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Abstract

We propose a multi-country model with occupational choice, heterogeneous firms, unemployment, and revenue-generating tariffs to study the aggregate and distributional consequences of tariff wars in a unified framework. Motivated by the 2018 global tariff war, we calibrate the model to fit a global economy with four countries, the United States, the European Union, China and the Rest of the World. If governments maximize aggregate welfare, the average optimal tariff and the average Nash-equilibrium tariff are about 16 percent. Multilateral trade negotiations lead to zero cooperative tariffs and free trade. No country can win a trade war. If governments adopt a political-economy perspective and maximize a weighted sum of entrepreneurial and worker interests with weights incorporating factual "autonomous rate" tariffs, then trade talks lead to positive cooperative tariffs in the range of 14 percent for the U.S. to 43 percent for China, and tend to increase unemployment and income inequality.

JEL Classification: F13, F14 J2, J3, J6, L1

Keywords: Trade Wars, Tariffs, Entrepreneurs, Income Inequality, Unemployment, Welfare Occupational Choice, Top Incomes

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1 Introduction

In February 2018, the Trump administration reversed more than seventy years of global trade liberalization supported by the United States leadership with the announcement of the imposition of 30 percent tariffs on solar panels and 20 to 30 percent tariffs on washing machines. This dramatic action initiated a global tariff war. According to Fajgelbaum et al. (2020), by the end of 2018 more than $300 billion (about 12 percent) of U.S. imports corresponding to more than 12,000 products were subject to tariffs in the range of 10 to 50 percent. These tariffs aimed primarily at Chinese imports and generated more than $12 billion of tariff revenue (Amiti et al. 2019).

In response, major U.S. trading partners, especially China, imposed tariffs on about $121 billion of U.S. exports. These retaliatory actions resulted in a 17 percent average tariff increase on more than 2,800 (about 34 percent of) U.S. exported products.[1] After trade talks with China ended without an agreement in May 2019, the U.S. increased tariffs on another $200 billion Chinese imports from 10 percent to 25 percent with China announcing more tariffs on $60 billion U.S. exports to China.

The causes and effects of the 2018 trade war constitute the subject of an ongoing debate and raise several questions. Are the observed tariffs consistent with government welfare-maximizing behavior? Does the government place different weights on the interests of firms and workers? What are the levels of welfare-maximizing tariffs and how do they compare to observed tariffs? What are the welfare effects of the global tariff war? Is there room for tariff reductions through trade negotiations? What is the impact of a tariff war on the personal income distribution and its two major components, top incomes and unemployment? This paper addresses these questions within a multi-country, general equilibrium model with occupational choice, equilibrium unemployment, heterogeneous firms, employer size-wage premium, and revenue-generating tariffs.

In our model, individuals within each country differ in managerial talent (entrepreneurial ability) and choose to become entrepreneurs or workers, as in Lucas (1978). Each entrepreneur creates and manages her own firm, and produces a different variety using her managerial talent and workers. As in Melitz (2003), firms have monopolistic competition, and face fixed market-entry costs and per-

[1] In addition to China, the European Union, Mexico, Canada, Russia and Turkey participated in this trade war by imposing retaliatory tariffs against U.S. exports. Amiti et al. (2019) and Fajgelbaum et al. (2020) offer detailed descriptions on the timeline and tariff composition of the 2018 global tariff war.

unit transportation costs if they wish to export. In addition, each exporter must pay an ad-valorem tariff which generates revenue that is distributed back to each resident of the tariff-imposing country in proportion to her free-trade income. Individuals who choose to become workers face the prospect of unemployment generated by search and matching frictions in labor markets. Using insights from Helpman et al. (2010), we introduce a worker-selection process that generates an employer size-wage premium according to which entrepreneurs with higher talent hire more workers and offer a higher negotiated wage.

