\min} = 1$. The scale parameter for sectoral mobility cost distributions is identical across countries and industries and is set to $\kappa = 2$, which implies a highly dispersed distribution.

Finally, we consider a fourth scenario where unskilled workers can pay an idiosyncratic training cost and become skilled workers. We assume that they draw their training cost from a Pareto distribution with a scale parameter $\varepsilon^i_{\min}$ for the H country and $\varepsilon^{*i}_{\min}$ for the F country. These scale parameters are proportional to the long-run skill premia in each country in the case where unskilled workers do not have the option to train. Therefore, $\varepsilon^i_{\min} = \frac{V^s_i}{V^l_i} = 1.30987$ and $\varepsilon^{*i}_{\min} = \frac{V^{*s}_i}{V^{*l}_i} = 2.79926$, where $\varepsilon^i_{\min} < \varepsilon^{*i}_{\min}$ by assumption since the H country is endowed with relatively more skilled labor than the F country. The shape parameter of the training costs is set to $\kappa^{train} = 2$. A full list of the parameters and their values is provided in Table 1.

4 Symmetric trade liberalization scenarios

In this section we describe the dynamic adjustment after a symmetric trade liberalization shock, i.e., the Iceberg trade costs are assumed to decrease for all sectors and countries from 1.3 to 1.2. Naturally, the length of adjustment depends on the ability of workers to move between sectors. In the long run workers are fully mobile so that they have to earn the same wage in both sectors. In the short run, however, adjustment costs can lead to wage differentials between sectors. This effect can only be captured by using a dynamic model that can distinguish between the short run and the long run.

To highlight the role of worker mobility, we will distinguish four different scenarios: i) the first scenario features the slowest adjustment. Here we take the extreme assumption that active workers cannot switch their sectors due to sector-specific skills. In other words, the minimum of the cost function for moving between sectors is assumed to be so high that nobody chooses to switch sector. However, we still have the retirement of older workers who get replaced by newly entering workers. These workers are more flexible because they have not invested in skills yet. ii) In the second scenario we assume that unskilled workers can retrain to switch the sector. We restrict this ability to unskilled workers, because unskilled workers are less likely to have invested in sector - specific skills. iii) In the third scenario we assume that skilled workers can also change the sector. Although the speed of adjustment is different, all of these scenarios will imply the convergence to the same steady state as a static model with perfectly mobile labor between sectors but with perfect immobility between skill classes. iv) In the fourth scenario we relax this assumption by assuming that unskilled workers can invest in training to become skilled workers. In our view scenarios ii) and iv) are the most realistic but the comparison with the other scenarios is useful to understand the role of mobility assumptions. In the following we concentrate on the analysis of the effect of trade liberalization on the country with higher endowment of skilled labor.

4.1 Scenario 1: No active switching

Figure 2 shows the dynamic adjustment of selected variables for the first scenario, where only newly entering workers can choose the sector. After the decrease in trade costs, demand in the import-competing sector goes down, relative to demand in the exporting sector. This increases the wages of workers in the exporting sector

relative to the import-competing sector, for both skilled and unskilled workers. This induces an increase in the number of workers in the exporting sector at the cost of employment in the import-competing sector, but the adjustment is very slow, because all active workers are stuck in the sector where they acquired their skills. Only newly entering workers are allowed to choose their sector of occupation.

The reduction of trade costs makes exports cheaper and thus increases the profits that can be gained from exporting. This has two separate implications. On the one hand existing exporters increase their sales on the foreign market (intensive margin of trade). On the other hand, the share of exporting firms increases. because more firms are able to finance the fixed exporting cost (extensive margin of trade). The share of exporting firms jumps up immediately, because the decision to export is not associated with any sunk investment costs, so that active firms can react immediately to the drop in transport costs. In contrast, the total number of active firms takes a long time to adjust. Remember that in our model firms that only serve the domestic market do not have to pay fixed production costs. Therefore, a firm that has paid the sunk entry costs always makes positive profits. Consequently, firms exit the market only when they are hit by an exogenous death shock. This explains why the number of firms in the import-competing sector decreases only slowly.[9]

Surprisingly, however, the number of firms in the exporting sector also decreases in the short, although it increases in the long run. The reason is that the slow movement of workers makes production very inefficient. There are too many workers in the import-competing sector and too few workers in the exporting sector. Consequently wages in the exporting sector are very high, depressing market entry in the early phases of the transition. In general the transition period appears very long. Note, however, that this scenario yields the longest transition since the assumed mobility of workers is the lowest. Recent results from structural estimations (see, e.g., Dix-Carneiro (2010) and Coşar (2013)) also point towards slow adjustment after trade liberalization shocks.

The focus of our analysis is on wage inequality. Due to restricted mobility in the short run, our model allows for wage inequality along two dimensions: i) a wage differential between the two sectors (see $IndexS$ and $IndexL$); ii) a wage differential between skilled and unskilled workers (the skill premium, see $Skill$). The first of the two wage differentials is due to mobility restrictions in the short run and will go away in the long run. The second exists even in the long run (otherwise workers would not have an incentive to invest in skills).

The drop in transport costs increases demand and, thus, raises the price in the exporting sector relative to the import-competing sector. This has an immediate impact on wages, which rise in line with the prices in the exporting sector relative to the import-competing sector. This is, of course, not only true for skilled workers but also for unskilled workers - both earn now higher wages in the exporting sector than in the import-competing sector, while they were earning the same wage in both sectors in the steady state. This implies that newly entering workers prefer the exporting sector, raising the supply of both skilled and unskilled workers in the exporting sector. This diminishes the sectoral wage differential over time, but due to the low worker mobility, the process takes a very long time. In the new steady state workers again have to earn the same wage in both sectors, so that the distribution of workers across sectors can be stationary. Thus, trade liberalization brings along a temporary increase in wage inequality between the two sectors for both skill classes.

[9] Setting the fixed cost of domestic production equal to zero implies that domestic firms cannot be driven out of the market through the competition from foreign firms. However, it is still true that the competition from foreign firms reduces the demand and thereby the market share of domestic firms.

While the wage differential across sectors peaks on impact and slowly recedes over time, the development of the skill premium is the exact opposite. The wage differential between skilled and unskilled workers within one sector is solely determined by the relative productivity of both kinds of labor, which in turn is determined by their relative input shares. In other words, the skill premium in both sectors can only change when the relative input of skilled and unskilled labor changes. In the short run, thus, the skill premium does not change much because the supply of workers is slow to adjust. In the medium and longer run, the increased demand for the skill-intensive exporting good increases the demand for skilled labor and, thus, increases the skill premium. In the process of moving workers from the import competing sector to the exporting sector, the ratio of unskilled to skilled workers rises in both sectors,[10] and with it the relative marginal product of skilled workers.

In the short run wage inequality increases mainly through the first effect, the increase in sectoral wage dispersion for each skill-class. With the movement of workers from the import-competing sector to the exporting sector, the wage inequality from this source decreases, but the skill premium increases. Thus, in the transition we have two counteracting effects on overall wage inequality. It turns out that the second effect dominates the first effect, so that overall wage inequality increases over time.

Another interesting feature can be found in the disaggregated data of wages. The wage of unskilled workers is overshooting quite substantially. This implies that for the most part of the transition real wages of unskilled workers are actually falling. Compared to the old steady state an unskilled worker always earns a higher wage after trade liberalization. But after the initial adjustment (the big jump in the wage on impact), the workers suffer a prolonged period of real wage losses. Assuming that in reality workers and labor unions have a shorter time horizon when evaluating their gains from trade, it is understandable why unskilled workers tend to perceive themselves as losers of globalization. As time progresses, the initial jump in the real wage is 'forgotten' and the prolonged period of wage declines leads unskilled workers to suffer a loss of wage income due to trade liberalization.

It might seem surprising that there are not any 'real' losers from trade liberalization, i.e., workers who suffer lower wages after trade liberalization than before.[11] After all, as described above, demand for labor in the import-competing sector falls. Why does that not lead to wage drops, at least in the short run? The reason is that there are two counteracting effects. The effect just described is a substitution effect, shifting labor demand from the import-competing sector to the exporting sector. This effect indeed tends to decrease wages in the import-competing sector. Note, however, that there is also an income effect. Trade liberalization reduces the costs of trade and makes production more efficient. This effect tends to increase the real wage of all workers.

A note of caution is expedient here. Being a 'real' model, our model can only be used to make inference about real wages. Thus, our model mixes the effects of trade liberalization on nominal wages and on nominal prices. The real wage can rise because the nominal wage rises or because the nominal price drops. The real wage can rise even when the nominal wage drops, if the ensuing drop in nominal prices is even larger. In terms of the income and substitution effects discussed in the paragraph above, the substitution effect tends to lower nominal wages in the import-competing sector, while the income effect tends to decrease the overall price level. In the current scenario the income effect is dominant and so real wages go up in each sector, but we will also see scenarios where this is not

[10] This is not necessarily so, but depends on the relative movement of both types of workers. Depending on the calibration and the scenario the skill premium might decrease in the import-competing sector.

[11] This will change in some of the following scenarios

necessarily the case. Let us stress that real wages are the appropriate measure to look at. Even if some workers would suffer nominal wage cuts, if their real wages go up, their welfare goes up, because they can afford to buy more products.

Note that our model allows for unbalanced trade in the short run. In this scenario with symmetric cuts in trade costs and low mobility of workers, this, however, does not play a role. Trade liberalization does not lead to unbalanced trade, not even in the short run.

4.2 Scenario 2: Active switching of unskilled workers

So far we have assumed that only workers newly entering the labor market can choose the sector where they want to work. We will now relax this assumption for the unskilled workers by assuming that they can switch the sector after paying a sector-migration cost, which is drawn each period from a random distribution. For the moment, we restrict this possibility to unskilled workers, because their sector mobility is less likely to be restricted by sector-specific investments in human capital.[12]

Figure 3 shows the results. Naturally, the assumption of increased inter-sectoral mobility for unskilled workers leads to a faster reduction in the sectoral wage differential for unskilled workers following the initial jump on impact. In contrast, the sectoral wage differential for skilled workers appears even larger now. The reason is that the faster migration of unskilled workers relative to skilled workers implies a stronger shift in their respective shares in the production process. This benefits the skilled workers in the exporting sector because the higher number of unskilled workers there increases their productivity. But it hurts the skilled workers in the import-competing sector because the low number of unskilled workers there reduces their productivity. As a result, the sectoral wage differential for skilled workers is even increasing in the short run and recedes only very slowly.

The asymmetric speed of adjustment has also important implications for the skill premium, which, in the short run, now goes in opposite directions in the two sectors. In the exporting sector the skill premium still goes up, and even more so and more quickly than in our baseline scenario, due to the described movement of unskilled workers, which benefits the skilled workers in the exporting sector. In contrast, the skill premium in the import-competing sector now goes down, although in the long run the skill premium in both sectors must be the same.

The faster sector migration of unskilled workers has also implications for firm dynamics. Due to the smaller increase in the unskilled wage in the exporting sector it pays off more to invest into new firms. The total number of firms in the exporting sector still goes down initially but recovers very quickly. After 20 periods the number of active firms is higher then in the old steady state, while this took almost 100 periods in scenario 1.

4.3 Scenario 3: Active switching of skilled and unskilled workers

This scenario allows both unskilled and skilled workers to pay a randomly chosen migration cost to switch the sector. Results are illustrated in figure 4. The results resemble those of scenario 1, but of course the adjustment is much quicker. The sectoral wage differential is receding much faster and the skill premium is rising much faster.

