KIEL INSTITUTE FOR THE WORLD ECONOMY

KIEL WORKING PAPER

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No. 2082 May 2017

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Kiel Institute for the World Economy
ISSN 2195–7525

KIEL **WORKING PAPER** NO. 2082 |MAY 2017

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ABSTRACT

THE DYNAMIC AND DISTRIBUTIONAL ASPECTS OF IMPORT TARIFFS

Wolfgang Lechthaler and Mariya Mileva

We use a dynamic trade model with two sectors and two types of workers to analyze the optimal setting of income-generating tariffs. This approach allows us to take account of adjustment dynamics, distributional aspects and the time horizon of policy makers and workers. In response to a unilateral increase in tariffs aggregate consumption increases only sluggishly so that policy makers with a short time horizon tend to set lower tariffs. Workers' preferences for tariffs depend on the sector where they are employed as well as their skill class, with the relative weight of both aspects determined by the time horizon of the workers. Unskilled workers in the unskilled-intensive sector are the ones most in favor of protectionism and might even benefit from a trade war.

Keywords: protectionism; optimal tariffs; dynamic trade model; inequality

JEL classification: F11, F12, F13

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1 Introduction

Motivated by the surge in protectionist tendencies on campaign trails all over developed countries, we take a fresh look at the optimal setting of and the preferences for income-generating tariffs. To do so we use a dynamic model with two countries, two factors, two sectors, endogenous firm entry and firm heterogeneity. This allows us to draw a rich picture of the dynamic distributional aspects of import tariffs.[1] We find that the preferences for tariffs depend on the sector where the worker is employed as well as her skill class, with the relative weight of both aspects determined by the time perspective of the worker. For a worker who is more concerned about the immediate future the sector of employment is more important, for a worker who is more concerned about long-run outcomes the skill-class is more relevant. The workers most in favor of tariffs are the unskilled workers in the unskilled-intensive sector.

The analysis of the setting of optimal tariffs has a long tradition in the trade literature. One short-coming of this literature is that it is typically based on static models. This is a short-coming for at least two reasons. On the one hand, adjustment dynamics are ignored. On the other hand, tariffs are typically set by elected politicians who tend to care more about the next couple of years than the infinite future (the new steady state). So, focusing on purely static models might yield implausible policy conclusions.

Two recent papers (Larch and Lechthaler (2013) and Lechthaler (forthcoming)) try to close this gap by analyzing the setting of tariffs in a dynamic version of the Melitz (2003) model. Both papers consistently find that a shorter time horizon implies lower optimal tariffs, because the short-run effects of higher tariffs are worse than the long-run effects. However, in both papers distributional aspects are missing because they rely on the representative agent framework of the Melitz-model. Thus there is only once sector and only one factor of production and each household is affected equally by changing tariffs. This is at odds with recent evidence showing that workers employed in import-competing sectors were especially adversely affected by trade liberalization with China (see, e.g., Autor, Dorn, and Hanson (2013), Dauth, Findeisen, and Suedekum (2014), Ebenstein, Harrison, McMillan, and Phillips (2009) or Pierce and Schott (2016)).

To be able to capture this differential exposure of workers to international trade as well as the sluggish adjustment of an economy after a trade shock and the potential short-sightedness of policy makers, we use the

[1] Felbermayr, Jung, and Larch (2013) have shown that including firm heterogeneity is crucial when analyzing optimal tariffs because the restriction to homogenous goods shuts off an important channel.

dynamic version of the model of Bernard, Redding, and Schott (2007) developed in Lechthaler and Mileva (2013), augmented by income-generating tariffs. The model features two factors of production, skilled and unskilled workers, two sectors that use both factors with different intensities and two countries with different endowments of skilled vs. unskilled workers. The model is calibrated to broadly match important features of the two economies of the US and China.

Following Ossa (2014) we first analyze unilaterally optimal tariffs, i.e., the optimal US-tariff under the assumption that the Chinese tariff does not change. In response to an increase in the US-tariff, aggregate US-consumption increases permanently, but due to enhanced firm investment the increase is very sluggish. Thus as in Larch and Lechthaler (2013) and Lechthaler (forthcoming) a policy maker who is interested in maximizing aggregate consumption sets a lower tariff the shorter his time horizon.

However, workers are very differently affected by the tariff-increase. In the short run, workers in the skill-intensive sector lose because an increase in tariffs partially unwinds the economy's specialization in its comparative advantage sector while workers in the unskilled-intensive sector gain (the US has a comparative advantage in skill-intensive production, because it has relatively more skilled workers than China). In the long run, skilled workers lose while unskilled workers gain, because the unwinding of specialization reduces the relative demand for skilled workers.

These effects, of course, perfectly resemble the well-known Stolper-Samuelson and Ricardo-Viner theorems. However, we combine both aspects in a unified framework and bring them together with preferences for trade protection and a worker's time perspective. Thus it is neither solely the skill-class of a worker nor the sector where she is employed that determines her preference for tariffs, but rather a combination of both, with the time perspective of the worker determining their respective weights.

Thus a skilled worker in the unskilled-intensive sector might prefer free trade if she has a long-term perspective but favor tariffs if she has a sufficiently short-term perspective. In contrast, an unskilled worker in the skill-intensive sector favors lower tariffs when she has a short-term perspective but a higher tariff when she has a long-run perspective. As expected, unskilled workers in the unskilled-intensive sector are the ones most in favor of tariffs and even more so if they have a short-term perspective.

It is often argued that the fear of retaliation prevents from raising tariffs because in a trade war in which both countries raise their tariff both countries would suffer lower welfare. Although from an aggregate

perspective this is still true in our model, our analysis adds a nuance to this outcome. In the Nash-equilibrium of a non-cooperative game (a "trade war" in the terminology of Ossa (2014)), aggregate consumption and the consumption of most worker-groups are lower than in the status quo but this is not true for the unskilled workers in the unskilled-intensive sector. Although their consumption in the new steady state with higher tariffs is basically the same as in the old steady state, during the transition period they enjoy substantial, albeit temporary gains in consumption. Thus even though the economy as whole would suffer from a trade war, some workers still gain and are thus willing to support an increase in tariffs even in the face of potential retaliation.

Our paper connects to three different strands of the literature. First, the large literature on the setting of Nash-equilibrium and optimal tariffs, see, e.g., Krugman (1991), Bond and Syropoulos (1996), Bagwell and Staiger (1999), Yi (2000), Ornelas (2005), Demidova and Rodriguez-Clare (2009), Felbermayr, Jung, and Larch (2013), or Ossa (2014). Second, the literature that analyzes the effects of trade with China, e.g., Autor, Dorn, and Hanson (2013), Dauth, Findeisen, and Suedekum (2014), Ebenstein, Harrison, McMillan, and Phillips (2009) or Pierce and Schott (2016). And finally, the relatively young but growing literature on the dynamic adjustment to trade shocks, see, e.g., Alessandria and Choi (2014), Burstein and Melitz (2013), Cacciatore (2014), Cacciatore and Ghironi (2014), Coşar (2013), Dix-Carneiro (2014) or Kambourov (2009). None of these papers, however, has considered the joint analysis of tariffs in a dynamic setting with inter-industry trade.

The rest of the paper is structured as follows. Section 2 describes the model. Section 3 discusses the dynamic adjustment of aggregate variables in response to an increase in tariffs, and the role of the policy-maker's planning horizon for the optimal unilateral tariff. Section 4 analyzes the dynamic adjustment of worker-specific variables and worker-specific preferences for tariffs. Section 5 discusses Nash-equilibrium tariffs ("trade wars"), section 6 sector-specific tariffs, and section 7 concludes.

2 Theoretical model

Our model economy consists of two countries, Home (H) and Foreign (F). Each country produces two goods, good S and good U . The production of each good requires two inputs, skilled and unskilled labor. The sector that produces good S is skill-intensive, i.e., the production of good S requires relatively more skilled labor than the production of good U. Country H has a comparative advantage in producing good S because it has a higher relative endowment of skilled labor. Similarly, F has a comparative advantage in sector U because it has a higher relative endowment of unskilled labor. We assume that unskilled labor is more abundant than skilled labor in both countries in order to generate a positive skill-premium.[2] In the long run, all factors of production are assumed to be perfectly mobile between sectors but not across countries. However, throughout most of the paper we assume that workers are imperfectly mobile across sectors in the short run.[3] In the following we describe all the decision problems in H; equivalent equations hold for F.

2.1 Households

In our model there are four types of workers, skilled workers in sector S, skilled workers in sector U and likewise for unskilled workers. In the following we describe the problem of skilled workers, but equivalent equations hold for unskilled workers.

The household of skilled workers active in sector $i = S,U$ maximizes the present discounted value of utility derived from consumption:

$$E_t \left\{ \sum_{k=0}^{\infty} \gamma^k log\left(C^s_{it+k}\right) S_{it} \right\}, \tag{1}$$

where C^s_{it+k} is the aggregate consumption bundle, γ is the subjective discount factor and S_{it} is the number of skilled workers in the household. The household faces the following intertemporal budget constraint:

$$B^s_{it+1} + \frac{\eta}{2}\left(B^s_{it+1}\right)^2 + Q_t B^s_{*,it+1} + Q_t \frac{\eta}{2}\left(B^s_{*,it+1}\right)^2 + C^s_{it} S_{it} = (1+r_t)B^s_{it} + Q_t(1+r^*_t)B^s_{*,it} + w^s_{it} S_{it} + \Pi_t S_{it} + T^S_t + T^t_t S_{it}, \tag{2}$$

where B^s_{it} are holdings of domestic bonds, $B^s_{*,it}$ are holdings of foreign bonds, η is the cost of adjusting

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

[3] In section 8 in the appendix we consider the case of perfect short-run mobility across sectors as well as the case of endogenous skill formation.

bond holdings, Q_t is the real exchange rate, r_t is the interest rate, w_{it}^s is the wage, Π_t are the transfers of a mutual fund to be described further below, and T_t^t is the tariff-income per worker that the government transfers to domestic workers in a lump-sum fashion. The cost of adjusting bond holdings is used to pin down steady state bonds to zero and to get a well-defined steady state.[4] As is standard, the costs of adjusting bond holdings are assumed to be reimbursed to the households (T_t^S) and η is set to a small enough level so that adjustment dynamics are not affected.

The household chooses C_{it}^s, B_{it+1}^s and $B_{*,it+1}^s$. The first order conditions yield:

$$\begin{aligned}(C_{it}^s)^{-1}\left(1+\eta B_{it+1}^s\right) &= \gamma E_t\left[\left(C_{it+1}^s\right)^{-1}(1+r_{t+1})\right],\\ (C_{it}^s)^{-1}\left(1+\eta B_{*,it+1}^s\right) &= \gamma E_t\left[\left(C_{it+1}^s\right)^{-1}\left(1+r_{t+1}^*\frac{Q_{t+1}}{Q_t}\right)\right],\end{aligned} \tag{3}$$

which are standard consumption Euler equations (for foreign and domestic bonds).