We can quantitatively solve the model for optimal, Nash-equilibrium, and cooperative tariffs, and investigate their effects on inequality, unemployment, and welfare across countries. We take the model to the data by performing a quantitative analysis with four countries (regions): the United States (U.S.), the European Union (EU), China (CHN), and the rest of the world (ROW). We focus on these countries because they are the main players of this global trade war. In the calibration exercise, we choose parameters that are commonly used in the literature or allow us to match several targeted moments in the data such as the fraction of entrepreneurs in the U.S., the share of exporters, unemployment rates, and inequality measured by Gini coefficients.

The main findings of the quantitative analysis are summarized as follows. First, we analyze the effects of three counterfactual tariff regimes under three distinct government objectives. We start with the assumption that governments care about national aggregate welfare. In this case, the first regime consists of each country's multilateral optimal tariffs. These are duties applied to imports across all import suppliers that maximize a country's welfare when its trade partners maintain their factual tariffs. Optimal multilateral tariffs are close to 16 percent for all 4 countries we consider. Interestingly, these tariffs are higher than average factual tariffs, which range between 3 percent for the U.S. and 10 percent for China, and close to the minimum of observed tariffs during the 2018 global trade war. For instance, the U.S. optimal tariff of 16 percent is less than the 25 percent U.S. tariff imposed on 2850 products in 2018 and on $200 billion imports from China in May 2019. We also find that Nash-equilibrium tariffs under a global-tariff war are numerically almost identical, although slightly higher than optimal tariffs.[2] Finally, we show that if governments care about national aggregate welfare, then cooperative tariffs are zero for all countries leading to global free

[2]The numerical proximity between optimal and Nash-equilibrium tariffs stems from the low sensitivity of optimal tariffs to tariffs imposed by other countries.

trade.

When governments maximize national aggregate welfare, the welfare and income distributional effects of these tariff regimes are substantial and highly country-specific. We find that a move from factual tariffs to a tariff war supported by Nash-equilibrium tariffs lowers welfare for each country. This implies that no country can win a global trade war.[3] Trade negotiations are universally beneficial and increase each country's aggregate welfare. We find that, while countries can unilaterally benefit from tariffs in the absence of retaliation, unilateral actions come at the cost of higher unemployment and inequality. Cooperation generally improves the income distribution and the unemployment rate in larger countries such as the U.S., but worsens them in smaller economies. In sum, if governments care about aggregate welfare and thus place equal weights on every real dollar no matter who earns it, then the 2018 trade war constitutes a "policy mistake" which can be fixed through trade negotiations leading to global free trade.[4]

Second, we show that preferred tariffs vary significantly by income group in each economy. While aggregate optimal and Nash-equilibrium tariffs are moderate and cooperative tariffs lead to free trade, they tend to be three to five times higher for smaller entrepreneurs who serve the domestic market. This finding leads to focus on income-distributional considerations and analyze the effects political-economy based government objectives. One objective coincides with the interests of the top 10 percent income earners in each economy which captures the interests of entrepreneurs (as opposed to workers). If the government were to maximize welfare of the median income earner among the top 10 percent income earners, then a global tariff war would lead to tariffs of 74 percent for the U.S. and China and 60 percent for Europe. In addition, trade negotiations would generally not lead to free trade but instead to about a 62 percent tariff imposed by the U.S. and China and a 50 percent tariff imposed by Europe. In this case, although trade talks are welfare improving, they increase unemployment and income inequality in each country.

Finally, we analyze the tariff effects under a calibrated (hybrid) government objective by allowing each government to place different weights on worker and entrepreneurial (firm) welfare. These

[3]These results support the findings of Amiti et al. (2019) and Fajgelbaum et al. (2020) who argue that the U.S. factual tariffs implemented during 2018 tariff war resulted in short-run U.S. welfare loss corresponding to about 0.04 percent of GDP.