[12] For empirical evidence see, e.g., Greenaway et al. (2000) or Elliott and Lindley (2006b), who find that unskilled workers are much more mobile across sectors than skilled workers. Elliott and Lindley (2006a) confirm this result and argue that this is due to the significant investments of high skilled workers in their specific human capital.

Our measure of overall wage inequality is lower than in scenario 1 in the first periods but then rises much faster.

Due to the faster movement of workers, the adjustment of firms also takes place much faster. The number of firms in the import-competing sector goes down much faster. The number of firms in the exporting sector drops only very briefly and quickly gets on a rising path.

4.4 Scenario 4: Training

In the model of BRS and in our scenarios 1-3 so far it is assumed that the endowments of skilled and unskilled workers are fixed. Although workers are mobile between the two sectors, it is not possible for unskilled workers to become skilled. This is certainly not realistic, so we want to relax this assumption in our fourth scenario.

We model the training decision in a similar way as the sector-migration decision. Each unskilled worker can invest in training to become a skilled worker. The cost of training is drawn each period from a random distribution. In contrast to the cost of sectoral migration, the training cost has a minimum larger than one which restricts access to become high skilled and in this way assures that the skilled wage is higher than the unskilled wage. The assumptions concerning sectoral migration we are using in this scenario are equivalent to scenario 2: unskilled workers can switch sectors, while skilled workers cannot, because of sector-specific skills.

Figure 5 demonstrates that this has dramatic consequences for the transitional dynamics. Naturally, the increased demand in the exporting sector induces some unskilled workers in the exporting sector to invest in their skills, speeding up the increase in the number of skilled workers in the exporting sector. The possibility to train and become skilled in the exporting sector also enhances incentives for unskilled workers in the import-competing sector to switch to the exporting sector. This reduces the productivity of skilled workers in the import-competing sector by even more than in the second scenario, with the consequence that their wage drops sharply after the initial upward jump.

This has the consequence that the skill premium decreases strongly and very persistently in the import-competing sector, while it sharply but only briefly increases in the exporting sector. This implies that some of the skilled workers in the import-competing sector would not have invested in skills before the trade liberalization shock, had they anticipated the development of wages. Note, however, that due to the way we have modelled the training decision, in the long run the skill premium must go back the old steady state level in both sectors. So in contrast to the earlier scenarios, in the long run the higher demand for skills due to trade liberalization materializes in a higher number of skilled workers instead of a higher skill premium. Ignoring training possibilities leads to exaggerated estimates of the skill premium effect of trade liberalization.

Sectoral wage inequality among skilled workers moves as expected, the wage in the exporting sector increases strongly and persistently relative to the wage in the import-competing sector. The development of sectoral wage inequality among unskilled workers is more puzzling. While the wage in the exporting sector jumps relative to the wage in the import-competing sector, this development is soon reversed so that the wage gets higher in the import-competing sector than in the exporting sector. This puzzling result is explained by the option value of unskilled workers. Unskilled workers in the exporting sector have the option to invest in training to become high-skilled workers in the exporting sector. This option is worth a lot in the aftermath of trade liberalization, which makes

the exporting sector very attractive for unskilled workers, who are willing to accept lower wages relative to the import-competing sector to have this option.

The consequences for overall wage inequality are also in stark contrast with the results we had so far. In the short run overall wage inequality increases, but after some time the opposing trends (skill premium rises in one sector and falls in the other; sectoral wage differentials rise for skilled workers but fall for unskilled workers) begin to dominate, so that total wage inequality actually drops in the medium run. By construction, in the long run overall wage inequality does not change (in the long run, the skill premium is fixed and sectoral wage dispersions has to vanish).

Overall, this scenario delivers much more polarizing labor market developments than the previous scenarios, with the skilled workers in the import-competing sector being the biggest losers, due to their investments in the 'wrong' sector.

5 Asymmetric trade liberalization scenarios

It is one of the advantages of having a model with multiple sectors that one can analyze asymmetric trade liberalization scenarios, i.e., scenarios in which only some of the sectors experience a decrease in trade barriers. These kind of scenarios might be appealing for policy makers for at least two reasons. i) It might be easier to negotiate partial trade liberalizations with other countries. ii) Partial trade liberalization might meet lower opposition at home based on the hope that the effects on wage inequality are less severe because vulnerable sectors are spared.

We analyze two different scenarios which we consider realistic. i) It appears plausible that the rich country is more powerful and thus able to push through its preferred agenda, liberalizing trade in the sector where it has its comparative advantage and leaving the other sector untouched. This is our fifth scenario. ii) If the poor country is more powerful it might be able to push for a liberalization strategy that lowers the trade costs for exports of both comparative-advantage industries. This strategy is our sixth scenario and involves the reduction of the costs of exporting the skill-intensive good from the rich country to the poor country and of the costs of exporting the low-skill-intensive good from the poor to the rich country.

In both scenarios, we restrict our analysis to the mobility assumption that we, in line with empirical results from other papers, consider the most realistic, namely assuming that low-skilled workers are more mobile across sectors. We will consider both the case with exogenous shares of skilled workers (analogous to scenario 2 of the previous section), to be comparable to BRS, and the case with sector specific training (analogous to scenario 4).

5.1 Scenario 5: Liberalization of the skill-intensive sector

In this scenario the rich country manages to push through the liberalization of trade in the sector where it has its comparative advantage, i.e., τ_1 and τ_1^* is reduced from 1.3 to 1.2. With this strategy the rich country might hope to gain from increased exports in its comparative advantage sector, while at the same time avoiding stronger competition in the import-competing sector. We show that this reasoning is flawed.

The results are illustrated in figures 6 and 7. Let us first concentrate on the case without training, figure 6. It is immediately evident that low-skilled workers are hard hit in this scenario. Although wages increase a bit on

impact, they soon drop and stay below the old steady state value. The development of exporting firms is also interesting. While the number of exporting firms in the liberalized sector goes up, the number of exporting firms in the not liberalized sector goes down.

Leaving out the import-competing sector from trade liberalization does not seem to protect that sector. It rather seems that this sector suffers from a loss of competitiveness because it cannot gain from the reduction in trade costs. This loss in competitiveness hurts mostly the unskilled workers who are relatively more important in the import-competing sector and thus their wages go down.

The wages of skilled workers in the exporting sector increase smoothly. The wages of skilled workers in the import-competing sector fall below the old steady state value for some time but must rise eventually to catch up with the skilled wage in the exporting sector (remember that in the long run wages have to equalized across sectors). Note, however, that the wage gains for the skilled workers are much smaller than in the scenario were both sectors were liberalized. Thus, it seems that leaving the import-competing sector untouched really takes away a large part of the gains from trade liberalization.

Allowing for endogenous training, as demonstrated in figure 7, has qualitatively similar implications as in our baseline scenario. Trade liberalization increases the demand for skilled workers. This induces more unskilled workers to pay the training cost to become skilled workers. Relative to the scenario without training, the supply of unskilled workers is thus lower, while the supply of skilled workers is higher. Consequently, the wages of unskilled workers are pushed up (relative to the scenario without training), while the wages of skilled workers are pushed down. This implies that skilled workers in the import-competing sector have to endure a prolonged period of wages below the pre-liberalization steady state. In contrast, the push-up in the unskilled wage is large enough so that the wage losses from the previous scenario are turned into wage gains. But again, wage increases are much higher when both sectors are liberalized.

It can be concluded that it is not a good idea to keep the import-competing sector protected from trade liberalization. The gains from trade are considerably reduced while the effects on wage inequality are minor at best. The reduction in trade in the import-competing sector that comes with a liberalization of the exporting sector might even considerably hurt unskilled workers and skilled workers who have invested their skills in the 'wrong' sector.

5.2 Scenario 6: Liberalization of comparative-advantage sectors

In this scenario we assume that both countries agree on a one-sided reduction of trade barriers for exports in their respective comparative advantage sectors, i.e., the poor country allows the rich country to export the products of the skill-intensive sector at lower costs (τ_1 goes down from 1.3 to 1.2), while the rich country allows the poor country to export the products of the low-skill-intensive sector at lower cost (τ_2^* goes down from 1.3 to 1.2).

The results for exogenous endowments of skilled and unskilled workers are illustrated in figure 8. This scenario yields the most dramatic effects so far. While the wage increases of skilled workers in the exporting sector are higher than in all previous scenarios, the wages of skilled workers in the import competing sector and the wages of unskilled workers in both sectors go down (the wage of unskilled workers in the exporting sector jumps up on

impact but becomes negative very quickly). The drop in wages of high-skilled workers in the import-competing sector is very large and very persistent. The drop in unskilled wages is even permanent. Note that the average wage of skilled workers still exhibits a strong increase, so looking only at the aggregates ignores the huge differentials revealed at a more disaggregate level. In line with these developments all our measures of wage inequality increase more sharply than in our baseline scenario.

In this scenario the import-competing sector is hit double. The sector cannot gain from lower trade barriers but at the same time it is still exposed to higher competition from abroad.

Figure 9 shows the results under the assumption that unskilled workers can invest in sector-specific human capital. Again partial trade liberalization hurts the skilled workers in the import-competing sector severely and persistently (even more severely than in the scenario without training). The wage of low-skilled workers in the import-competing sector drops only temporarily and then increases even above the unskilled wage in the exporting sector. The reason is that the option to train in the exporting sector is very attractive and pushes up the number of unskilled workers in the exporting sector, so that unskilled workers in the import-competing sector become relatively scarce.

Again we conclude that the partial liberalization of trade in specific sectors is not a good idea. This strategy cannot protect vulnerable workers or sectors. Rather to the contrary, this kind of policy has the potential to hurt vulnerable workers even more than a full liberalization of trade which affects all sectors equally.

6 Robustness

In this section we perform robustness checks and try to investigate more closely the importance of various channels for dynamic adjustment after trade liberalization. First we shut off firm dynamics. Then we analyze the role of selection into export markets and of firm heterogeneity. Finally, a scenario with higher trade costs is simulated. We restrict ourselves to symmetric liberalization scenarios 2 (with active switching of unskilled workers only) and 4 (with training) because we consider them the most realistic. Results for the other scenarios are available upon request.

6.1 Firm dynamics

In Ghironi and Melitz (2005) all the dynamics arises from the slow adjustment of firms. As noted in Burstein and Melitz (2012), the model would not yield any transitional dynamics if domestic firms had to pay fixed costs as well, because unproductive firms would drop out of the market immediately. This is different in our model, because mobility and training costs give rise to slow labor market adjustment and reallocation of resources takes time. Thus, even without the slow adjustment of firms, our model yields transitional dynamics.

To demonstrate this we shut off firm dynamics completely, by making the number of domestic firms, the number of newly entering firms and the share of exporting firms exogenous variables during the transition. We assume that these variables immediately jump to the new steady state. The result is demonstrated by the dash-dot black line in figures 10 and 11. Since none of the parameters are changed, the initial and final steady states are the same as in our baseline simulations; only the transition is affected.

For most variables the shutting-off of firm dynamics only implies quantitative changes but no qualitative changes. There is one notable exception, however: wages in the import-competing sector now decrease on impact, whereas they increased in our baseline scenario. For unskilled workers this effect is very short-lived, but the wage of skilled workers in the import-competing sector goes down very persistently.

Due to the instantaneous adjustment of firms, the number of firms in the import-competing sector drops much faster than in our baseline scenarios. This implies that the demand for labor in the import competing sector falls much faster. The low-skilled workers are more mobile, migrate more quickly to the exporting sector and, therefore, the effect is very short-lived. The high-skilled workers are more immobile and, therefore, endure lower wages for a much longer period. Note, however, that ultimately the wage of high-skilled workers in the import-competing sector catches up with the wage of high-skilled workers in the exporting sector.