The composition of the aggregate consumption bundle is the same for all workers; only the quantity of consumed goods differs across workers. Therefore, in the following description we omit the indices for workers to avoid cumbersome notation. The aggregate consumption bundle C_t is a Cobb-Douglas composite of the goods produced in the two sectors:

$$C_t = C_{St}^{\alpha_S} C_{Ut}^{\alpha_U}, \tag{4}$$

where α_S is the share of good S in the consumption bundle for both H and F and $\alpha_U = 1-\alpha_S$. We can obtain relative demand functions for each good from the expenditure minimization problem of a household. The implied demand functions are:

$$C_{St} = \alpha_S \frac{P_t}{P_{St}} C_t \;\; and \;\; C_{Ut} = \alpha_U \frac{P_t}{P_{Ut}} C_t, \tag{5}$$

where $P_t = \left(\frac{P_{St}}{\alpha_S}\right)^{\alpha_S}\left(\frac{P_{Ut}}{\alpha_U}\right)^{\alpha_U}$ is the price index that buys one unit of the aggregate consumption bundle C_t.

Goods S and U are consumption bundles defined over a continuum of varieties Ω_i:

$$C_{it} = \left[\int_{\omega\varepsilon\Omega_i} c_{it}(\omega)^{\frac{\theta-1}{\theta}} d\omega\right]^{\frac{\theta}{\theta-1}}, \tag{6}$$

[4] See, e.g, GM for more details.

where $\theta > 1$ is the elasticity of substitution between varieties. Varieties are internationally traded. Thus a variety can either be produced at home or imported. At any given time, only a subset of varieties $\Omega_{it} \in \Omega_i$ is available in each sector. The consumption based price index for each sector is $P_{it} = \left[\int_{\omega \varepsilon \Omega_i} p_{it}(\omega)^{1-\theta} d\omega\right]^{\frac{1}{1-\theta}}$ 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. Let us 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 the sector bundles, respectively. Then, we can rewrite the demand functions for varieties and sector bundles as $c_{it} = \left(\frac{\rho_{it}}{\psi_{it}}\right)^{-\theta} C_{it}$ and $C_{it} = \alpha_i \psi_{it}^{-1} C_t$, respectively.

2.2 Worker allocation

Recent empirical evidence indicates that workers are very immobile across sectors in response to trade shocks (see e.g., Autor, Dorn, and Hanson (2013) Wacziarg and Wallack (2004), Autor, Dorn, Hanson, and Song (2014) and Dix-Carneiro (2014)). Therefore, we assume that incumbent workers have to stick to their sector of employment. However, to nevertheless allow for worker reallocation we assume that incumbent workers retire at an exogenous rate s and are replaced by an equal number of newly entering workers. These workers are free in their choice of sector.[5]

The main factor influencing their choice of sector is the wage differential. Naturally, workers tend to prefer the sector that pays the higher wage.[6] However, due to numerical reasons we assume that newly entering workers also need to bear an entry cost for each sector that differs across sectors and across workers.[7]

What is relevant for the sector choice is not the absolute value of the entry cost, but the difference across sectors. A worker who has a lower entry cost for sector U tends to prefer that sector, other things being equal. We denote the difference in entry costs by ε, with a positive number meaning that the worker can enter sector S relatively cheaply and a negative number meaning that the worker can enter sector U relatively cheaply. Every newly entering worker draws her relative entry cost from the random distribution $J(\varepsilon)$ with zero mean and support on $(-\infty, \infty)$. We will parameterize the random distribution such that it has a negligible effect

[5] In section 8 in the appendix we will also consider the case of free mobility of workers across sectors.

[6] This assumption is in line with empirical evidence in, e.g., Ryoo and Rosen (2004) who find that the fraction of college graduates who are engineers is closely related to a measure of relative earnings prospects in engineering.

[7] Without this sector entry costs the choice of sector would not be well defined in the steady state, because workers are indifferent between the two sectors in the absence of wage differentials. Additionally, there would be no mechanism assuring that the steady state is hit, potentially implying overshooting and oscillatory dynamics.

on the choice of sector, but it simplifies numerical simulations and implies a smooth transition to the new steady state.

Thus an entering skilled worker will choose to enter sector S if:

$$V_{St}^{s} + \varepsilon_t > V_{Ut}^{s}. \tag{7}$$

where V_{it}^{s} is the present discounted value of consumption utility of a skilled worker in sector i. Equation 7 defines a threshold value $\overline{\varepsilon^{S}}$, for which a worker is indifferent between both sectors:

$$\overline{\varepsilon_t^{S}} = V_{Ut}^{s} - V_{St}^{s}, \tag{8}$$

and the share of the newly entering skilled workers that choose sector S is $1 - J(\overline{\varepsilon_t^{S}})$. The resulting law of motion for skilled workers in sector S thus is:

$$S_{St} = (1-s)S_{St-1} + \left(1 - J(\overline{\varepsilon_t^{S}})\right) sS. \tag{9}$$

where $S = S_{St} + S_{Ut}$ is the exogenously given total number of skilled workers.

2.3 Production

There are two sectors of production in each country. An endogenous number of firms with heterogeneous productivity operates in each sector.[8] To avoid cumbersome notation, we omit a firm-specific index in the following description of production. The production technology is assumed to be Cobb-Douglas in the two inputs of production:

$$Y_{it} = z S_{it}^{\beta_i} L_{it}^{(1-\beta_i)}, \tag{10}$$

where z is firm-specific productivity, while S_{it} and L_{it} is the amount of skilled and unskilled labor used by a firm. β_i is the share of skilled labor required to produce one unit of output Y_i in sector i. Sector S is assumed to be skill-intensive and sector U unskilled-intensive which implies that $1 > \beta_S > \beta_U > 0$. The labor market

[8] Felbermayr, Jung, and Larch (2013) have shown that including firm heterogeneity is crucial when analyzing optimal tariffs because the restriction to homogenous goods shuts off an important channel.

is assumed to be perfectly competitive implying that the real wage of both skilled and unskilled workers equals the values of their marginal products of labor. In addition, workers are perfectly mobile across all firms in a specific sector which implies that all firms within a sector pay the same wage. Consequently, relative labor demand can be described by the following condition:

$$\frac{w_{it}^s}{w_{it}^l} = \frac{\beta_i}{(1-\beta_i)} \frac{L_{it}}{S_{it}}, \tag{11}$$

which says that the ratio of the skilled real wage w_{it}^s to the unskilled real wage w_{it}^l for sector i is equal to the ratio of the marginal contribution of each factor in producing one additional unit of output. Note that this condition implies that relative demand for labor is the same across all firms within a sector. Since relative demand for labor is independent of firm-specific productivity, equation 11 also holds at the sector level, i.e., relative labor demand per sector is entirely determined by the relative wages paid by firms in that sector. This condition is valid for both sectors.

Firms are heterogeneous in terms of their productivity z. The productivity differences across firms translate into differences in the marginal cost of production. Measured in the units of the aggregate consumption bundle, the marginal cost of production is $\frac{\left(w_{it}^s\right)^{\beta_i}\left(w_{it}^l\right)^{1-\beta_i}}{z}$.

Prior to entry, firms are identical and face a sunk entry cost f_e, which is produced by skilled and unskilled labor, equal to $f_e\left(w_{it}^s\right)^{\beta_i}\left(w_{it}^l\right)^{1-\beta_i}$ units of aggregate H consumption. Note that entry costs can differ between sectors due to different factor intensities and due to inter-sectoral wage differentials. Upon entry firms draw their productivity level z from a common distribution $G(z)$ with support on $[z_{min}, \infty)$. This firm productivity remains fixed thereafter. As in GM there are no fixed costs of production, so that all firms produce each period until they are hit by an exit shock, which occurs with probability $\delta\varepsilon(0,1)$ each period. This exit shock is independent of the firm's productivity level, so $G(z)$ also represents the productivity distribution of all producing firms.

Exporting goods to F is costly and involves an iceberg trade cost $\tau^* \geq 1$, an import tariff $t_{it}^* \geq 1$ as well as a fixed cost f_x, again measured in units of effective skilled and unskilled labor. In real terms, these costs are $f_x\left(w_{it}^s\right)^{\beta_i}\left(w_{it}^l\right)^{1-\beta_i}$. The fixed cost of exporting implies that not all firms find it profitable to export.

All firms face a residual demand curve with constant elasticity in both H and F. They are monopolisti-

cally competitive and set prices as a 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:

$$\rho_{d,it}(z) = \frac{p_{d,it}(z)}{P_t} = \frac{\theta}{\theta-1}\frac{(w_{it}^s)^{\beta_i}\left(w_{it}^l\right)^{1-\beta_i}}{z}, \rho_{x,it}(z) = \frac{p_{x,it}(z)}{P_t^*} = \frac{1}{Q_t}\tau^* t_{it}^* \rho_{d,it}(z). \tag{12}$$

Profits, expressed in units of the aggregate consumption bundle of the firm's location are $d_{it}(z) = d_{d,it}(z) + d_{x,it}(z)$, where

$$d_{d,it}(z) = \frac{1}{\theta}\left(\frac{\rho_{d,it}(z)}{\psi_{it}}\right)^{1-\theta}\alpha_i R_t \tag{13}$$

$$d_{x,it}(z) = \begin{cases} \frac{Q_t}{\theta t_{it}^*}\left(\frac{\rho_{x,it}(z)}{\psi_{it}^*}\right)^{1-\theta}\alpha_i R_t^* - f_x\left(w_{it}^s\right)^{\beta_i}\left(w_{it}^l\right)^{1-\beta_i}, & \text{if firm z exports} \\ 0 & \text{otherwise,} \end{cases} \tag{14}$$

with R_t denoting total expenditures on the aggregate consumption bundle. A firm will export if and only if it earns 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} is identical for both sectors and low enough relative to the fixed cost of exporting so that $z_{x,it}$ is above z_{min}. Firms with productivity between z_{min} and $z_{x,it}$, serve only their domestic market.

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 $G(z)$, which is identical for both sectors and both countries. The number of exporters is $N_{x,it} = [1 - G(z_{x,it})]N_{d,it}$, which might differ across sectors. It is useful to define two average productivity levels, an average $\tilde{z}_{d,it}$ for all producing firms in sector i of country H and an average $\tilde{z}_{x,it}$ for all exporters in sector i of country H:

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

As in Melitz (2003), these average productivity levels summarize all the necessary information about the productivity distributions of firms.