[4]This claim abstracts from national-defense and intellectual property protection consideration which are not modeled in the present paper.

country-specific weights are consistent with the set of non-cooperative tariffs (called "autonomous rates") observed in the data.[5] Specifically, we solve the model for the Nash-equilibrium tariffs under the restriction that the predicted Nash-equilibrium tariffs must equal to the observed average autonomous tariffs for each country: 23 percent for the U.S.; 25 percent for Europe; and 69 percent for China. Our estimates imply that governments in the U.S. and the EU place a comparably larger weight on worker interests than China; and that trade talks lead to strictly positive tariffs in the range of 14 percent for the U.S., 16 percent for Europe and 43 percent for China. In this case, trade talks lead to higher unemployment and more concentrated incomes. In other words, cross-country differences in government preferences reduce the success of trade talks and worsen income inequality.

The rest of the paper is organized as follows. Section 2 offers an overview of related studies. Section 3 develops the multi-country model. Section 4 presents the quantitative analysis and examines the income distributional effects of revenue-generating tariffs. Section 5 offers several concluding remarks.[6]

2 Related Literature

This paper is related to several strands of literature. An important area of research has examined the effects of trade openness on inequality and unemployment. Helpman and Itskhoki (2010) analyze formally the relationship between trade openness and unemployment. Helpman et al. (2010) use a two-country framework with an employer size-wage premium to explore the effects of a move from autarky to free trade on wage inequality. Dinopoulos and Unel (2015, 2017) employ two-country models with occupational choice to examine the effects of trade openness on unemployment and income distribution. The present paper complements this strand of literature in scope and methodology by analyzing the effects of revenue-generating tariffs (as opposed to a move from autarky to trade) on overall income distribution and unemployment within the context of a multi-country computational model.

[5] These are non-cooperative tariffs applied by China, Japan, the EU and the U.S. against a number of non-WTO member countries with which these four countries do not have normal trade relations. Autonomous tariffs are available from MAcMap or TRAINS database (Ossa 2014).

[6] The online appendix, which is available upon request, contains a detailed description of the model and presents additional tables and figures associated with the quantitative analysis.

Another strand of literature examines the nexus between globalization and relative income inequality. Autor et al. (2014) found that import competition from China has affected more adversely the earnings of low-wage workers worsening U.S. wage-income inequality. Lee and Yi (2018) employ a multi-country model with endogenous labor supply and find that global value chains play a prominent role in raising the skill premium in both the U.S. and China. Bourguignon (2016) and Milanovic (2016) argue that globalization has been an important driving force of falling inequality between countries and rising inequality within countries.[7] The Congressional Budget Office (2018), Piketty et al. (2019), and Auten et al. (2019) document the substantial increase in top U.S. incomes. Helpman et al. (2017) employ Brazilian data to estimate the model of wage inequality proposed by Helpman et al. (2010) and find a non-monotonic relationship between wage inequality and trade openness with wage inequality first rising and then declining. Goldberg and Pavcnik (2007) present a comprehensive survey of studies, most of which suggest a contemporaneous increase in globalization and inequality in developing countries. The present paper contributes to this literature by analyzing the effects of tariffs on top incomes and overall income inequality measured by the Gini coefficient. The distributional effects of global tariffs, optimal tariffs and trade wars, which constitute the main scope of our paper, are not the main focus of these studies.

Several studies analyze formally the welfare effects of optimal and Nash-equilibrium tariffs utilizing a two-country framework with perfectly competitive labor markets and exogenous factor supplies (Johnson 1953-54, Gros 1987, Kennan and Riezman 1988, Syropoulos 2002, Felbermayr et al. 2013). Our paper complements this strand of literature by focusing on the analysis of income distributional affects of tariff regimes in a multi-country analytical framework with labor markets exhibiting equilibrium unemployment, wage bargaining, endogenous labor supply, and an employer size-wage premium.

A large number of studies use econometric and quantitative methods to estimate the effects of tariffs.[8] Broda et al. (2008) argue that export supply elasticities are finite leading to positive unilateral optimal tariffs. Caliendo and Parro (2015) employ simulation analysis to examine the welfare effects of NAFTA. Ossa (2011, 2014) proposes a Krugman (1980) type multi-country computational model to analyze the welfare and wage effects of different tariff regimes including a global

[7]Ravallion (2018) offers a comprehensive overview of the literature on inequality and globalization.