This has also implications for wage inequality. The figures illustrate that all our measures of wage inequality react much more strongly in the short-run, especially the sectoral wage inequality among high-skilled workers. The skill premium in the import-competing sector even becomes negative for a long period of time.

6.2 Selection into export markets and firm heterogeneity

In this section we analyze the role of selection into export markets and of firm heterogeneity. In contrast to Melitz (2003), in our model the two are indistinguishable because we do not have selection into the domestic market. Shutting off selection into export markets in our model implies that both the average productivity of domestic firms and the average productivity of exporting firms are fixed. This makes firm heterogeneity irrelevant because the model is isomorphic to one in which only one firm exists (with its productivity equal to the average of the productivity distribution of the heterogenous firm model).

To study the role of selection into export markets and firm heterogeneity we set the fixed cost of exporting equal to zero. This implies that all active firms take up exporting, i.e., the share of exporting firms is always equal to one. It further implies that the average productivity of exporting firms is equal to the average productivity of domestic firms (in fact, the two sets are identical). The results are illustrated in figures 12 and 13.

It can be seen that generally wages react by less in the model with selection into export markets. Selection into export markets provides an additional margin of adjustment. In response to the increase in demand that follows from trade liberalization, the share of exporting firms increases, especially in the exporting sector. Since exporting firms are more productive than domestic firms, the increase in the share of exporting firms makes production generally more efficient. This implies that less reallocation between sectors is needed to increase production, both in terms of firms and in terms of workers. In the model where all firms export this adjustment mechanism is missing and therefore reallocation between sectors is necessary.

Due to the lower reallocation that is necessary in the model with selection into export markets, wage differentials need to rise by less. In the end these wage differentials drive the reallocation of workers and if less reallocation is needed, wage differentials tend to be lower. Note that the differences are quite sizeable, not so much in the short run as in the long run. E.g., in scenario 2 without training the decrease in the number of both skilled and unskilled workers in the import-competing sector is about 5% higher in the model without selection into export

markets, while the increase in the skill premium is 50% higher.[13] Thus, it can be concluded that selection into export markets and firm heterogeneity are dampening the effects of trade liberalization on wage inequality.

6.3 Trade costs

In our baseline scenario we have used the standard approach of reducing trade costs from 1.3 to 1.2. This is arguably quite low, given that we want to capture the trade between a rich, developed country and a poor, developing country. As demonstrated in Larch and Lechthaler (2011) the magnitude of trade costs matters for the type of trade: for high trade costs inter-industry is dominant, while for low trade costs intra-industry becomes more and more important. Therefore, we check how robust our results are to the type of trade (intra- versus inter-industry) by simulating a scenario with higher trade costs.

Figures 14 and 15 compare scenarios 2 and 4 of our baseline with the same scenarios under a trade shock that decreases τ and τ^* from 2.5 to 2, so that the trade costs decrease from 150% to 100%. In relative terms this is the same reduction as in our baseline simulations where we decreased the trade costs from 30% to 20%.

The results from the higher transport cost simulation are qualitatively the same as in our baseline scenarios: all variables move in the same direction and the shapes of the response functions are also very similar. The magnitude of the reactions is harder to compare because the experiments are so different. Most variables move by less in the scenario with higher trade costs, even though the absolute reduction in trade costs is higher. This is also true for all our measures of wage inequality, suggesting that trade liberalization has a larger impact on wage inequality when trade costs are already low to begin with. One exception is again the number of exporting firms which is much more responsive if trade costs are higher. This is not surprising, given that the number of exporting firms is much lower when trade costs are high.

6.4 Summary

In this section we have explored in more detail the effects of various features of our model on the effects of wage inequality. We have found that the slow adjustment of firms and the selection of firms into export markets lead to more modest increases in wage inequality after trade liberalization. For the most part, changing the importance of the various features of our model has only quantitative, but no qualitative implications. One notable exception is the development of skilled wages in the import-competing sector when firm dynamics are shut off. The immediate adjustment of firms reduces the demand for skilled workers in the import-competing sector to such an extent that their wage goes down for a prolonged period of time.

7 Conclusion

We build a two-country-two-sector dynamic trade model in which worker mobility is costly in order analyze the transitional dynamic effects from permanent trade liberalization. We focus on the dynamic effects of permanent trade liberalization on wage inequality. Our analysis concentrates on the effect of the welfare of workers in highly

[13] The skill premium increases by 2 percentage points within the context of the model.

developed countries from increased trade with developing countries. We find that worker mobility assumptions are critical for wage inequality dynamics. We distinguish two potential sources of inequality, the wage differential between workers who are in the same skill class but in different sectors (comparative advantage versus comparative disadvantage sectors) and the skill premium, i.e., the wage differential between skilled and unskilled workers.

In the short run, wage inequality is dominated by changes in the wage differential across sectors: it rises due to rising relative demand for workers in the exporting sector. In the medium to the long run, wage inequality is dominated by changes in the skill premia. When low skilled workers are not allowed to train, inequality rises due to the rising skill premium in the exporting sector. When skilled workers face costs of switching sectors that are too high due to having invested in sector-specific human capital and when low skilled workers face low mobility and are allowed to train and become skilled, wage inequality can actually fall in the medium run. This is due to the sharply falling skill premium in the import-competing sector. The option of unskilled workers in the import-competing sector to switch to the exporting sector and train to become skilled workers there leads to a sharp and persistent decrease in the productivity of skilled labor in the shrinking sector.

Labor mobility assumptions are also critical for the distribution of income across workers. In a scenario where skilled workers are relatively less mobile than low skilled ones due to having invested in sector-specific human capital, they also become the biggest losers and winners from trade liberalization, with the skilled workers in the import-competing sector being the biggest losers and skilled workers in the exporting sector being the biggest winners. This is a striking result considering the fact that popular concern with the negative effect on wage inequality from trade liberalization is usually associated with the *low-skilled* workers in the import-competing sector.

Our results also suggest that it is not a good idea to keep the import-competing sector protected from trade liberalization. When trade liberalization is restricted to only the high-skill intensive sector the gains from trade are considerably reduced, while the effects on wage inequality are minor at best. If both countries restrict their trade liberalization to their respective comparative advantage sectors, the effects are even more striking. Not only are the gains from increased trade reduced but the most vulnerable workers are hurt even more than under symmetric trade liberalization. The reduction in trade in the import-competing sector that comes with a liberalization of the exporting sector hurts high-skilled workers who have invested their skills in the 'wrong' sector.

While a full analysis of policy implications is left for future research, a few conclusions are suggestive. Labor market policies of increasingly globalized developed countries should concentrate on providing moving subsidies to high skilled workers so that they can switch their sector of employment more easily. In addition, low-skilled workers value the option to train and become high-skilled in the exporting sector very highly. In fact, having this option to train is behind the result that they are not the main losers from trade liberalization. Our findings suggest that a training subsidy can make this option to train even more valuable and mitigate their losses from trade liberalization. The option to train can lead to a fall in the skill premium in the medium run and can reduce overall wage inequality.

Finally, we show that restricting trade liberalization to comparative advantage sectors and protecting comparative disadvantage sectors is not a good policy decision. Our results indicate that not only the gains from trade are considerably reduced but also the most vulnerable workers are hurt even more from increased trade with developing countries.

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8 Tables and Figures

Table 1		
Parameter	Description	Value
α	share of high-skilled intensive good in household consumption	0.5
γ	household discount factor	0.99
θ	elasticity of substitution between varieties	3.8
η	cost of international bond trading parameter	0.0025
δ	probability of firm death	0.025
$z_{\min}$	minimum value of firm productivity	1
k	shape parameter for firm Pareto distribution	3.4
β_1	skilled labor intensity parameter	0.6
β_2	unskilled labor intensity parameter	0.4
S	endowment of skilled labor at Home	900
L	endowment or unskilled labor at Home	1100
S^*	endowment of skilled labor at Foreign	500
L^*	endowment or unskilled labor at Foreign	1500
s	retirement rate of workers	0.02
$\varepsilon^s_{\min}$	minimum cross-sector mobility cost for skilled labor	$5(1,2,4,5,6),1(3)$
$\varepsilon^l_{\min}$	minimum cross-sector mobility cost for unskilled labor	$5(1),1(2,3,4,5,6)$
κ	Pareto shape parameter for cross-sectoral mobility cost distribution	2
$\varepsilon^i_{\min}$	minimum cost of training at Home	1.30987
$\varepsilon^{*i}_{\min}$	minimum cost of training at Foreign	2.79926
κ^{train}	Pareto shape parameter of training cost distribution	2
f_x	fixed trade cost at Home	$0.235[1-\beta(1-\delta]/[\beta(1-\delta)]f_e$
f^*_x	fixed trade cost at Foreign	$0.235[1-\beta(1-\delta)]/[\beta(1-\delta)]f^*_e$
f_e	fixed entry cost at Home	1
f^*_e	fixed entry cost at Foreign	1
τ	iceberg trade cost at Home	1.3
τ^*	iceberg trade cost at Foreign	1.3
Z	aggregate productivity at Home	1
Z^*	aggregate productivity at Foreign	1

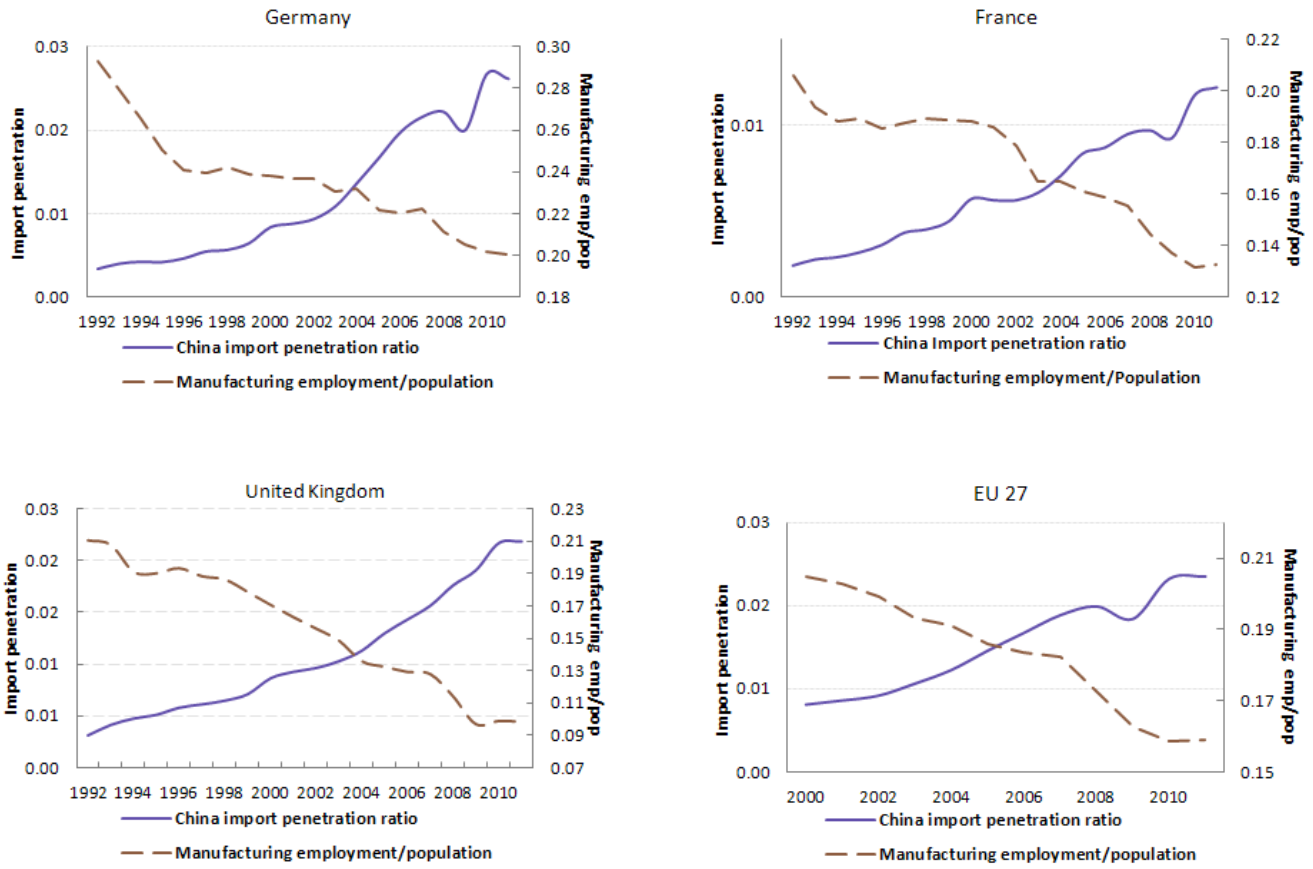

Figure 1: Import Penetration Ratio for Imports from China (left scale), and Share of Working-Age Population Employed in Manufacturing (right scale)