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 in the foreign market is $\tilde{p}_{x,it} = p_{x,it}(\tilde{z}_{x,it})$. The price index for sector i in H reflects prices for the $N_{d,it}$ home firms and F's exporters to H. Then, the price index for sector i in H can be written as $P_{it}^{1-\theta} = [N_{d,it}\left(\tilde{p}_{d,it}\right)^{1-\theta} + N_{x,it}^{*}\left(\tilde{p}_{x,it}^{*}\right)^{1-\theta}]$. Written in real terms of aggregate consumption units this becomes $\psi_{it}^{1-\theta} = [N_{d,it}\left(\tilde{\rho}_{d,it}\right)^{1-\theta} + N_{x,it}^{*}\left(\tilde{\rho}_{x,it}^{*}\right)^{1-\theta}]$, 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's producers and F's exporters.

Similarly we can 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 $\tilde{d}_{it} = \tilde{d}_{d,it} + [1 - G(z_{x,it})]\,\tilde{d}_{x,it}$ are average total profits of H firms in sector i.

2.3.2 Firm Entry and Exit

The firms are owned by a mutual fund that invests in new firms, collects all the profits, and distributes any surplus in a lump-sum fashion to the households.[9] The mutual fund acts on behalf of the whole population and therefore uses the stochastic discount factor $\gamma^{s-t}(1-\delta)^{s-t}\left(R_s/R_t\right)^{-1}$ to discount between periods s and t.

In every period there is an unbounded mass of prospective new firms in both sectors and both countries. 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 each period, after entry and production. Thus a proportion δ of new entrants will never produce. The mutual fund is forward looking and computes the expected post-entry value of a firm entering sector i in period t as the present discounted value of its expected stream of profits $\{\tilde{d}_{is}\}_{s=t+1}^{\infty}$,

$$\tilde{v}_{it} = E_t \sum_{s=t+1}^{\infty} \left[\gamma^{s-t}(1-\delta)^{s-t} \left(\frac{R_s}{R_t} \right)^{-1} \tilde{d}_{is} \right]. \tag{15}$$

This also corresponds to the average value of incumbent firms after production has occurred. The mutual fund discounts future profits using the aggregate stochastic discount factor adjusted for the probability of firm

[9] The purpose of modelling firm entry this way is to separate firm entry and household heterogeneity.

survival $(1-\delta)$. Note that equation 15 can be written in recursive form as:

$$\tilde{v}_{it} = \gamma(1-\delta)E_t\left[\left(\frac{R_{t+1}}{R_t}\right)^{-1}\left(\tilde{v}_{it+1}+\tilde{d}_{it+1}\right)\right]. \tag{16}$$

Entry occurs until the average firm value is equal to the entry cost:

$$\tilde{v}_{it} = f_e\left(w_{it}^s\right)^{\beta_i}\left(w_{it}^l\right)^{1-\beta_i}. \tag{17}$$

The surplus of the mutual fund is distributed in a lump-sum fashion to the households:

$$\Pi_t(S+L) = \tilde{d}_{St}N_{d,St} + \tilde{d}_{Ut}N_{d,Ut} - \tilde{v}_{St}N_{h,St} - \tilde{v}_{Ut}N_{h,Ut} \tag{18}$$

Finally, the number of firms evolves according to:

$$N_{d,it} = (1-\delta)(N_{d,it-1}+N_{e,t-1}). \tag{19}$$

2.3.3 Productivity distribution of firms

Productivity z follows a Pareto distribution 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

$$\tilde{z}_{d,it} = \nu z_{min} \text{ and } \tilde{z}_{x,it} = \nu z_{x,it}. \tag{20}$$

The share of exporting firms in sector i in H is

$$\frac{N_{x,it}}{N_{d,it}} = 1 - G(z_{x,it}) = 1 - \left(\frac{\nu z_{min}}{\tilde{z}_{x,it}}\right)^k. \tag{21}$$

Together with the zero export profit condition for the cutoff firm, $d_{x,it}(z_{x,it}) = 0$, this implies that average export profits must satisfy

$$\tilde{d}_{x,it} = (\theta-1)\left(\frac{\nu^{\theta-1}}{k}\right) f_x\left(w_{it}^s\right)^{\beta_i}\left(w_{it}^l\right)^{1-\beta_i}. \tag{22}$$

2.4 Market Clearing Conditions, Aggregate Accounting and Trade

Market clearing requires that total production in each sector must equal total income so that:

$$N_{d,it}\left(\frac{\tilde{\rho}_{d,it}}{\tilde{\psi}_{it}}\right)^{1-\theta}\alpha_i R_t + Q_t\frac{1}{t^*_{it}}N_{x,it}\left(\frac{\tilde{\rho}_{x,it}}{\tilde{\psi}_{it}}\right)^{1-\theta}\alpha_i R^*_t + \tilde{v}_{it}N_{e,it} = w^s_i S_{it} + w^l_{it}L_{it} + \tilde{d}_{it}N_{d,it}. \tag{23}$$

Total production of the sector (on the left hand side) includes the production of the aggregate consumption bundle (both for the domestic market and the foreign market) and the production of new firms. Total income generated by the sector (on the right hand side) includes wage earnings and profits.

The trade balance is defined as exports minus imports in both sectors:

$$tb_t = \sum_{i=S,U}\left[Q_t\frac{1}{t^*_{it}}N_{d,it}\left(\frac{\rho_{x,it}}{\psi^*_{it}}\right)^{1-\theta}\alpha_i R^*_t - \frac{1}{t_{it}}N^*_{d,it}\left(\frac{\rho^*_{x,it}}{\psi_{it}}\right)^{1-\theta}\alpha_i R_t.\right] \tag{24}$$

Let us define aggregate bond holdings in H as $B_t \equiv (B^S_{St} + B^S_{Ut} + B^L_{St} + B^L_{Ut})$ and $B_{*,t} \equiv (B^S_{*,St} + B^S_{*,Ut} + B^L_{*,St} + B^L_{*,Ut})$ and similarly for aggregate bond holdings in F. In equilibrium, the international net supply of bonds is zero for H bonds such that $B_t + B^*_t = 0$ and for F bonds such that $B_{*,t} + B^*_{*,t} = 0$. Then net foreign assets evolve according to the following law of motion:

$$B_t + Q_t B_{*,t} = (1 + r_{t-1})B_{t-1} + (1 + r^*_{t-1})B_{*,t-1}Q_t + tb_t. \tag{25}$$

2.5 Parametrization

This section describes the parametrization of the model that we use for our analysis of optimal tariffs. In most aspects we follow GM, and interpret the home country as the US. Furthermore, we assume that both economies are symmetric except for their relative endowments of skilled/unskilled workers and the steady state tariffs they charge. To calibrate these variables we interpret the foreign country as China. We take this approach because it is not our goal to provide a precise quantitative assessment of optimal tariffs but rather to highlight the role of comparative advantage, distributional aspects and dynamic adjustment. To this end we want to keep the asymmetries across countries at a minimum.

We interpret each period as a quarter and set the household discount rate γ to 0.99, the standard choice

for quarterly dynamic models. We set the elasticity of substitution between varieties to $\theta = 3.8$, based on the estimates from plant-level U.S. manufacturing data in Bernard, Eaton, Jensen, and Kortum (2003). We set the parameters of the Pareto distribution to $z_{\min} = 1$ and $k = 3.4$, respectively. This choice satisfies the condition for finite variance of log productivity: $k > \theta - 1$.

Changing the sunk cost of firm entry f_e only re-scales the mass of firms in an industry. Thus without loss of generality we can normalize it so that $f_e = 1$. We set the fixed cost of exporting f_x to 23.5 percent of the per-period, amortized flow value of the sunk entry costs, $[1-\gamma(1-\delta)]/\left[\gamma(1-\delta)\right]f_e$. We set the size of the exogenous firm exit probability to $\delta = 0.025$, to match the level of 10 percent job destruction per year in the US. These choices of parameter values are based on GM.

To focus on comparative advantage, we assume that all industry parameters are the same across industries and countries except factor intensity (β_i). We calibrate (β_i) based on our own calculations using the NBER-CES Manufacturing Industry Database[10] which provides annual industry-level data from 1958-2009 on output, employment, payroll and other input costs, investment, capital stocks, TFP, and various industry-specific price indexes. We aggregate the data set to feature 19 3-digit NAIC industries and then classify these industries based on their revealed comparative advantage. In order to distinguish between comparative advantage and comparative disadvantage sectors, we use a measure of revealed comparative advantage (*RCA*) which takes account of exports and imports at the sector level. *RCA* is defined as the ratio of the export share of the sector in total manufacturing exports over the import share of the sector in total manufacturing imports ($RCA = \frac{(Ex_{it}/Ex_{manuf,t})}{Im_{it}/Im_{manuf,t})}$), with $RCA > 1$ referring to comparative advantage sectors and $RCA < 1$ referring to comparative disadvantage sectors.[11] In order to calibrate factor intensities of each sector, we calculate the wage share of production workers in total payroll for comparative advantage sectors and comparative disadvantage sectors, where production workers are defined as blue-collar, unskilled workers. We take the period average from 1980 and 2009 and find that the implied wage share for skilled workers in comparative advantage sectors is $\beta_S = 0.45$ and in comparative disadvantage sectors is $\beta_U = 0.32$. Similarly, we calculate the average share of comparative advantage sectors in total sector revenue to be 0.627 for 1980-2009. We use it

[10] The data can be accessed at http://www.nber.org/nberces/.

[11] We prefer this measure over the more traditional measure of revealed comparative advantage introduced by Balassa because it not only takes account of the export structure of the sector but also of its import structure. In addition, data on US exports and imports at the NAICs industry classification is readily available at Peter Schott's website. In contrast the Balassa measure of RCA requires data on world export shares at the NAICs level which has to be converted from other industry classification systems.

to calibrate $\alpha_S = 0.6$ and $\alpha_U = 0.4$.

Given the definition of skilled workers and unskilled workers in the NBER-CES data, we calibrate the endowments based on the ratio of production workers to managers in figure 4 in Ebenstein, McMillan, Zhao, and Zhang (2011). For the US this ratio is 4 to 1 in 1990 and 3 to 1 in 2005. For China the ratio is 8 to 1 in 1990 and 11 to 1 in 2005. Taking the average over the two available years and for a total population of 2000 workers these ratios imply that S=444 and L=1356 for the Home country and S*=191 and L*=1809 for the Foreign country. These endowments imply that the US has a higher relative endowment of skilled workers than China and thus a comparative advantage in producing skill-intensive goods.

According to data from the World Trade Organization (WTO) there is a significant difference in the tariffs both economies charge (see https://tao.wto.org/). Over the past ten years, the US charged on average a tariff of 3% for imports from China, while China charged on average a tariff close to 6% for imports from the US. We set tariffs in the initial steady state (the status quo) accordingly.