[8]Ossa (2016) provides a survey of quantitative models analyzing the effects of trade policies.

tariff war and cooperative tariffs as in the present paper. Amiti et al. (2019) and Fajgelbaum et al. (2020) use standard supply and demand tools to analyze empirically the effects of factual tariffs implemented during the 2018 trade war on U.S. welfare, prices and traded varieties. Our paper complements this strand of literature as well by proposing a multi-country model highlighting the effects of tariffs on personal income distribution measured by the Gini coefficient, unemployment and top incomes. These distributional effects are absent from these studies.

3 The Model

This section introduces the model's building blocks which consist of the behavior of individuals differing in managerial talent, the labor-market equilibrium, and the system of equations that determine the model's general-equilibrium solution for any given tariffs. Appendix A contains the full derivation of the expressions presented in this section.

3.1 Consumers

Consider a world of I countries (indexed by i), each of which is populated by L_i individuals. Consumers have identical preferences described by the following Cobb-Douglas utility function

$$U_i = \left(\frac{q_{0i}}{1-\theta}\right)^{1-\theta}\left(\frac{Q_i}{\theta}\right)^{\theta}, \qquad 0<\theta<1, \tag{1}$$

where q_{0i} denotes consumption of the homogeneous good. Q_i is an aggregate consumption index defined as

$$Q_i = \left[\int_{\omega\in\Omega_i} q_i(\omega)^{\rho} d\omega\right]^{1/\rho}, \qquad 0<\rho<1, \tag{2}$$

where Ω_i is the set of varieties available to consumers in country i, and $q_i(\omega)$ is the quantity consumed of variety ω. The price elasticity of demand for each variety equals the constant elasticity of substitution between any two brands $\sigma = 1/(1-\rho) > 1$.

Utility maximization implies that consumers spend $(1-\theta)E_i$ on the homogeneous good and θE_i on the differentiated-good sector, where E_i denotes country i's aggregate expenditure. The demand for a typical variety

$$q_i(\omega) = D_i p_i(\omega)^{-\sigma}, \qquad D_i \equiv Q_i P_i^{\sigma}, \qquad P_i Q_i = \theta E_i, \tag{3}$$

where D_i captures the market size in country i, and P_i is aggregate price index

$$P_i = \left[\int_{\omega \in \Omega_i} p_i(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}}. \tag{4}$$

We choose the homogeneous good as the model's numeraire and set its price equal to one, that is $p_{0i} = 1$. Substituting $q_{0i} = (1-\theta)E_i$ and $Q_i = \theta E_i / P_i$ in the utility function (1) delivers the following aggregate indirect utility function

$$\mathbb{V}_i = E_i P_i^{-\theta}. \tag{5}$$

Equation (5) is an aggregate welfare measure for country i. Per-capita welfare is then $\mathbb{V}_i / L_i$. Finally, an individual's real income can be derived by replacing E_i in (5) with that individual's nominal income.

Individuals in each country, however, differ in managerial talent (ability) indexed by a and governed by an exogenous cumulative distribution $G(a)$ with support $[1, \infty)$. We assume that talent levels in each country are drawn from the following Pareto distribution

$$G(a) = 1 - a^{-k}, \qquad g(a) = k a^{-(1+k)}, \tag{6}$$

where k is the dispersion parameter and $g(a)$ is the density function. We assume that $k > \sigma - 1$ so that aggregate variables have finite values. Pareto distribution is commonly used in trade models with heterogeneous firms, and adds analytical tractability.[9]

3.2 Firms

We assume that identical single-worker firms produce the freely-traded homogeneous good under perfect competition. Firms in this sector face labor-market frictions as in Helpman and Itskhoki (2010): each firm posts a job vacancy which is not instantaneously filled. If a vacancy is filled, one unit of output is produced generating one dollar in firm revenue (since $p_{0i} = 1$). After a successful match, the firm and worker bargain over firm revenue. Assuming equal bargaining power between firm and worker, and no unemployment benefits, the worker receives half of the revenue, that is $w_{0i} = 1/2$. The remaining revenue equals hiring costs per worker.