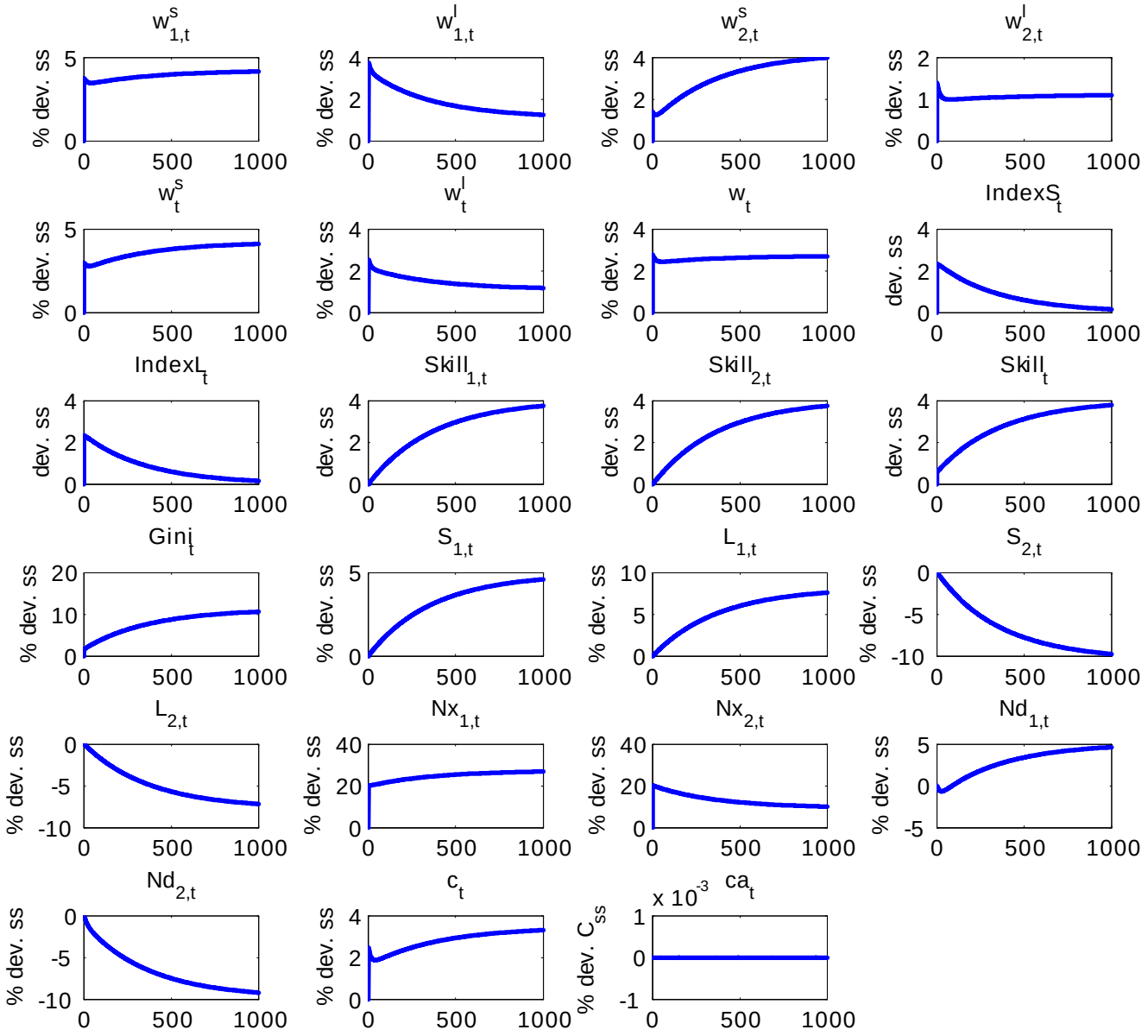

Figure 2: Scenario 1 Symmetric Liberalization With No Active Switching of Workers

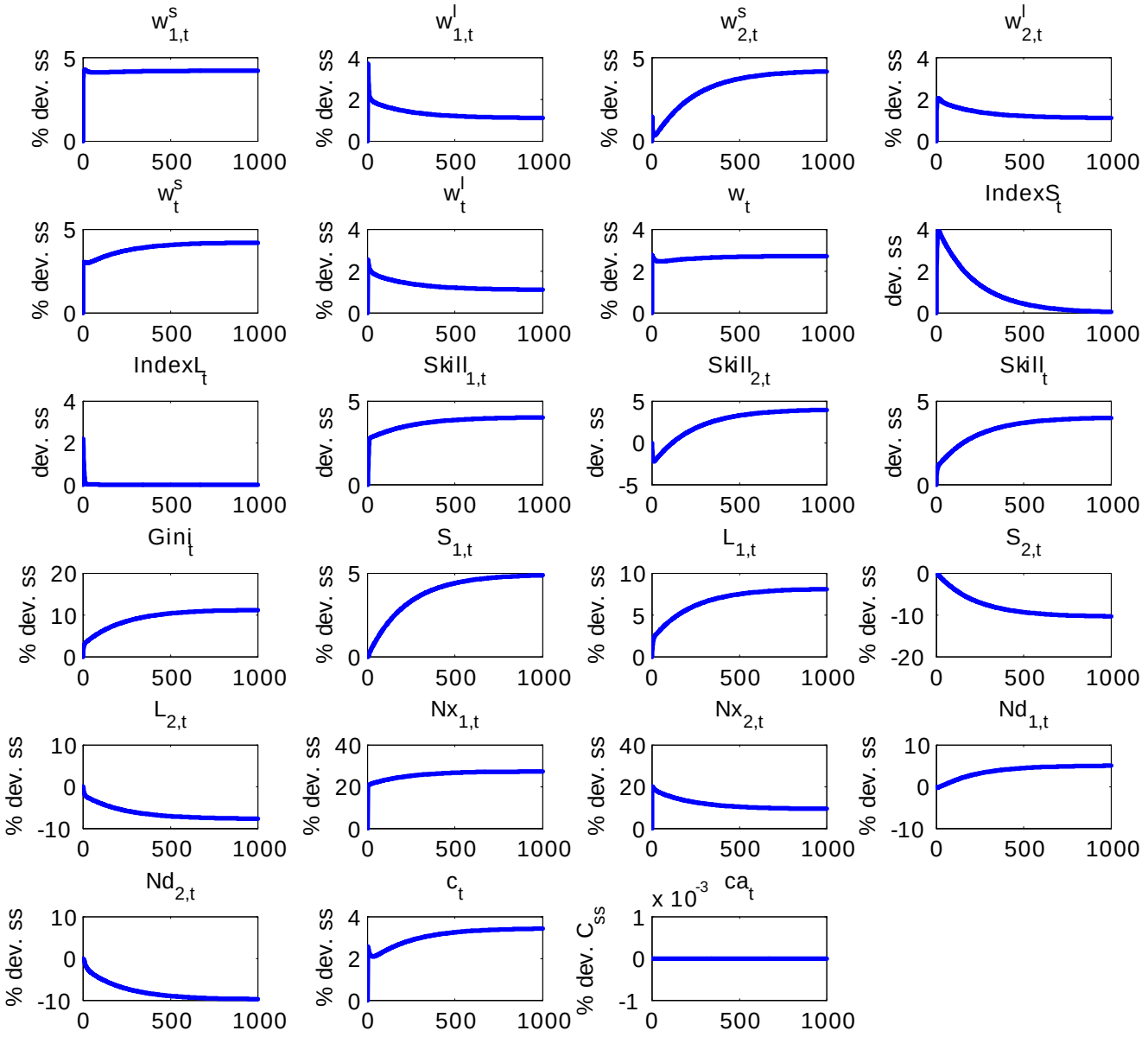

Figure 3: Scenario 2 Symmetric Liberalization With Active Switching of Unskilled Workers Only