Iceberg trade costs are calibrated to deliver a share of US trade with China to US GDP of 0.206. This corresponds to the average share of US China manufacturing trade in manufacturing value added for the US over the period 1994-2014. Assuming symmetric trade costs, this share implies trade costs of $\tau = \tau^* = 1.71$.

Finally, we assume that the entering worker's relative sector entry cost follows a normal distribution with a mean of zero and a standard deviation of $sd = 0.1$. We have set the standard deviation parameter in order to ensure a very narrow distribution so that the entry decision of a worker regarding sector entry is mostly determined by sectoral wage differentials instead of fixed entry costs. This assumption is in line with empirical evidence in Ryoo and Rosen (2004) who find that the fraction of college graduates who are engineers is closely related to a measure of relative earnings prospects in engineering.

3 Optimal economy-wide tariffs

3.1 The dynamic adjustment after an increase in tariffs

This section discusses the setting of unilaterally optimal tariffs under the assumption that the same tariff is set for both sectors. As in Ossa (2014), we assume that for this experiment the tariff of the other country is held constant. In later sections we will relax this assumption and discuss Nash-equilibrium tariffs (trade

wars in the terminology of Ossa). Later we will also consider sector-specific tariffs.

It is a well established result in the trade literature that due to the terms of trade externality, and starting from a low tariff, a permanent unilateral increase in the tariff yields a permanent increase in the consumption of the country that imposes the higher tariff. Basically, there are two counteracting effects. On the one hand, a positive tariff drives a wedge between the consumer price and the producer price and thus creates an inefficiency. On the other hand, since the tariff is partly born by foreign producers whereas the ensuing income is solely distributed to domestic consumers, income is redistributed from foreign producers to domestic consumers. Starting from a low tariff the second effect dominates and raising the tariff increases domestic consumption (as long as there is no retaliation). The higher the tariff gets, the stronger the distortion becomes so that for high tariffs the first effect can dominate. This reasoning implies that there exists a tariff that maximizes consumption.

Following the traditional approach in the trade literature that is based on a static analysis and ignores dynamic adjustment, our model yields an optimal tariff for the US of 32.5%, given the observed tariff of China. Figure 1 shows the dynamic adjustment of selected aggregate variables in response to a permanent increase of the US tariff from 3%, the status quo, to this static optimum, 32.5%. Obviously, aggregate US consumption does not jump immediately to its new long-run equilibrium, but rather takes a long time to converge. This implies that the short-term gains from raising tariffs are actually much smaller than a purely static analysis would suggest. Consequently, the optimal tariff of a dynamic analysis is expected to be smaller than the optimal tariff of a static analysis. We will come back to the optimal tariff later, but first discuss the dynamic adjustment in a bit more detail.

The main reason for the sluggish increase in aggregate consumption is the surge in firm investment. An increase in the import-tariff implies lower competition for domestic firms. This implies that the number of firms in the new steady state must be higher than the number for firms in the old steady state (as is standard in the Melitz-model). During the adjustment period the stock of firms must be built up which implies especially high investment in firms. Enhanced investment in new firms reduces consumption so that the short run gain in consumption is considerably smaller than the long-run gain.

In contrast to the adjustment of aggregate consumption, imports and exports adjust very quickly. The increase in the tariff immediately makes imports more expensive, so that imports drop by more than 40% on

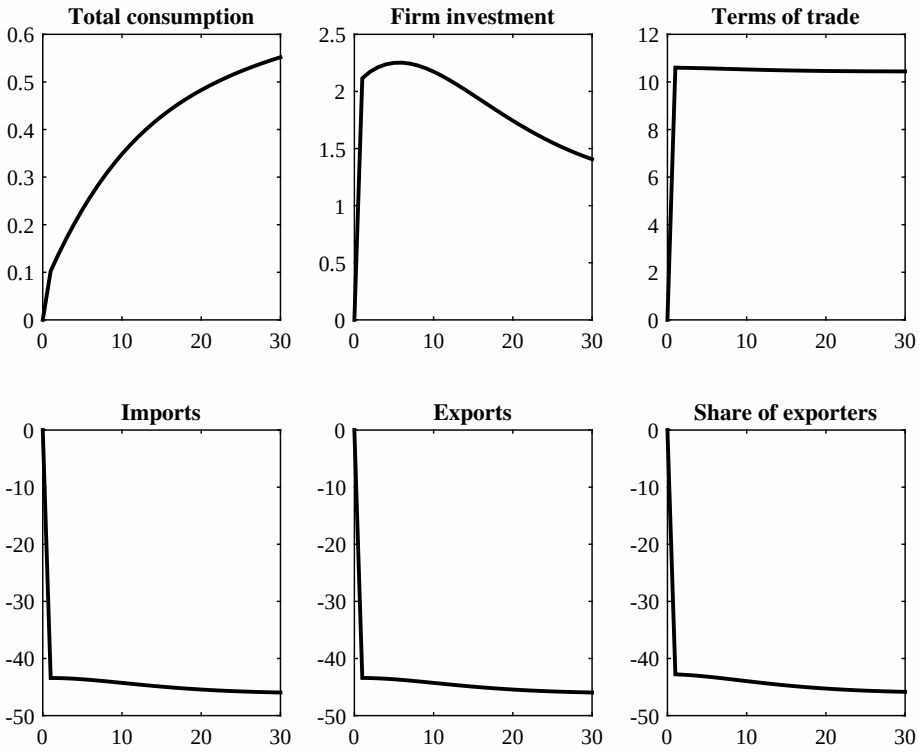

Figure 1: Effects of an increase in the US tariff from 3% to 32.5%. Quarters on the horizontal axis, percent deviations from the old steady state on the vertical axis.

impact. However, the reduced demand for foreign products and the less efficient mix of domestic varieties and foreign varieties in the US induces a sharp increase in the US's TOT, defined as the price of exports relative to the price of imports (and the US real exchange rate appreciates). This partly offsets the decreased demand for Chinese imports and at the same time reduces the demand for US exports. As a consequence the trade balance (not depicted) doesn't move much, which is in line with empirical evidence (see, e.g., Gagnon (2017)). The reduced export demand is also visible in the significant reduction in the number of exporting firms. Note that this reduction in the number of exporting firms also corresponds to less efficient production because exporting firms are more productive than firms that solely serve the domestic market.

3.2 Optimal tariffs and the planning horizon

Taking account of adjustment dynamics has two major advantages. First, adjustment costs are not ignored. Second, it allows us to analyze the optimal behavior of policy makers who might be more interested in the next couple of years than the infinite future. As discussed above the slow adjustment in aggregate consumption implies that a dynamic analysis yields smaller gains from raising tariffs than a static analysis. Taking account of this adjustment thus yields an optimal (aggregate consumption maximizing) tariff of 30.5%, not much but still noticeably less than the 32.5% of the static analysis.

Because of the slow adjustment of consumption, policy makers tend to set lower tariffs the shorter their planning horizon.[12] This is illustrated in figure 2. In analogy to Larch and Lechthaler (2013) and Lechthaler (forthcoming) this figure shows the optimal US-tariff in dependence of the planning horizon of the US-policy maker. By planning horizon we mean that the policy maker does not care about the infinite future but rather about the next x periods where x is measured along the horizontal axis. The optimal tariff shown is the tariff that maximizes the present discounted value of aggregate consumption up to period x. E.g., for a policy maker who cares about the next four years, a common term of office, the optimal tariff is just 24%.

So far this perfectly resembles the results in Larch and Lechthaler (2013) and Lechthaler (forthcoming). However, the use of a model with comparative advantage and inter-industry trade allows for a broader perspective, with the potential to put more weight on specific worker groups or to charge different tariffs for different sectors. In the following discussion we will concentrate on the first of these aspects, analyzing cases where the policy maker might care more for certain groups of workers than for others.

[12] Conconi, Faccini, and Zanardi (2014) have recently shown that politicians close to reelection tend to be more protectionist than other politicians. This might seem at odds with our result that politicians with a shorter time horizon should be in favor of smaller tariffs. Note, however, that even the optimal tariff for politicians with a very short time horizon is with around 20% much higher than the status quo of 3%. So no matter how long the planning horizon of a policy maker is, if she faces reelection our model suggests that she should favor an increase in tariffs.

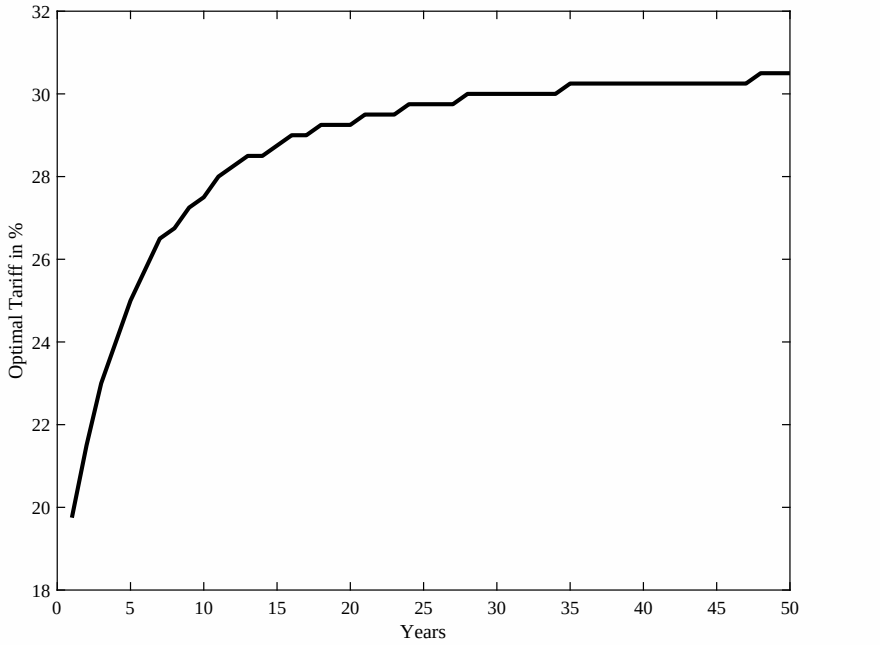

Figure 2: Optimal tariff in dependence of the policy maker's planning horizon.

4 Tariffs and specific workers groups

4.1 Worker-specific effects of tariffs

So far we have concentrated on the adjustment of aggregate variables. In this section we take a closer look at the experience of specific workers groups and their preferences for tariffs. Going back to the scenario where the US raises the tariff to 32.5%, we see from figure 3 that the experience of different types of workers diverges a lot.

The economy is very much specialized in the production of the sector where it has its comparative advantage. Since the US has a relatively large share of skilled workers it specializes more in the production of the skill-intensive sector, sector S. Raising import-tariffs partially reverses this specialization. Imports from China become more expensive and thus it becomes profitable for the US to increase its production in the unskilled-intensive sector, sector U.