[9] See Helpman et al. (2004), Chaney (2008), Helpman et al. (2010), and Dinopoulos and Unel (2015, 2017) among many others.

Differentiated goods are produced by a continuum of firms under monopolistic competition with each firm producing a single variety and employing multiple workers. Each firm is owned and managed by an entrepreneur with managerial talent a. Following Lucas (1978), we assume that income of an active entrepreneur equals firm profits. Firm output depends on managerial talent a and the measure of retained (hired) workers h_i

$$q_i(a) = a^{1+\lambda_i} h_i, \tag{7}$$

where $\lambda_i \geqslant 0$ is a constant and term $a^{1+\lambda_i}$ equals worker productivity (output per hired worker) which increases with managerial talent a.

The measure of hired workers h_i is determined through a process of worker training. Specifically, if an entrepreneur incurs $c_i n_i$ costs measured in units of the homogeneous good, then she is matched with a sample of n_i workers (trainees). Parameter c_i denotes acquisition costs per matched worker in country i and is derived in the unemployment subsection below. We assume that matched workers must undertake training to acquire firm-specific human capital and learn the firm's technology. Out of n_i trainees only $h_i < n_i$ complete their training successfully and become retained workers.

There are various ways to link sampled to hired workers. For example, Helpman et al. (2010) propose a process of worker-ability screening involving variable costs and resulting in larger firms hiring workers with higher average ability. We propose a worker-training process of human-capital acquisition.[10] We provide a formal description of this process in Appendix A, and derive the following "reduced-form" equation that relates the measure of hired workers h_i to the measure of sampled workers n_i and entrepreneurial talent a:

$$h_i = n_i \xi_i a^{-\lambda_i}, \qquad \xi_i > 0. \tag{8}$$

Equation (8) states that the fraction of retained workers h_i/n_i increases with parameter ξ_i and declines with managerial talent a and parameter λ_i.[11] This specification delivers three advantages.

[10]Franzis et al. (1998) report that workers spend roughly 4 percent of their working hours on training and that the incidence of training tends to be higher in larger establishments. Barron et al. (1987) document that larger employers devote substantially more resources to worker search and worker training: a 10 percent increase in employer size is associated with 1.65 percent increase in the number of applicants interviewed per job position.

[11]Based on purely tractability considerations, we assume that worker training involves no (or only fixed) costs; and that the fraction of workers completing training successfully declines with the target level of human capital per worker. In other words, by setting a higher target of human capital a firm becomes more selective. Finally, we assume that the human-capital target (capturing the level of firm technology) equals the entrepreneur's managerial talent.

First, it states that entrepreneurs with higher managerial talent are more selective. Because firm productivity increases with managerial talent in accordance to (7), unemployment related to the worker-training process is one form of technological unemployment. Second, an entrepreneur with talent a determines the measure of hired workers by choosing the measure of matched workers n_i; as a result, the model becomes more tractable.[12] Third, by assuming that parameters ξ_i and λ_i are country specific, we can match measures of unemployment rates and income inequality in each country when we calibrate the model. Substituting (8) into (7) yields

$$q_i(a) = a\xi_i n_i, \tag{9}$$

thus, output increases with managerial talent and the measure of sampled workers.

If an entrepreneur residing in country i wishes to serve market j, she faces transportation costs, market access fixed costs, and an ad-valorem tariff imposed by the government of country j. Transport and foreign market-access costs are modeled as in Melitz (2003). The former take the familiar iceberg form: $\delta_{ij} \geqslant 1$ units of output must be produced in country i to deliver one unit of output to consumers in country j. We assume that firms do not face transport costs when serving their domestic market ($\delta_{ii} = 1$ for all i) and incur strictly positive transport costs when serving a foreign market ($\delta_{ij} > 1$ if $i \neq j$). Market-access costs are modeled as follows. An entrepreneur producing in country i who serves country j incurs fixed market-entry costs denoted by $f_{ij} > 0$, which are measured in units of the homogeneous good.