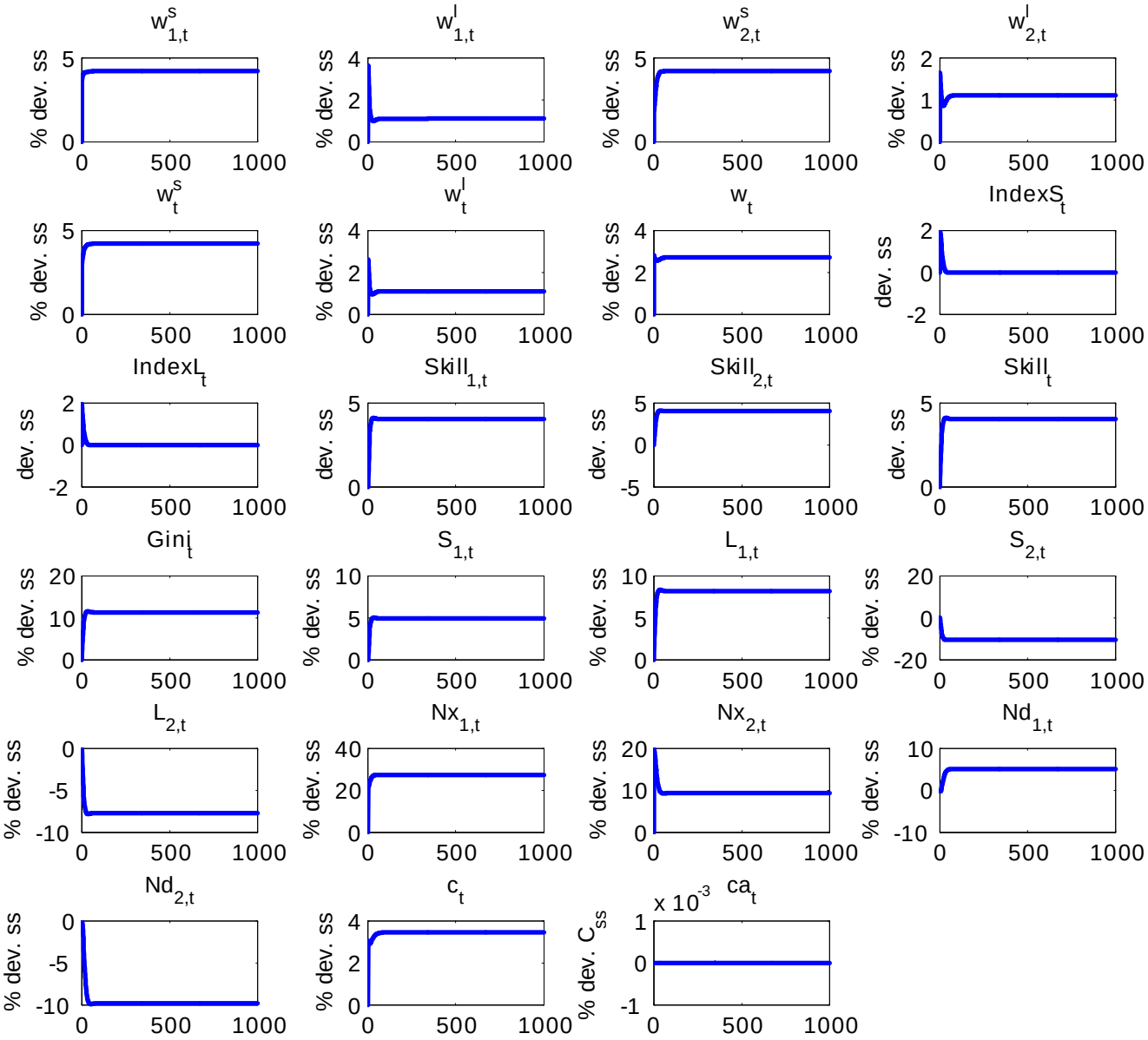

Figure 4: Scenario 3 Symmetric Liberalization With Active Switching of Skilled and Unskilled Workers

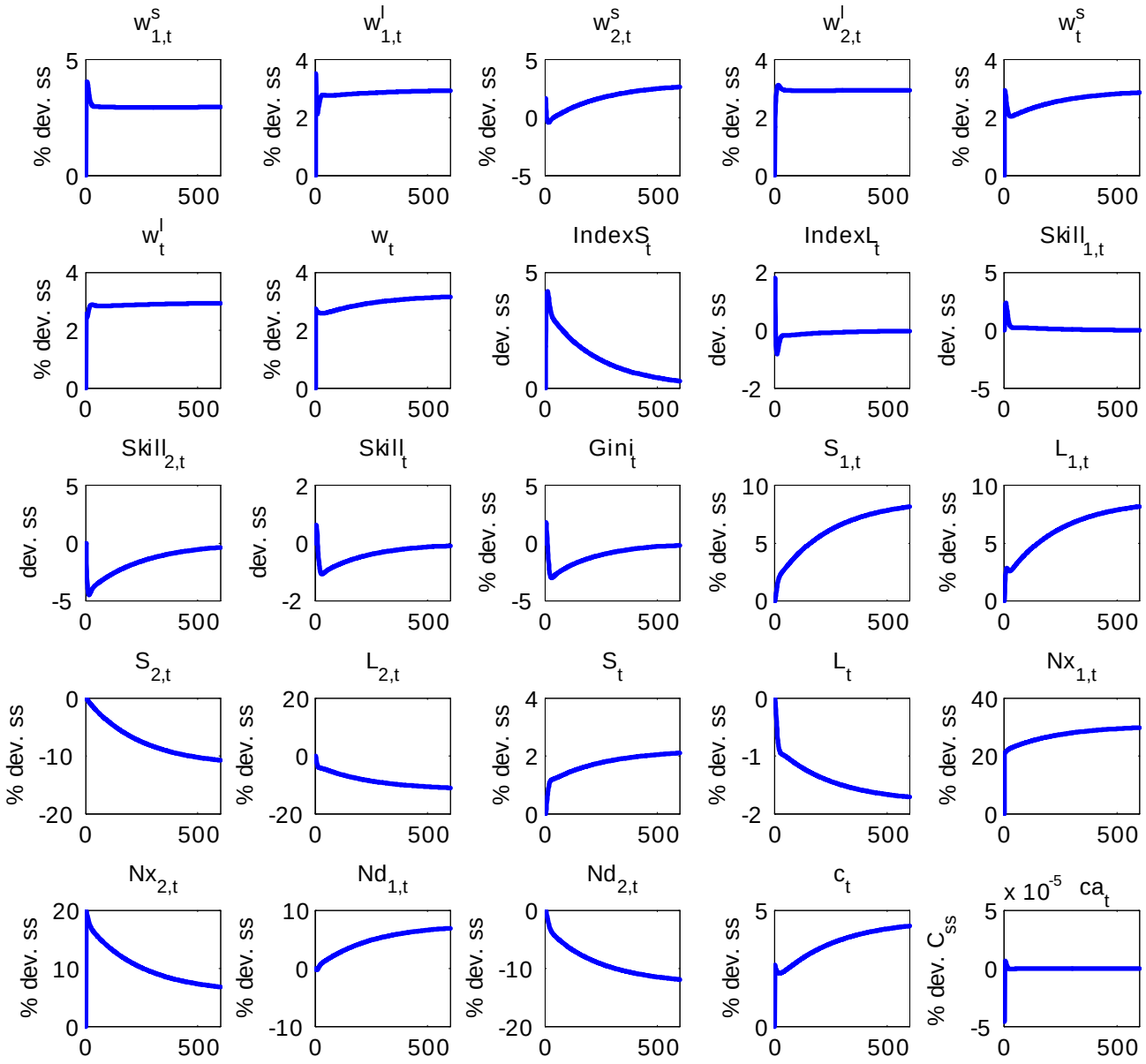

Figure 5: Scenario 4 Symmetric Liberalization With Training

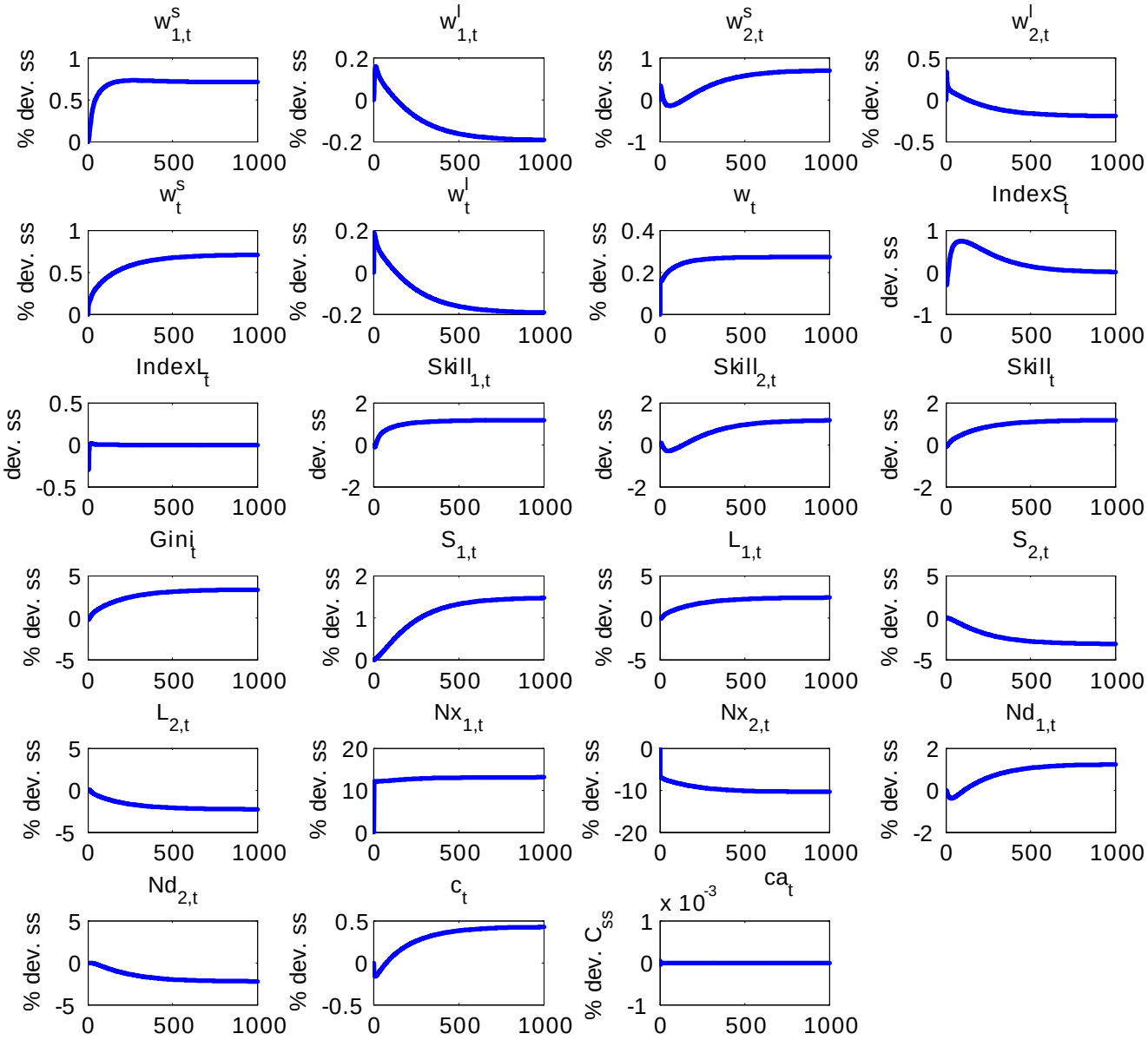

Figure 6: Scenario 5a Liberalization of the Skill-Intensive Sector With Active Switching of Unskilled Workers Only