In the short run this implies that the price of sector U, p_U rises relative to sector S and consequently the wages of workers employed in sector U rise relative to the wages of workers in sector S, irrespective of the

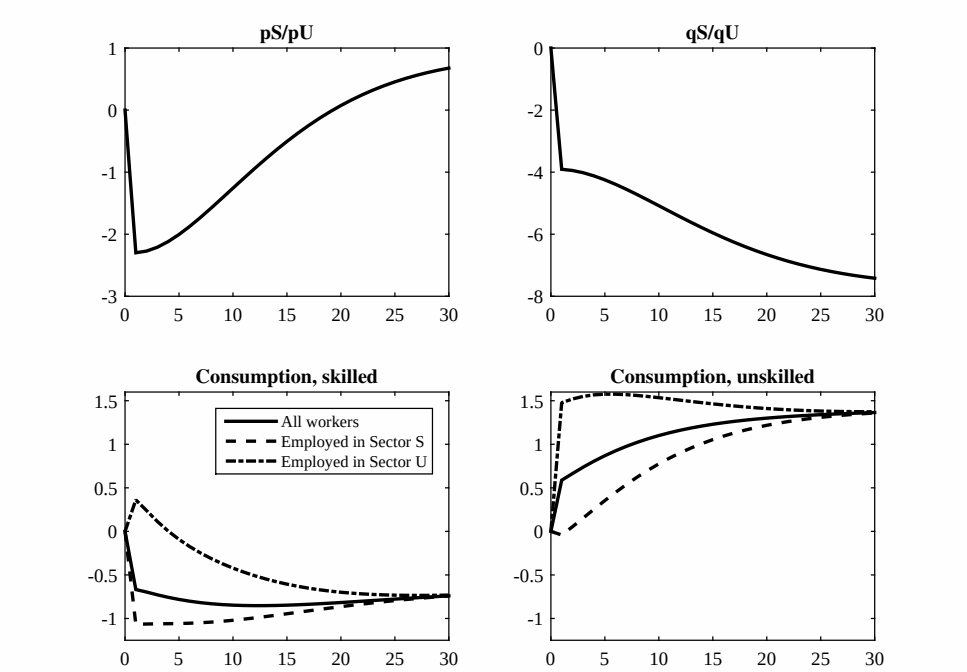

Figure 3: Effects of an increase in the US tariff from 3% to 32%. Quarters on the horizontal axis, percent deviations from the old steady state on the vertical axis.

skill-class of the worker. In the longer run, both firms and workers migrate from sector S to sector U. This not only tends to equalize wages across sectors but also has the implication that the skill-mix changes in both sectors, making unskilled workers relatively more productive. Put differently, the reduced importance of the skill-intensive sector puts downward pressure on the wage of skilled workers but this effect takes time to fully materialize because production factors need to reallocate.

As seen in figure 3 the described adjustment implies very diverse developments in the consumption of different types of workers. Skilled workers in the unskilled-intensive sector gain in the short run due the increased importance of sector U but lose in the long run due to the lower demand for skills. In contrast, unskilled workers in the skill-intensive sector lose a bit in the short run due to the decreased importance of their sector but gain in the long run due to the increased demand for unskilled workers. Skilled workers in skill-intensive sector are worst off, losing both in the long run and even more in the short run. The biggest winners of the increase in tariff are the unskilled workers in the unskilled-intensive sector, gaining both in the short run and in the long run with short-run gains even overshooting their long-run equilibrium.

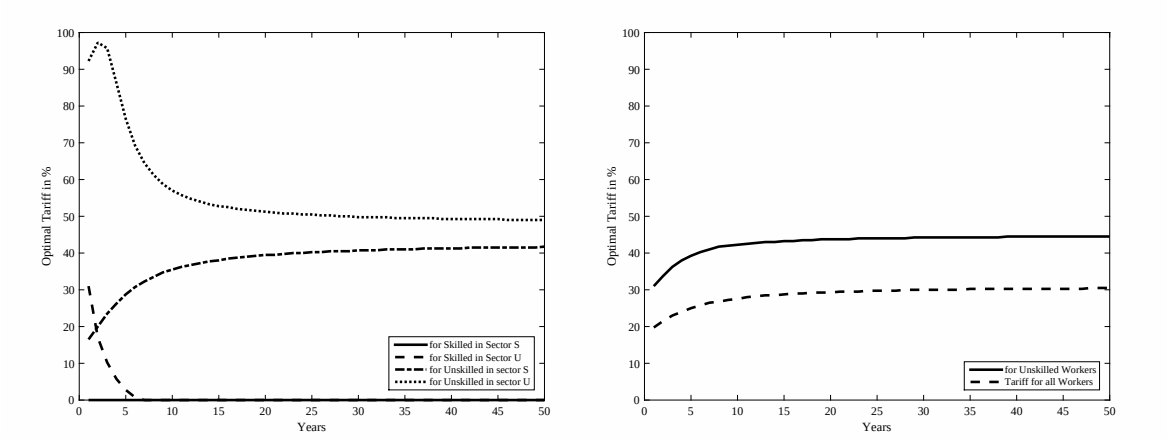

Figure 4: Optimal tariff in dependence of the worker's planning horizon.

4.2 Worker-specific preferences for tariffs

Naturally, these diverse developments imply very different preferences for trade policy. This is illustrated in the left-hand panel of figure 4 which shows the tariff that maximizes the present discounted value of consumption of specific workers up to period x, where x is measured on the horizontal axis. Skilled workers in the skill-intensive sector always prefer zero-tariffs, whereas skilled workers in the unskilled-intensive sector might vote for tariffs as high as 30% if they have a short-run perspective, but also prefer zero-tariffs when having a long-run perspective. While unskilled workers tend to prefer higher tariffs, it is not generally true that they always want higher tariffs than skilled workers. If their horizon is sufficiently short-run, unskilled workers in the skill-intensive sector actually prefer lower tariffs than skilled workers in the unskilled-intensive sector. As expected, unskilled workers in the unskilled-intensive sector are the most in favor of protectionism, especially (but not only) when they have a short-run perspective.[13]

Thus, figure 4 paints a rich picture for trade protection preferences and powerfully demonstrates the important role of the dynamic adjustment in response to trade shocks and the time-perspective of policy makers and voters. It is neither solely the skill-class of a worker nor the skill-intensity of the sector in which the worker is employed that determines her preferences for trade protection. It is rather a combination of both aspects that matters with the time perspective importantly affecting the relative weight of both.

[13]These results are broadly in line with the empirical evidence that finds that unskilled workers and workers in comparative disadvantage sectors tend to favor protectionism, see, e.g., Beaulieu (2002), Mayda and Rodrik (2005), Sanz and Martinez i Coma (2008), or Scheve and Slaughter (2001).

The potential preference of voters with a short-run perspective for higher tariffs is in stark contrast with the analysis in Larch and Lechthaler (2013) and Lechthaler (forthcoming) where a shorter perspective robustly implies a preference for lower tariffs. Given these previous results it is a bit of a puzzle that politicians nevertheless often promote protectionism on their campaigns and that indeed many voters tend to favor protectionism. Figures 3 and 4 provide an explanation for this result showing that specific worker groups benefit more in the very short run and might thus support protectionism even more strongly if they have a shorter time perspective.

Finally, this section presents an alternative approach to determine the political economy equilibrium: the tariff chosen by a coalition of unskilled workers. Our model features four different types of workers, depending on the skill class of the workers and the sector where they are employed. According to our calibration none of these groups is in absolute majority, but, in line with the data, unskilled workers have a majority over skilled workers. Since unskilled workers are affected similarly by tariffs, at least in the medium and long run, it is natural for these workers to form a coalition.

The solid line in the right-hand panel of figure 4 illustrates the tariff chosen by such a coalition (along with the tariff of the benchmark case where aggregate consumption is maximized). As discussed above an import-tariff benefits unskilled workers since it increases the relative demand for the unskilled-intensive sectors and thereby the relative wage and consumption of unskilled workers. Therefore, such a coalition would choose a higher tariff than the tariff that maximizes overall consumption irrespective of the time perspective.

5 Nash-equilibrium economy-wide tariffs

So far we have analyzed unilaterally optimal tariffs, i.e., we have assumed that the US can set its tariffs as it likes while Chinese tariffs stay at their old level. It seems likely, however, that China would not just accept the increase in US-tariffs, but rather retaliate by increasing tariffs on its own. In fact, the same argument as for raising US-tariffs (the terms of trade externality) applies, of course, also for the Chinese tariff: by increasing its tariff China can raise its own consumption (given a certain US-tariff).

Therefore, in this section we consider what Ossa (2014) calls a trade war, a non-cooperative game be-

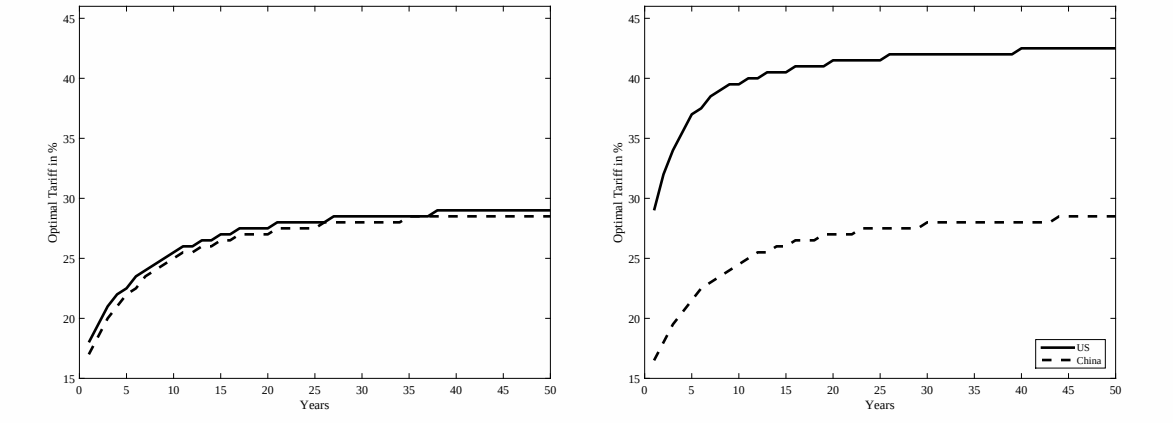

Figure 5: Nash-equilibrium tariffs in dependence of the policy maker's planning horizon. Left panel: US maximizes consumption of all workers; right panel: US maximizes consumption of unskilled workers.

tween two countries. The equilibrium of this game is a Nash-equilibrium that is defined as the combination of US-tariff and Chinese tariff from which neither country has an incentive to deviate.[14]

To determine the Nash-equilibrium we compute the best-response function for both countries, i.e., for a wide range of tariffs for the US we calculate the optimal tariff of China and vice versa. The intersection of both best-response functions is the Nash-equilibrium. No country has an incentive to deviate from this equilibrium because consumption is already maximized, given the tariff of the other country.