Finally, we assume that an entrepreneur located in country i pays ad-valorem tariff $\tau_{ij} \geqslant 0$ when exporting to country j. The tariff revenue is collected by country j's government and distributed back to each consumer in proportion to her free-trade income. Let p^x_{ij} denote the price that the exporting firm producing in country i receives from selling one unit of its product in country j. Consumers in country j pay $p_{ij} = (1 + \tau_{ij})p^x_{ij}$. Hereafter we use the tariff factor $T_{ij} = 1 + \tau_{ij} \geqslant 1$, and assume that $T_{ii} = 1$ for all i and $T_{ij} > 1$ for any $i \neq j$. Notice that the ad-valorem tariff is country-specific and *uniform* across all varieties imported from a particular country.[13]

[12] We offer the following rationale for this specification. Equation (7) indicates that labor and firm productivity $a^{1+\lambda_i}$ is the product of entrepreneurial talent a and worker human capital a^{λ_i}. Equation (8) can be written as $h_i/n_i = \xi_i/a^{\lambda_i}$ and states that the fraction of matched workers who acquire the targeted human capital (or the probability that a matched worker acquires a^{λ_i} units of human capital) captured by term h_i/n_i, declines with the level of human capital. Because more talented entrepreneurs manage more productive firms, the targeted human capital level of trainees increases with managerial talent a. This interpretation is robust to assuming that human capital is proportional instead of equal to managerial talent, and to the introduction of fixed training costs.

[13] This feature is consistent with the evidence that, during the 2018 global tariff war, the U.S. imposed tariffs on

Let $q_{ij}(a)$ denote output of variety a produced in country i and *consumed* in country j. The firm must produce $\delta_{ij} q_{ij}(a)$ units of output destined for the j market. As a result,

$$q_i(a) = \sum_j \mathbb{I}_j \delta_{ij} q_{ij}(a) = a\xi_i n_i, \tag{10}$$

where $\mathbb{I}_j$ is an indicator function that equals one if the firm serves market j and zero otherwise. Revenue in market j is given by

$$r_{ij}(a) = \frac{D_j^{1-\rho} q_{ij}(a)^\rho}{T_{ij}}. \tag{11}$$

It increases with quantity sold in market j and declines with the ad-valorem tariff imposed by country j.

An exporter allocates output between the domestic market i and foreign market j by setting domestic marginal revenue equal to marginal revenue in each foreign market, which yields

$$r_i(a) = \left[\sum_{j \in I} \mathbb{I}_j D_j \delta_{ij}^{-\frac{\rho}{1-\rho}} T_{ij}^{-\frac{1}{1-\rho}} \right]^{1-\rho} (a\xi_i n_i)^\rho, \tag{12}$$

where country j's market size D_j is defined in (3) (see the technical Appendix for the derivation). Profits of a firm managed by an entrepreneur with talent a residing in country i are then

$$\pi_i(a) = r_i(a) - c_i n_i - w_i h_i - \sum_{j \in I} \mathbb{I}_j f_{ij}, \tag{13}$$

where $r_i(a)$ is firm revenue given by (12), $c_i n_i$ is the costs of acquiring n_i trainees, $w_i h_i$ is the wage bill, and the last term captures market-entry fixed costs.

Profits are maximized in three stages. First, an entrepreneur incurs matching costs $c_i n_i$ to obtain n_i trainees. Second, she goes through the selection process to determine the measure of retained workers h_i. Finally, she engages in bargaining with retained workers to determine the negotiated wage w_i. We solve this maximization problem backwards.