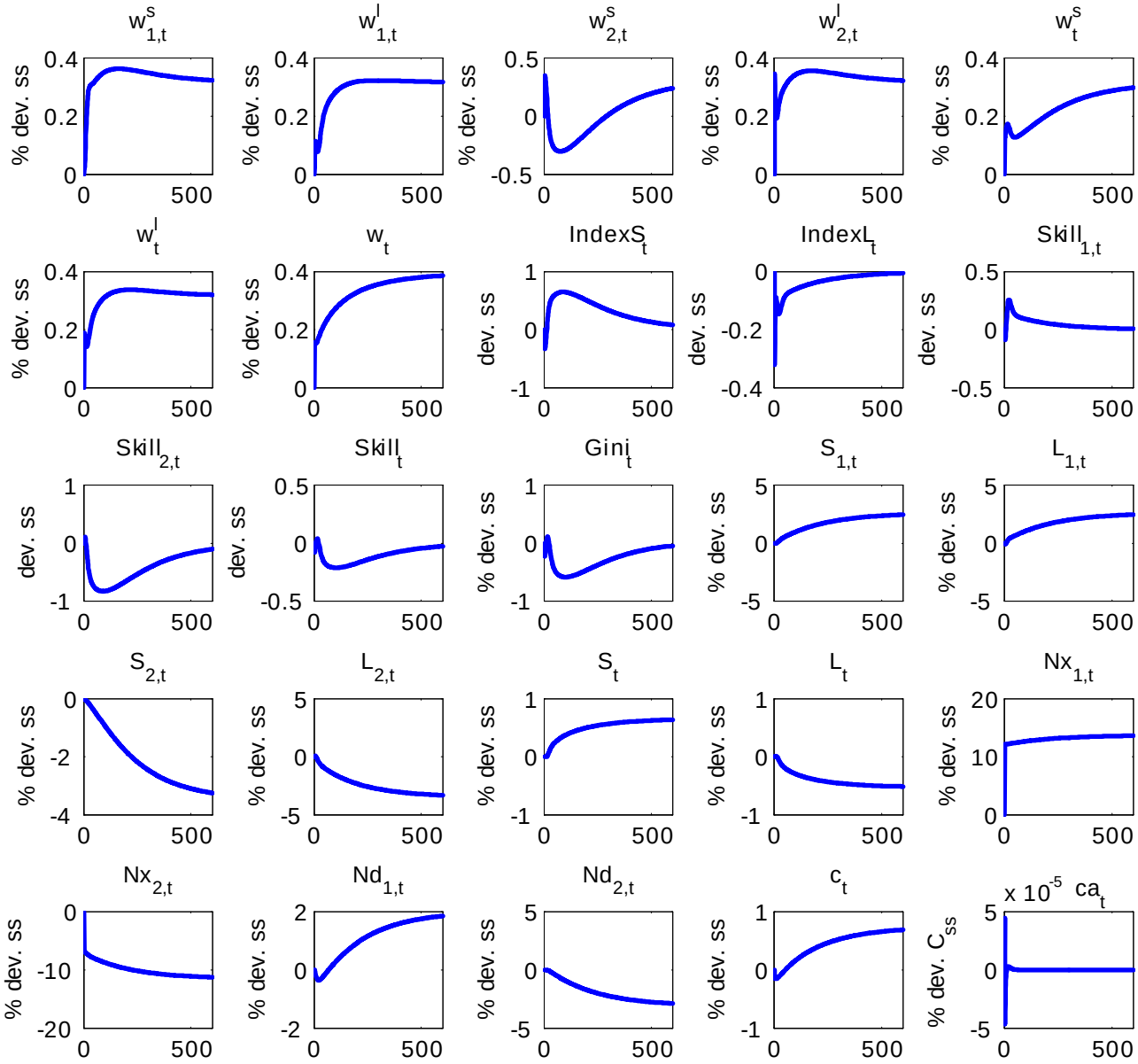

Figure 7: Scenario 5b Liberalization of the Skill-Intensive Sector With Training

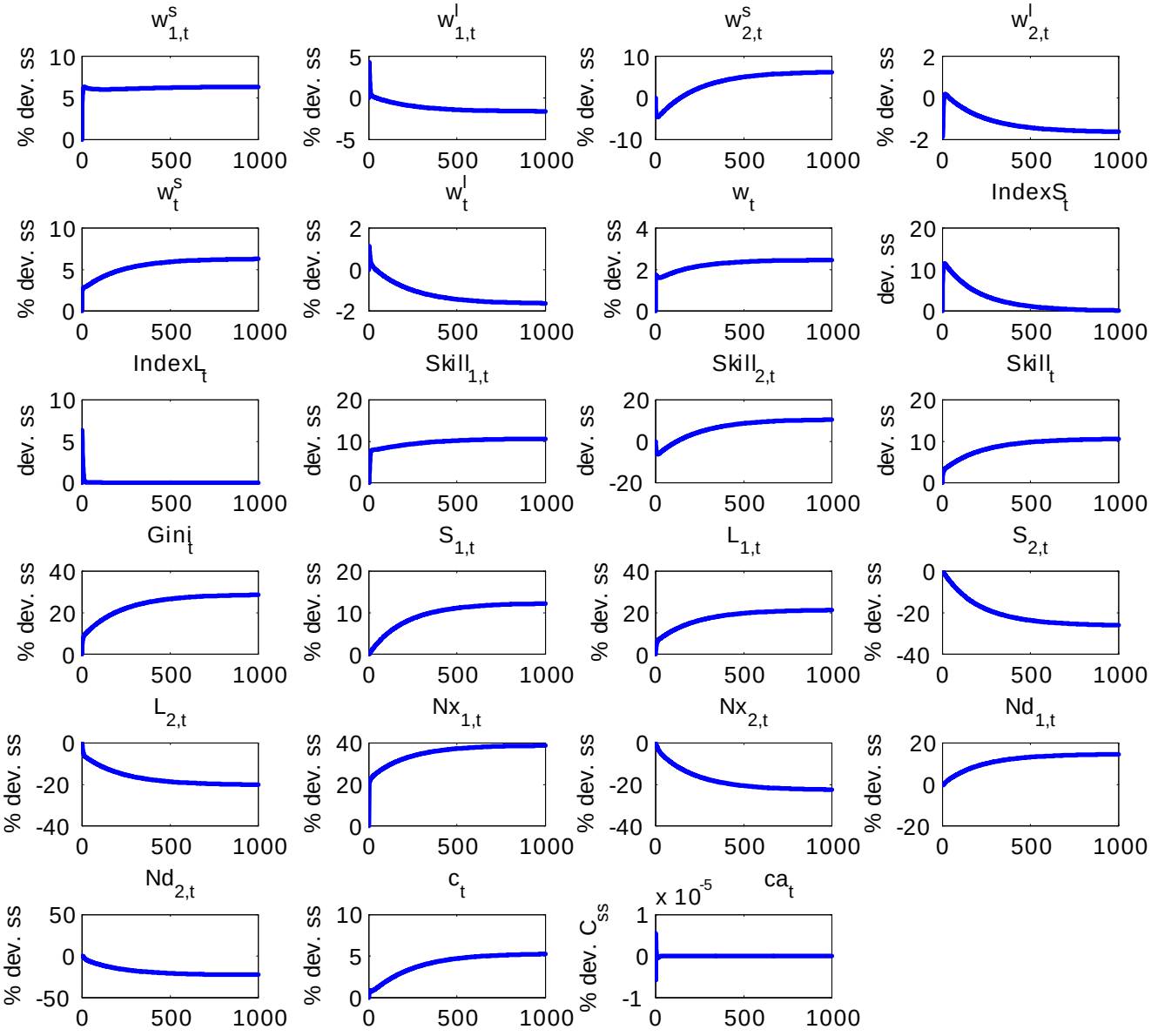

Figure 8: Scenario 6a Liberalization of the Comparative Advantage Sectors With Active Switching of Unskilled Workers Only

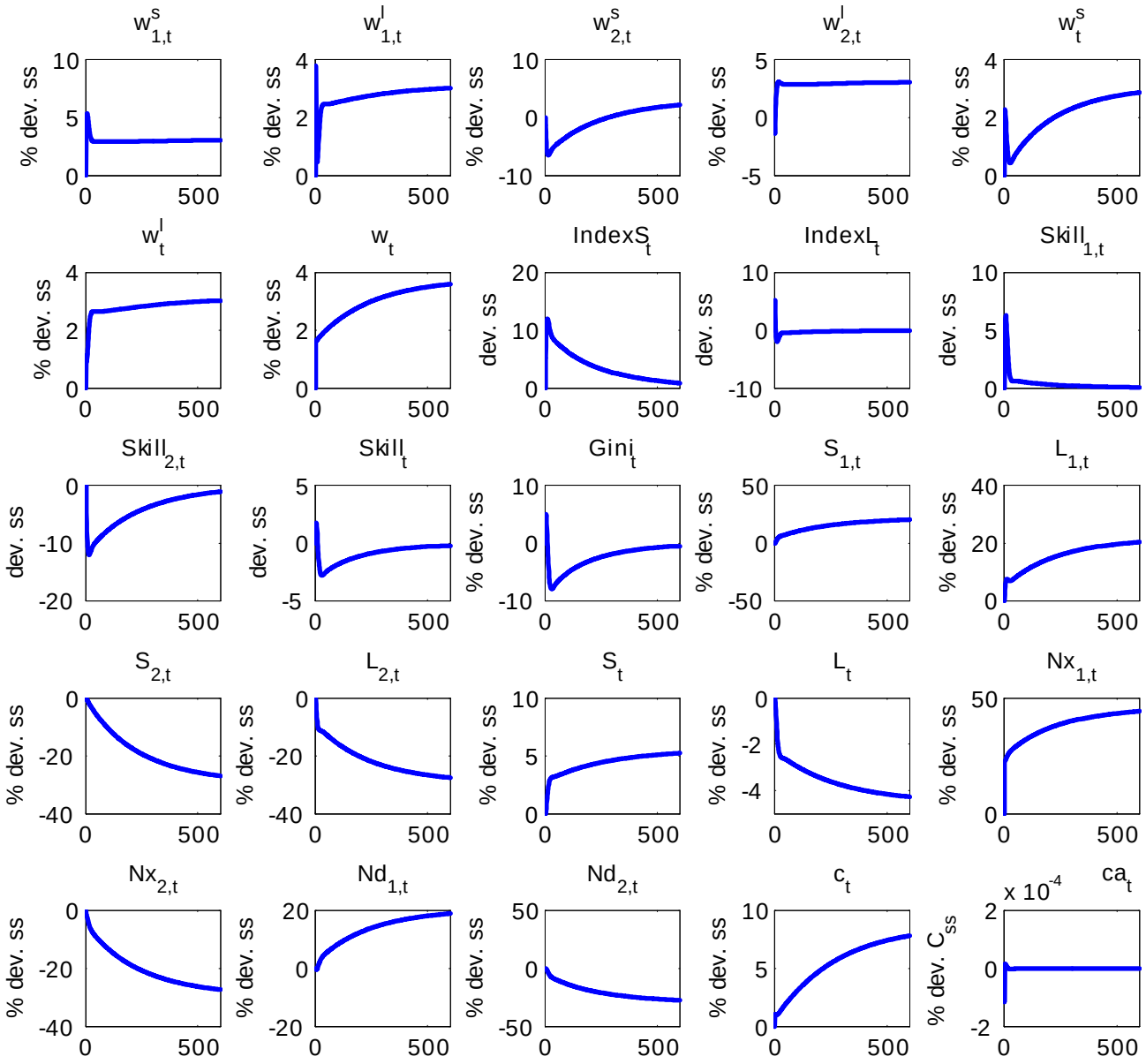

Figure 9: Scenario 6b Liberalization of the Comparative Advantage Sectors With Training