Figure 5 shows the resulting Nash-equilibrium tariff for both countries, for different planning horizons of the policy maker and under two different assumptions of whose consumption is maximized. In the left-hand panel policy makers of both countries maximize aggregate consumption, whereas for the right-hand panel it is assumed that in the US policy is determined by a coalition of unskilled workers (whereas Chinese policy still maximizes China's aggregate consumption).

The same basic pattern applies as before. Concentrating on a short time horizon implies lower tariffs and concentrating on unskilled workers implies higher tariffs. When both country's policy makers maximize their respective country's aggregate consumption, China sets a slightly lower tariff, because it gains more from international trade. When policy makers in the US maximize the consumption of unskilled workers only, then the two countries charge very different tariffs with the gap lying around 15 percentage points.

[14]The non-cooperative game is basically a prisoners dilemma. From an aggregate perspective both countries would prefer lower tariffs, but this is not a Nash-equilibrium since both countries have an incentive to deviate from this equilibrium, given the strategy of the other country.

Probably more interesting than the level of optimal tariffs in a potential trade war is the adjustment of the US economy in case such a trade war occurs. The dynamic adjustment of different measures of consumption and the terms of trade is illustrated in figure 6. The terms of trade of the US still increase but due to the increase in the Chinese tariff much less than in our benchmark case of unilateral tariffs. Aggregate consumption no longer increases but rather decreases both in the long run and even more in the short run.

Remember that unilaterally raising tariffs implies two counteracting effects. On the one hand, the tariff reduces the efficiency in production because international trade is reduced and with it specialization and concentration of production in more productive firms. On the other hand, a tariff redistributes income from the affected country to the imposing country. However, if both countries raise their tariff, the first effect is still in place, while the second effect is largely reduced (as illustrated by the much weaker increase in the US's TOT), or even negative in the case of China. This explains why in this scenario aggregate US consumption declines (along with China's consumption).

So from an aggregate perspective the trade war scenario resembles a prisoner's dilemma. Given the strategy of the other country each country acts in its own best interest, but from a joint perspective this leads to an inferior equilibrium. Both countries would be better off if they could coordinate on an equilibrium with lower tariffs.

Thus figure 6 reconfirms that protectionism is harmful. However, the figure adds a nuance to that picture. As before the different groups of workers are affected very differently by the increase in tariffs, and while most workers are negatively affected, the unskilled workers in the import-competing sector actually gain even in this scenario. In the new steady state their consumption is basically the same as in the old steady state but during the transition period they can enjoy temporarily enhanced consumption. Thus even in this trade war scenario some workers are gaining and might lend political support to protectionist ideas.

6 Optimal sector-specific tariffs

So far it was assumed that the same tariff is charged in both sectors. We now relax this assumption to allow for the setting of different tariffs in both sectors. In this setup we again look at unilaterally optimal tariffs, i.e., we go back to our assumption that only the US is allowed to change its tariff, while China keeps its

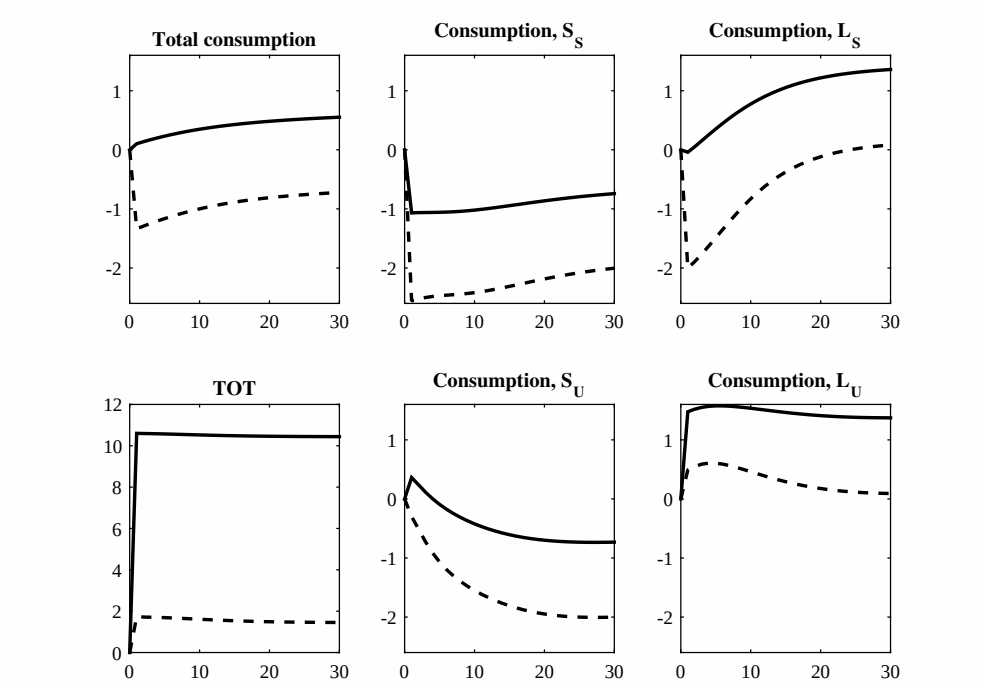

Figure 6: Effects of a trade war; US raises tariff to 29%, China raises tariff to 28.5%. Quarters on the horizontal axis, percent deviations from the old steady state on the vertical axis. Solid line: benchmark of unilateral tariff; dashed line: trade war

tariff at the empirically observed 6%. It is important to consider sector-specific tariff increases because our previous analysis showed that workers employed in different sectors have very different preferences about tariffs, especially if they have a short-run perspective.

In our analysis of sector-specific tariffs we again compare the tariffs chosen under the assumption that policy makers only care about the infinite future, the new steady state, with the outcome when policy makers care about short-run effects, too. Based on the steady state analysis, the unilaterally optimal tariffs are 30.5% for the unskilled-intensive sector and 34.3% for the skill-intensive sector. Thus the optimal tariff for the skill-intensive sector is substantially larger than the optimal tariff for the unskilled-intensive sector. The reason is that the imports of the skill-intensive good are quantitatively less important than the imports of the unskilled-intensive sector. Consequently the distortions created by a tariff on the skill-intensive good are also quantitatively less important and a higher tariff can be afforded.

Figure 7 shows the dynamic adjustment to the optimal equilibrium of the static analysis under the as-

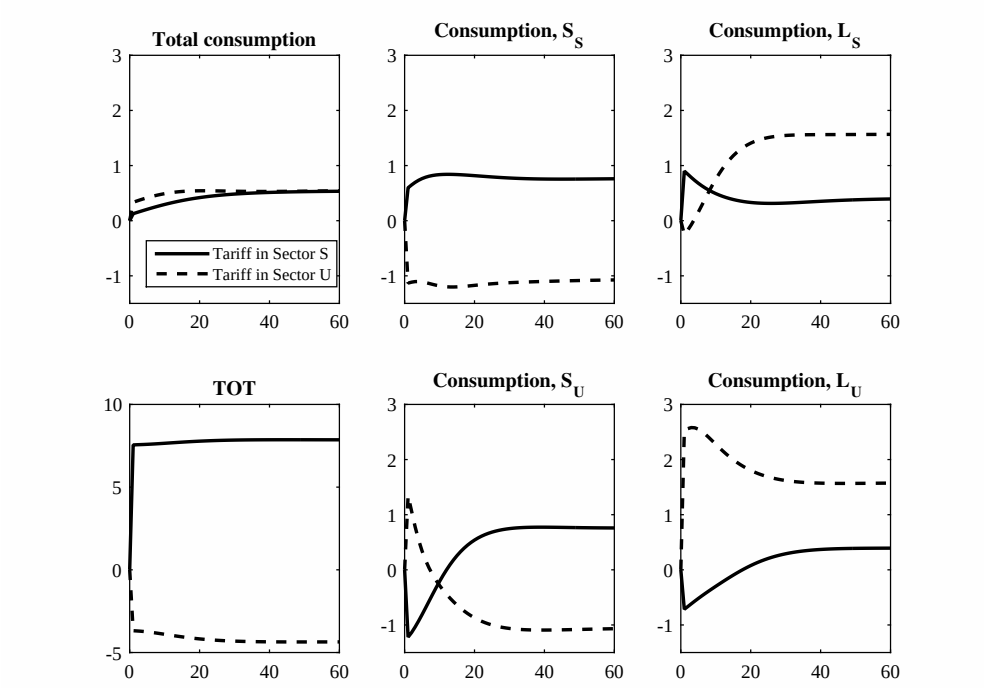

Figure 7: Effects of an increase in sector-specific US tariffs from 3% to the optimum of the static analysis. Quarters on the horizontal axis, percent deviations from the old steady state on the vertical axis.

sumption that in the initial steady state one sector-tariff is already at this optimal level while the other tariff is still at the calibrated level of 3%. Thus the solid line shows the adjustment from an equilibrium with $t_S = 3\%$ and $t_U = 30.5\%$ to an equilibrium with $t_S = 34.3\%$ and $t_U = 30.5\%$, while the dashed line shows the adjustment from an equilibrium with $t_S = 34.3\%$ and $t_U = 3\%$ to an equilibrium with $t_S = 34.3\%$ and $t_U = 30.5\%$. We are showing this specific experiment because it is the situation that is most representative of the decision problem of a policy maker who has to determine the optimal level of one tariff given the optimal level of the other tariff.