Following Stole and Zwiebel (1996), we assume that an entrepreneur engages in bilateral bargaining with each worker and internalizes the effect of a worker's departure on the wage of remaining workers. Assuming that the value of outside options is zero for each departing worker and equal relative bargaining power between each worker and entrepreneur, the negotiated wage is given by

$$w_i(a) = \left(\frac{\rho}{1+\rho} \right) \frac{r_i(a)}{h_i}, \tag{14}$$

more that 12,000 products with 99.8 percent of these varieties facing either a 10 percent or a 25 percent ad-valorem tariff (Fajgelbaum et al. 2020).

and thus a firm earning larger revenue pays a higher wage bill $w_i h_i$.

Anticipating the bargaining process, each entrepreneur maximizes residual profits with respect to the measure of trainees (job applicants) n_i. It then follows that

$$n_i(a) = \frac{\rho r_i(a)}{(1+\rho)c_i}, \tag{15}$$

and thus firms earning higher revenue acquire more trainees.

These first-order conditions allow us to express entrepreneurial profit as

$$\pi_i(a) = \sum_{j \in I} \mathbb{I}_j \left[\frac{\phi D_j}{T_{ij}^{\sigma}} \left(\frac{\xi_i a}{\delta_{ij} c_i} \right)^{\sigma-1} - f_{ij} \right] = \sum_{j \in I} \mathbb{I}_j \pi_{ij}(a), \tag{16}$$

where $\sigma = 1/(1-\rho)$ is the elasticity of substitution and $\phi = (1-\rho)(1+\rho)^{-\sigma}\rho^{\sigma-1} > 0$. Thus, firm profit equals the sum of residual profit in each market.

Next, we solve for the measure of retained workers and the negotiated wage as functions of entrepreneurial talent. The former is given by

$$h_i(a) = \frac{\rho \xi_i a^{-\lambda}}{(1+\rho)c_i} r_i(a) = \sum_{j \in I} \mathbb{I}_j \left(\frac{\xi_i \rho}{(1+\rho)c_i} \right)^{\sigma} \frac{D_j}{\delta_{ij}^{\sigma-1} T_{ij}^{\sigma}} a^{\sigma-1-\lambda_i}, \tag{17}$$

which states that, within each market, firms managed by more talented entrepreneurs hire more workers if and only if $\sigma - 1 > \lambda_i$. Entrepreneurs with higher talent earn higher revenues and thus acquire more trainees, but are more selective as well. The revenue effect dominates if and only if $\sigma - 1 > \lambda_i$. We assume that this condition holds.[14]

The negotiated wage is given by

$$w_i(a) = \frac{c_i}{\xi_i} a^{\lambda_i}. \tag{18}$$

This equation states that firms managed by entrepreneurs with higher managerial talent negotiate a higher wage because they are more selective. Managerial talent is governed by Pareto distribution (6), and therefore the negotiated wage w_i also follows a Pareto distribution with scale parameter c_i/ξ_i and shape parameter k/λ_i. The wage distribution has a finite mean if $k > \lambda_i$, and this condition holds because $k > \sigma - 1$ and $\sigma - 1 > \lambda_i$.

Combining equations (14) and (15) yields

$$w_i(a) \frac{h_i(a)}{n_i(a)} = c_i, \tag{19}$$

[14]Helpman et al. (2010, p. 1250) impose a similar condition. In their model, selection among sampled workers is based on worker-ability screening with more productive firms earning higher revenues, engaging in more intense screening, and hiring workers with higher average ability.

which states that the expected negotiated wage is equal to matching costs per trainee c_i. All entrepreneurs offer the same expected wage and therefore workers are ex-ante indifferent across firms managed by entrepreneurs. Ex-post wage differences across firms managed by entrepreneurs arise purely from the selection (training) process with larger and more productive firms offering higher wages. The following proposition summarizes the main findings so far.