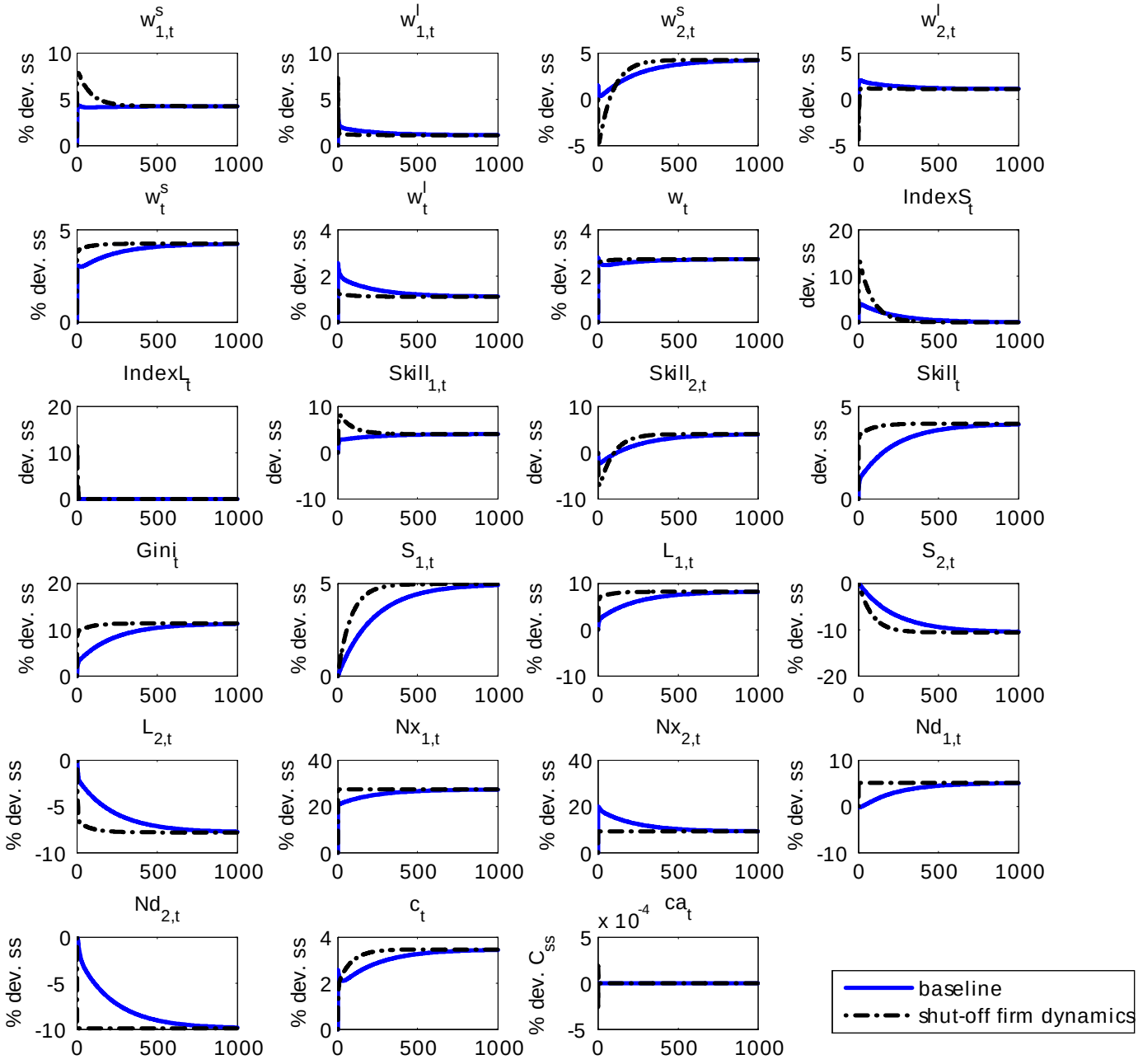

Figure 10: Symmetric Liberalization With Firm Dynamics Shut-Off With Active Switching of Unskilled Workers Only (S2)

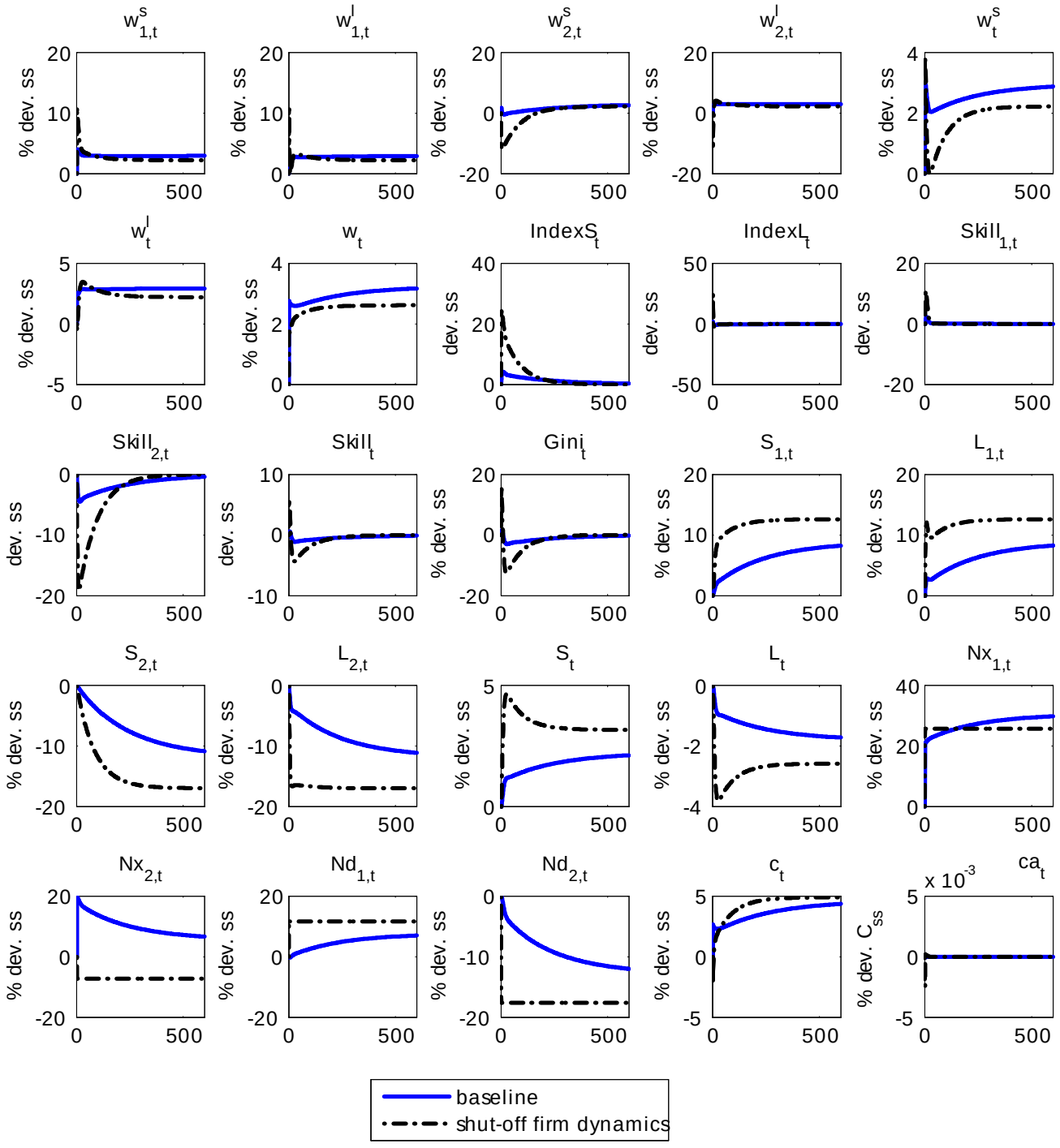

Figure 11: Symmetric Liberalization With Firm Dynamics Shut-Off With Training (S4)

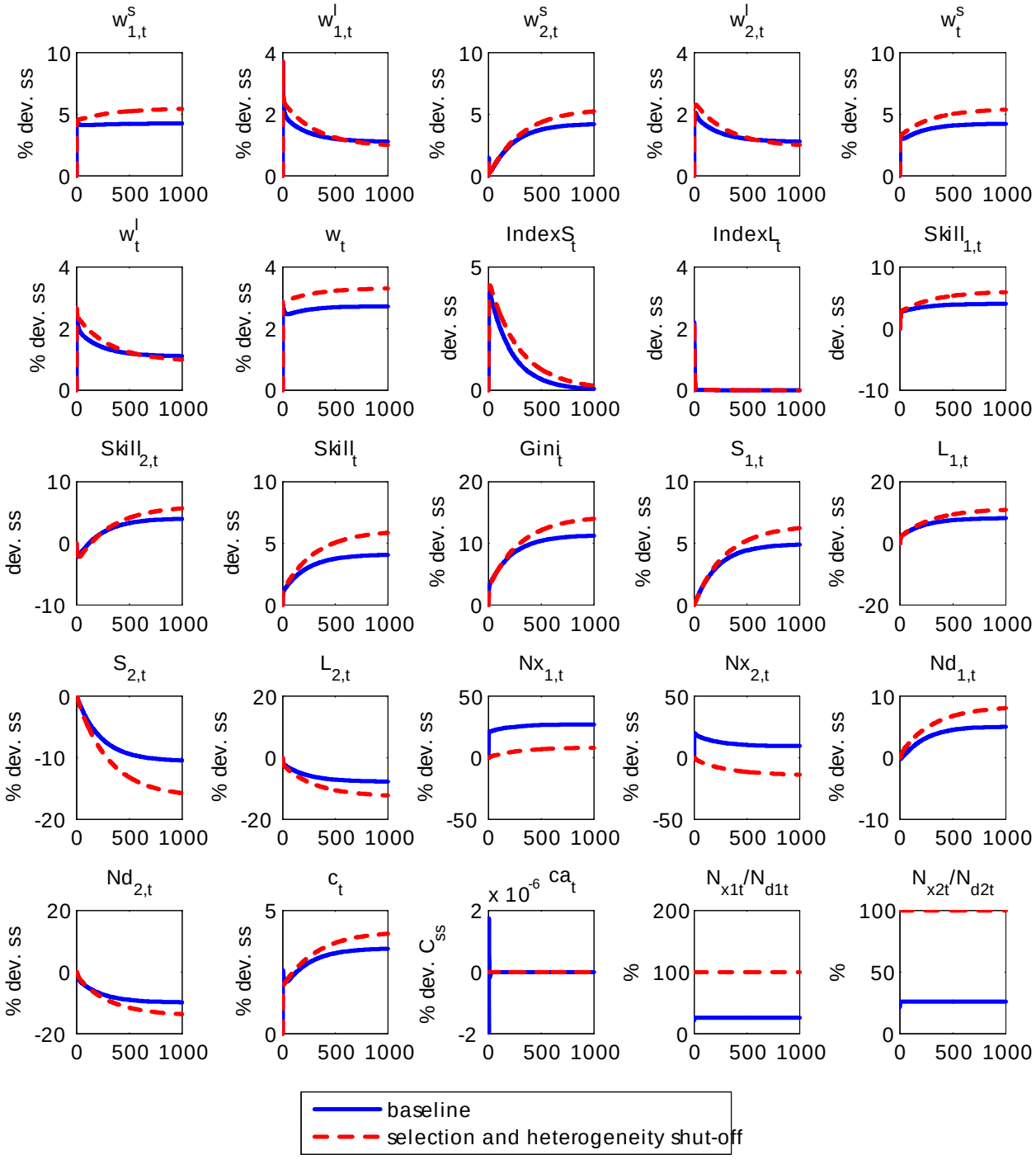

Figure 12: Symmetric Liberalization Without Selection Into Export Markets With Active Switching of Unskilled Workers Only (S2)