Figure 8 shows the optimal tariff of the dynamic analysis for different time-horizons of the policy maker. The left panel represents a policy maker who maximizes welfare of all workers, the right panel a policy maker who maximizes welfare of unskilled workers. Looking at the tariff chosen by a policy maker with a very long time-horizon we see again the pattern that optimal tariffs of the dynamic analysis are lower than the optimal tariffs of the static analysis. As in the previous analysis, consumption increases only sluggishly

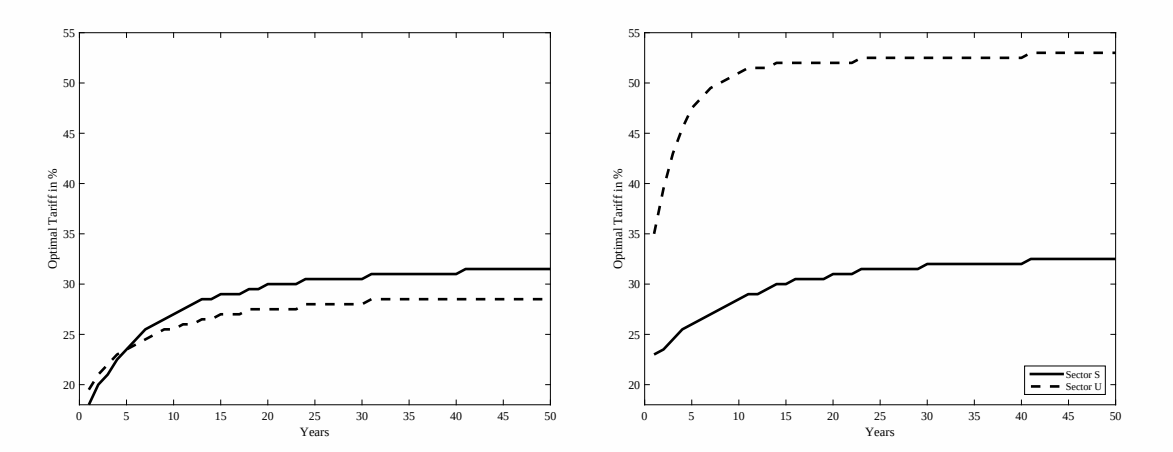

Figure 8: Optimal sector-specific tariffs in dependence of the policy maker's planning horizon. Left panel: tariff maximizes consumption of all workers; right panel: tariff maximizes consumption of unskilled workers.

following an increase in tariffs (see 'total consumption' in figure 7). For this reason a policy maker that cares about the adjustment process chooses a lower tariff than a policy makers that only cares about the new steady state.

Figure 7 also reveals that consumption increases much more slowly in response to an increase in t_S compared to an increase in t_U. This explains the steeper profile for t_S in figure 8, so that the tariff of the skill-intensive sector depends more strongly on the time-horizon of the policy maker. For policy makers with a very short time-horizon it is even possible that a higher tariff is chosen for the unskilled-intensive sector rather than the skill-intensive sector.

While the effects of both tariffs on aggregate consumption are relatively similar, figure 7 also shows that their effects on worker-specific outcomes are very different. Both sector-specific tariffs imply a shift in production towards the sector where the tariff is raised because imports in that sector become directly more expensive so that consumption has to rely more strongly on domestic production. In the long run this favors the production factors that are used more intensively in the sector where the tariff is increased. In the short run this favors the production factors currently employed in that sector. This explains why unskilled workers prefer substantially higher tariffs in the import-competing sector, especially when they have a long time-perspective because their gains are larger once most of the adjustment to the new equilibrium is accomplished.

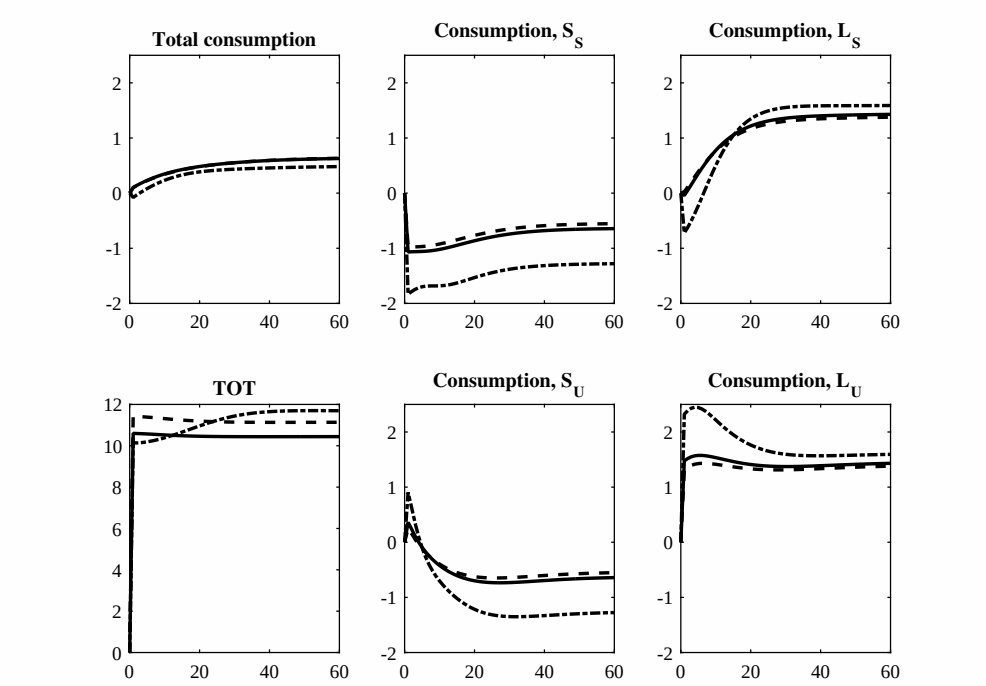

Figure 9: Effects of an increase in sector-specific US tariffs from 3% to the long-run optimum of the dynamic analysis. Quarters on the horizontal axis, percent deviations from the old steady state on the vertical axis. Solid line: benchmark of unilateral tariff; dashed line: sector-specific tariff; dotted-dashed line: sector-specific tariff for unskilled workers.

Finally, figure 9 shows the dynamic adjustment of selected variables from the old steady state with tariffs of 3% to the new steady state of optimal sector-specific tariffs under the assumption that the policy makers have a very long time-horizon (50 years or more) and that the policy makers either maximize the welfare of all workers (dashed line) or the welfare of unskilled workers (dotted-dashed line).[15] The adjustment processes of these scenarios are compared to the adjustment process of our benchmark case in which the tariff of both sectors is increased by the same amount.

Figure 9 shows that the adjustment of aggregate consumption is virtually the same in our benchmark case and the case where the policy makers set different tariffs in both sectors but maximize consumption of all workers. Nevertheless, there are some minor differences concerning worker-specific outcomes. Skilled workers lose a bit less if tariffs are sector-specific while unskilled workers gain a bit less.

Naturally, the effects are stronger when the policy maker maximizes the welfare only of unskilled work-

[15]The main difference to figure 7 is that here both tariffs are increased at the same time, while tariffs were increased separately in figure 7.

ers, but the picture is also more diverse. Again we see the pattern that unskilled workers in the skill-intensive sector lose in the short run while they gain in the long-run. Thus a policy that maximizes the welfare of all unskilled workers might even hurt some unskilled workers in the short run. Aggregate consumption is generally lower in this scenario and even drops in the very short run. We can conclude that sector-specific tariffs are especially bad for skilled workers if policy makers care more about unskilled workers.

7 Conclusion

This paper analyzes the optimal setting of import tariffs and worker preferences for import tariffs in a dynamic model with two countries, two sectors, two factors of production, endogenous firm entry and firm heterogeneity. This setup allows for rich and diverse distributional effects of import tariffs, while at the same building on a tractable and intuitive model. It also allows for the consideration of adjustment dynamics and potential short-sightedness of workers and policy makers.

We find that the distributional effects of tariffs depend both on the skill class of a worker and on the sector where she is employed but the weight of both factors depends importantly on the time perspective of the worker/policy maker. The shorter the time perspective the more important is the sector. With a very long-run time perspective the sector becomes more or less irrelevant.

Due to these diverse and time-dependent distributional effects the preferences for import tariffs can differ substantially across workers and time. E.g., although skilled workers tend to lose from tariffs in the long run, if they are employed in the unskilled-intensive sector and have a sufficiently short time perspective, they might still vote in favor of higher tariffs. Conversely, even though unskilled workers gain from tariffs in the long run, if they are employed in the skill-intensive sector and have a sufficiently short time perspective, they might vote for low tariffs.

The workers gaining most from raising tariffs are unskilled workers in the unskilled-intensive sector and thus they are the ones most in favor of raising tariffs, irrespective of their time perspective. Interestingly, we find that these workers even gain in a trade war in which not only the domestic country raises the tariff but in which the trading partner country retaliates by also raising the tariff. In this scenario aggregate consumption of both countries falls. The same is true for the consumption of skilled workers and for the consumption of

unskilled workers in the skill-intensive sector falls, but not for the consumption of unskilled workers in the unskilled-intensive sector. Thus these workers might be willing to support raising tariffs even in the face of threats of retaliation.

References

ALESSANDRIA, G., AND H. CHOI (2014): "Establishment Heterogeneity, Exporter Dynamics, and the Effects of Trade Liberalization," *Journal of International Economics*, 94(2), 207–223.

AUTOR, D., D. DORN, AND G. HANSON (2013): "The China Syndrome: Local Labor Market Effects of Import Competition in the United States," *American Economic Review*, 103(6), 2221–2168.

AUTOR, D. H., D. DORN, G. H. HANSON, AND J. SONG (2014): "Trade Adjustment: Worker Level Evidence," *Quarterly Journal of Economics*, 129(4), 1799–1860.

BAGWELL, K., AND R. STAIGER (1999): "An Economic Theory of GATT," *American Economic Review*, 89(1), 215–248.

BEAULIEU, E. (2002): "The Stolper–Samuelson Theorem Faces Congress," *Review of International Economics*, 10(2), 343–360.

BERNARD, A., J. EATON, J. JENSEN, AND S. KORTUM (2003): "Plants and Productivity in International Trade," *American Economic Review*, 93(4), 1268–1290.

BERNARD, A., S. REDDING, AND P. SCHOTT (2007): "Comparative Advantage and Heterogeneous Firms," *Review of Economic Studies*, 74(1), 31–66.

BOND, E., AND C. SYROPOULOS (1996): "The Size of Trade Blocs: Market Power and World Welfare Effects," *Journal of International Economics*, 40(3/4), 411–437.

BURSTEIN, A., AND M. MELITZ (2013): "Trade Liberalization and Firm Dynamics," in *Advances in Economics and Econometrics, Econometric Society Monographs*, vol. 2. Cambridge, United Kingdom.

CACCIATORE, M. (2014): "International Trade and Macroeconomic Dynamics with Labor Market Frictions," *Journal of International Economics*, 93, 17–30.

CACCIATORE, M., AND F. GHIRONI (2014): "Trade, Unemployment, and Monetary Policy," *unpublished manuscript*, available at: https://sites.google.com/site/cacciatm/research.

COŞAR, K. (2013): "Adjusting to Trade Liberalization: Reallocation and Labor Market Policies," *unpublished manuscript*.

CONCONI, P., G. FACCINI, AND M. ZANARDI (2014): "Policymakers' horizon and trade reforms: The protectionist effect of elections," *Journal of International Economics*, 94, 102–118.

DAUTH, W., S. FINDEISEN, AND J. SUEDEKUM (2014): "The Rise of the East and the Far East: German Labor Markets and Trade Integration," *Journal of the European Economic Association*, 12(6), S.1643–1675.

DEMIDOVA, S., AND A. RODRIGUEZ-CLARE (2009): "Trade Policy under Firm-Level Heterogeneity in a Small Economy," *Journal of International Economics*, 78(1), 100–112.

DIX-CARNEIRO, R. (2014): "Trade Liberalization and Labor Market Dynamics," *Econometrica*, 82(3), 825–885.

EBENSTEIN, A., A. HARRISON, M. MCMILLAN, AND S. PHILLIPS (2009): "Why are American Workers getting Poorer? Estimating the Impact of Trade and Offshoring Using the CPS," Working Paper 15107, National Bureau of Economic Research.

EBENSTEIN, A., M. MCMILLAN, Y. ZHAO, AND C. ZHANG (2011): "Understanding the Role of China in the 'Decline' of US Manufacturing," .

FELBERMAYR, G., B. JUNG, AND M. LARCH (2013): "Optimal Tariffs, Retaliation and the Welfare Loss from Tariff Wars in the Melitz Model," *Journal of International Economics*, 89(1), 13–25.

GAGNON, J. (2017): "We Know What Causes Trade Deficits," *Peterson Institute for International Economics*.

KAMBOUROV, G. (2009): "Labour Market Regulations and the Sectoral Reallocation of Workers: The Case of Trade Reforms," *Review of Economic Studies*, 76(4), 1321–1358.

KRUGMAN, P. (1991): "Is Bilateralism Bad," in: Helpman, E., and A. Razin (eds.), International Trade and Trade Policy. MIT Press, Cambridge, pp. 9–23.

LARCH, M., AND W. LECHTHALER (2013): "Whom to Send to Doha? The Shortsighted Ones!," *Review of Economic Dynamics*, 16(4), 634–649.

LECHTHALER, W. (forthcoming): "Ben Bernanke in Doha: The effect of monetary policy on optimal tariffs," *Journal of Money, Credit, and Banking*.

LECHTHALER, W., AND M. MILEVA (2013): "Trade liberalization and wage inequality: New insights from a dynamic trade model with heterogeneous firms and comparative advantage," Discussion paper, Kiel Working Paper.

MAYDA, A., AND D. RODRIK (2005): "Why are Some People (and Countries) More Protectionist than Others?," *European Economic Review*, 49(6), 1393–1430.

MELITZ, M. (2003): "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 71(6), 1695–1725.

ORNELAS, E. (2005): "Rent Destruction and the Political Viability of Free Trade Agreements," *Quarterly Journal of Economics*, 120(4), 1475–1506.

OSSA, R. (2014): "Trade Wars and Trade Talks with Data," *American Economic Review*, 104(12), 4104–4146.

PIERCE, J. R., AND P. K. SCHOTT (2016): "The Surprisingly Swift Decline of U.S. Manufacturing Employment," Discussion Paper 7.

RYOO, J., AND S. ROSEN (2004): "The Engineering Labor Market," *Journal of Political Economy*, 112(S1), S110–S140.

SANZ, I., AND F. MARTINEZ I COMA (2008): "Skill and support to globalization in the EU," *Applied Economic Letters*, 15, 271–275.

SCHEVE, K., AND M. SLAUGHTER (2001): "What determines individual trade-policy preferences?," *Journal of International Economics*, 54, 267–292.

WACZIARG, R., AND J. S. WALLACK (2004): "Trade Liberalization and Intersectoral Labor Movements," *Journal of International Economics*, 64(2), 411–439.

YI, S. (2000): "Free-Trade Areas and Welfare: An Equilibrium Analysis," *Review of International Economics*, 8(2), 336–347.

8 Appendix: The role of worker mobility

8.1 Endogenous skill formation

So far it was assumed that the number of skilled workers is exogenously given. This is the standard assumption in the trade literature and allows for a simpler model. However, we have seen that an increase in the tariff reduces the demand for skilled workers and thus it is to be expected that workers would be investing less in their skills.

To take account of this we extend the model to introduce endogenous skill formation, by allowing newly entering workers to train to become skilled workers. To model this we assume that newly entering workers need to pay a training cost ε^T that is drawn from the random distribution $\Gamma(\varepsilon^T)$ with support on $[\varepsilon^T_{\min}, \infty)$. An entering worker decides to train if the value of being skilled is high enough to justify the training cost, i.e., if:

$$V^s_t - \varepsilon^T_t > V^l_t. \tag{26}$$

where V^s is the expected present discounted value of consumption for a skilled worker and V^u is the same value for an unskilled worker. Equation 26 defines a threshold $\overline{\varepsilon^T_t}$ for which a worker is indifferent between training and not training and the probability of training then is:

$$\eta^t_T = \Gamma\left[\max(\overline{\varepsilon^T_t}, \varepsilon^T_{\min})\right]. \tag{27}$$

The simulate the model we assume that the training cost follows an exponential distribution with a

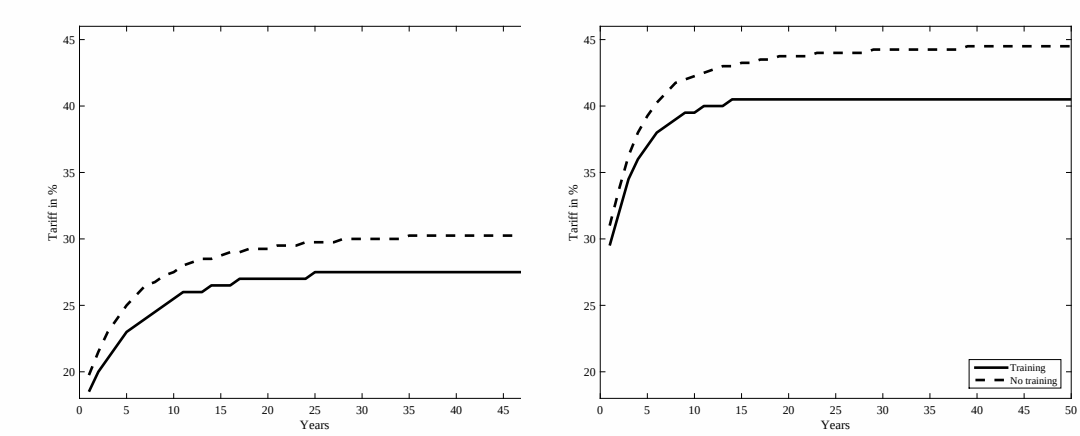

Figure 10: Optimal tariff in dependence of the policy maker's planning horizon with endogenous training. Left panel: tariff maximizes consumption of all workers; right panel: tariff maximizes consumption of unskilled workers.

parameter $scaleT$ for H and $scaleT^*$ for F.[16] The parameters are set so that the pre-liberalization steady state training probability in H and F match the shares of skilled workers in the labor force of each country, such that $\eta_T = 0.222$ for H and $\eta_T = 0.0955$ for F. This ensures that the pre-liberalization steady state is the same in the model with and without training.

The implications of endogenous skill formation for optimal tariffs are illustrated in figure 10 which compares the case of endogenous skill formation to our benchmark case with an exogenously given number of skilled and unskilled workers. The left panel shows the case where the tariff maximizes the present discounted value of consumption of all workers, the right panel the tariff that maximizes the consumption of unskilled workers.

In both cases the optimal tariff is lower under endogenous skill formation. As explained above, raising tariffs lowers the demand for skills with the implication that fewer workers find it worthwhile to invest in their skills to become a skilled worker. Thus raising tariffs is more costly under endogenous skill formation and the optimal tariff is lower. Note that in this scenario raising tariffs is also less beneficial for unskilled workers, because this leads to an increase in the supply of unskilled workers putting downward pressure on their wages. They still prefer higher tariffs than skilled workers but to a lesser extent than in our benchmark.

[16] We choose the exponential distribution because it has only one parameter, the scale parameter, and its minimum is always zero.

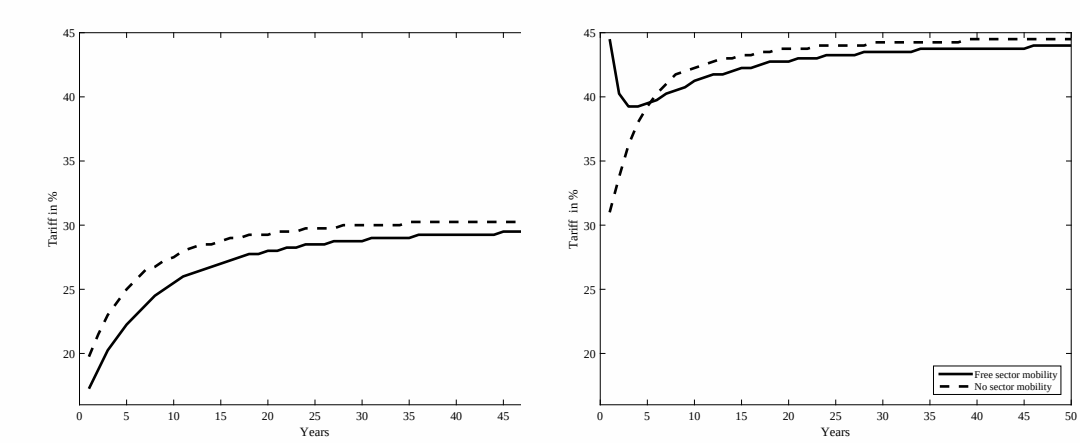

Figure 11: Optimal tariff in dependence of the policy maker's planning horizon with free sector mobility. Left panel: tariff maximizes consumption of all workers; right panel: tariff maximizes consumption of unskilled workers.

8.2 Sector mobility

In line with recent empirical evidence we have assumed that the mobility of workers across sectors is very limited. In this section we take the opposite case and assume that workers can freely move across sectors at any time. This implies that the wage differential across sectors completely vanishes. If the wage in one sector was slightly higher, workers would move to that sector until the wage differential has vanished. The number of workers in each sector is then endogenously determined by the condition that the wage is the same in both sectors.

Given a specific tariff the steady states of both versions of the model are basically the same. So according to a static analysis the optimal tariff would be the same in both cases. However, as figure 11 shows, the dynamic analysis yields quite different results, especially but not only in the short run.

The tariff that maximizes aggregate consumption is always lower when workers are mobile across sectors than when they are immobile. The reason is that under full mobility of workers firm investment increases much more strongly. In the version of the model with limited mobility, firm investment during the transition is subdued due to the 'wrong' allocation of workers. This is no longer the case under full mobility, implying more firm investment and thus lower aggregate consumption during the transition. Since aggregate consumption is lower, the tariff that maximizes the present discounted value of consumption of all workers is smaller.

For the unskilled workers there is an additional effect. As explained above, an increase in the tariff raises the relative demand for unskilled workers, but workers need to reallocate across sectors for this effect to become important. Under full mobility of workers this reallocation happens much faster and thus unskilled workers gain much more quickly. Due to the slow adjustment of firms the consumption of unskilled workers is actually overshooting their long run equilibrium. This explains why the tariff that maximizes the consumption of unskilled workers is especially high in the short run and might even be higher than in the benchmark with immobile workers.