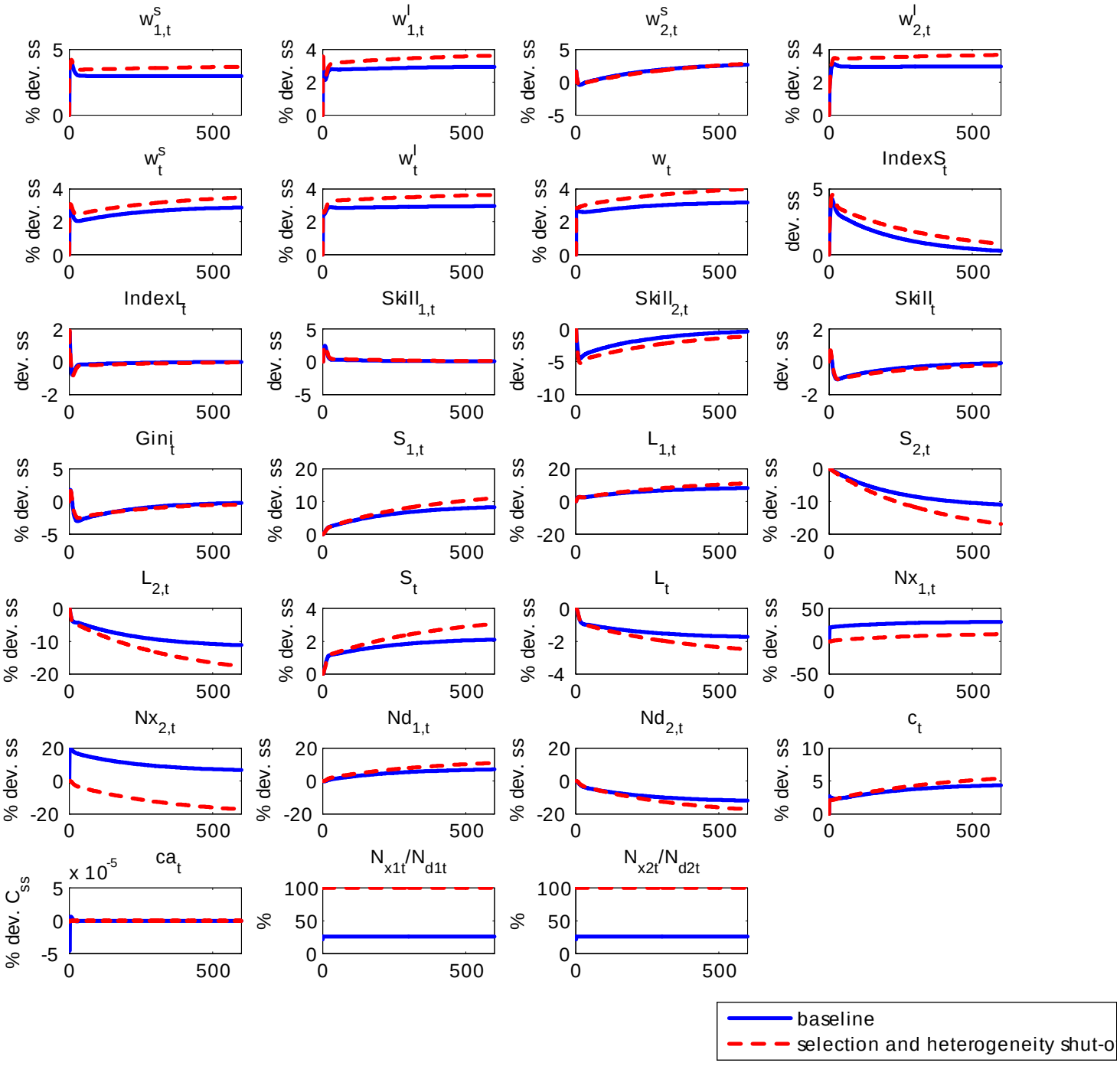

Figure 13: Symmetric Liberalization Without Selection Into Export Markets With Training (S4)

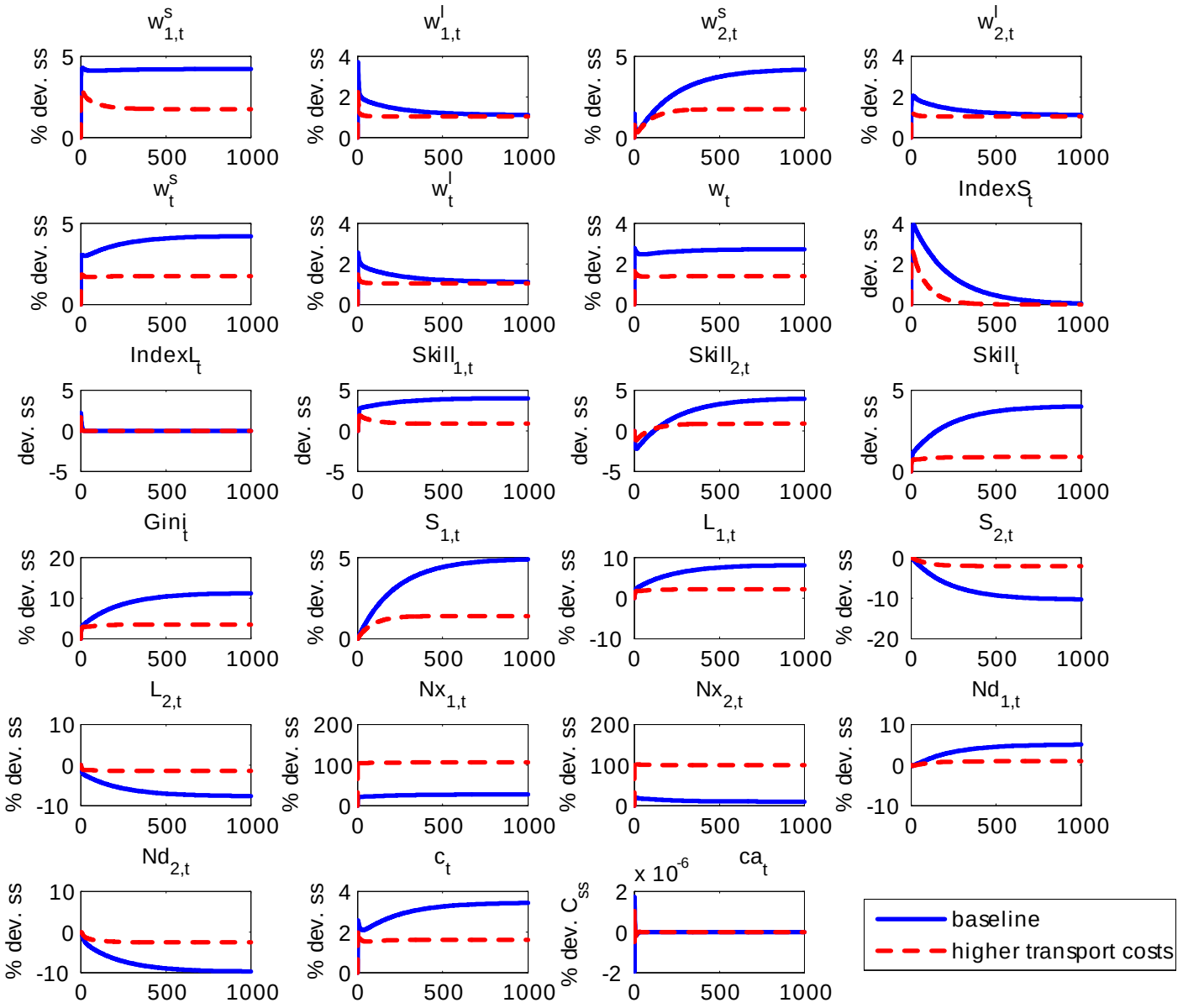

Figure 14: Symmetric Liberalization With Higher Transport Costs With Active Switching of Unskilled Workers Only (S2)

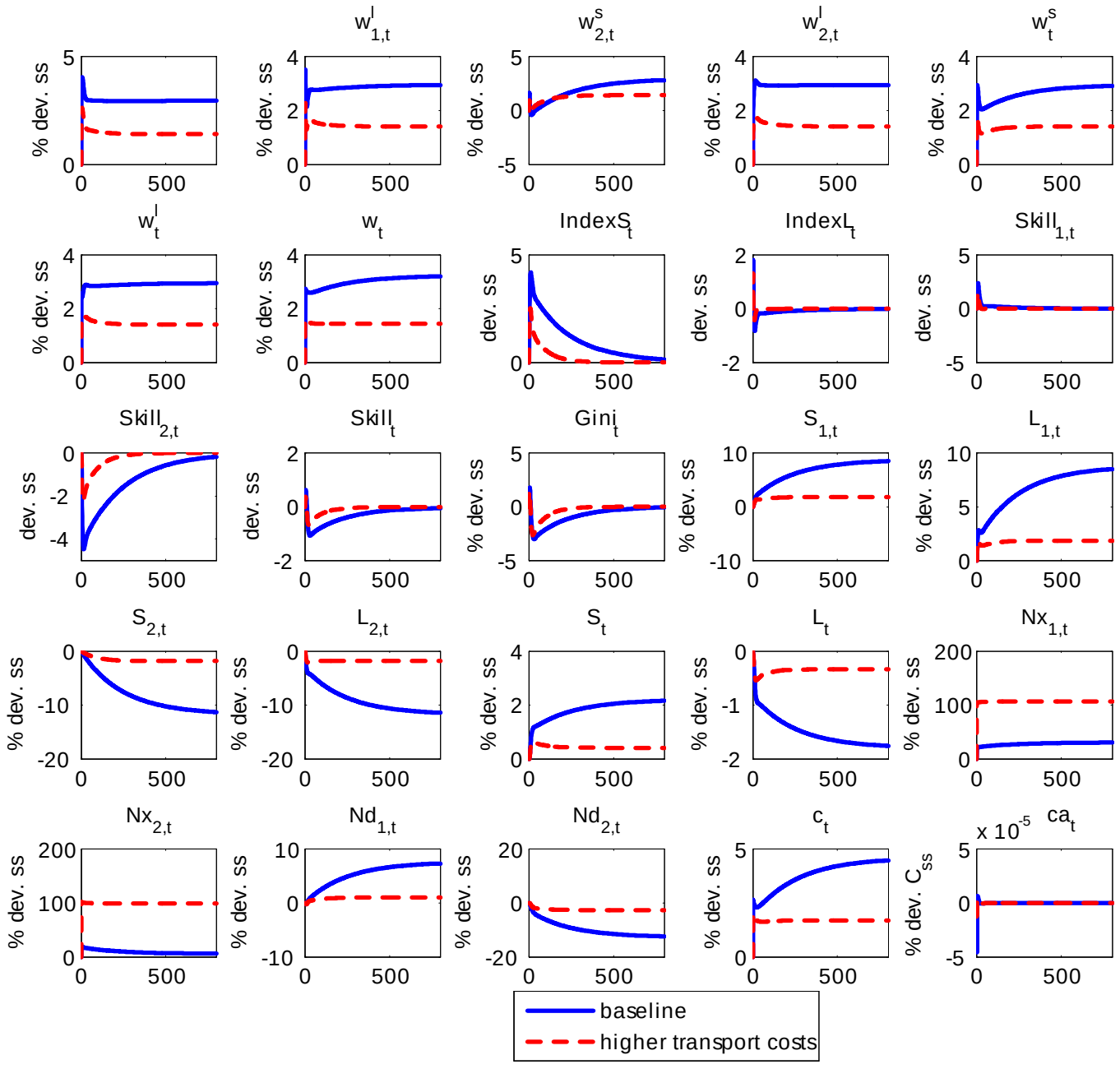

Figure 15: Symmetric Liberalization With Higher Transport Costs With Training (S4)

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Project Information

Welfare, Wealth and Work for Europe

A European research consortium is working on the analytical foundations for a socio-ecological transition

Abstract

Europe needs a change: The financial crisis has exposed long neglected deficiencies in the present growth path, most visibly in unemployment and public debt. At the same time Europe has to cope with new challenges ranging from globalisation and demographic shifts to new technologies and ecological challenges. Under the title of Welfare, Wealth and Work for Europe – WWWforEurope – a European research consortium is laying the analytical foundations for a new development strategy that enables a socio-ecological transition to high levels of employment, social inclusion, gender equity and environmental sustainability. The four year research project within the 7th Framework Programme funded by the European Commission started in April 2012. The consortium brings together researchers from 33 scientific institutions in 12 European countries and is coordinated by the Austrian Institute of Economic Research (WIFO). Project coordinator is Karl Aiginger, director of WIFO.

For details on WWWforEurope see: www.foreurope.eu

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