Proposition 1. *A firm managed by a more talented entrepreneur produces more output, earns more revenue, samples more workers, and pays a higher wage. More talented entrepreneurs hire more workers if and only if $\sigma - 1 > \lambda_i$. Workers receive the same expected wage across all firms in the differentiated-good sector.*

Proposition 1 highlights the presence of an employer size-wage premium. This property is consistent with several empirical studies which document a robust positive correlation between firm size and wages.[15]

3.3 Occupational Choice

Individuals choose their occupation as workers or entrepreneurs by maximizing expected income. Workers are ex-ante mobile between sectors and therefore each worker must earn the same expected wage. We assume that matching frictions in the homogeneous-good sector are identical across all countries. This assumption implies that expected worker income equals $\zeta_0/2$, where ζ_0 equals the probability of finding a job in the homogeneous-good sector and $1/2$ equal the corresponding negotiated wage.

Because entrepreneurial income increases monotonically with managerial ability, there is a unique talent cutoff a_{ii} that solves $\pi(a_{ii}) = \zeta_0/2$. Solving this equation yields

$$a_{ii} = \left(\frac{\zeta_0 + 2f_{ii}}{2\phi D_i} \right)^{\frac{1}{\sigma-1}} \frac{c_i}{\xi_i}. \tag{20}$$

The supplies of workers and entrepreneurs in country i can be expressed as $L_{wi}(a_{ii}) = G(a_{ii})L_i = (1-a_{ii}^{-k})L_i$ and $M(a_{ii}) = [1-G(a_{ii})]L_i = a_{ii}^{-k}L_i$, where $M(a_{ii})$ denotes the measure of entrepreneurs

[15] See, for instance, Brown and Medoff (1989) and Troske (1999). These studies typically use employment to measure firm size and thus provide an empirical justification for assumption $\sigma - 1 > \lambda$. Helpman et al. (2010) generate an employer size-wage premium by focusing on differences in worker ability and a screening process that assigns more productive workers to larger firms.

and firms (varieties) producing in country i. A decline in the domestic talent cutoff raises the measure of entrepreneurs and reduces the supply of workers.

An entrepreneur serves a foreign market if exporting is profitable. Equation (16) states that profit in market j for an entrepreneur producing in country i increases with entrepreneurial talent a. The export cutoff talent a_{ij} solves equation $\pi_{ij}(a_{ij}) = 0$ and is given by

$$a_{ij} = \left(\frac{f_{ij} T_{ij}^{\sigma}}{\phi D_j} \right)^{\frac{1}{\sigma-1}} \frac{\delta_{ij} c_i}{\xi_i}, \tag{21}$$

where $D_j = Q_j P_j^{\sigma}$ captures the market size of destination country j. The export cutoff talent a_{ij} is country specific, and a higher value of it implies a lower measure of exported varieties. Thus, the measure of exported varieties declines with market access costs f_{ij}, tariff factor $T_{ij} = 1 + \tau_{ij}$, and iceberg transport costs δ_{ij}. Because export profits increase with managerial talent and export cutoffs are country specific, firms managed by more talented entrepreneurs are more profitable and serve more foreign markets.

Combining (20) and (21) yields

$$a_{ij} = \frac{\delta_{ij}(c_i/\xi_i)}{(c_j/\xi_j)} \left[\frac{2 f_{ij} T_{ij}^{\sigma}}{\zeta_0 + 2 f_{jj}} \right]^{\frac{1}{\sigma-1}} a_{jj}. \tag{22}$$

Consequently, the export talent cutoff in country i is proportional to the domestic talent cutoff of the destination country j.

3.4 Unemployment

The labor market exhibits search frictions as in the celebrated Diamond-Mortensen-Pissarides theory of equilibrium unemployment (e.g., Pissarides 2004). Following Blanchard and Gali (2010) and especially Helpman and Itskhoki (2010) and Helpman et al. (2010), we assume that hiring costs per worker differ across sectors and are given by

$$c_0 = \mu_0 \zeta_0^{\gamma}, \qquad\qquad c_i = \mu_i \zeta_i^{\gamma}, \tag{23}$$

where parameters μ_0 and μ capture the degree of labor-market frictions in the homogeneous-good and differentiated-good sectors, respectively; ζ_0 and ζ_i are the corresponding job-matching rates (market tightness); and $\gamma > 0$ is a constant. Observe that matching (hiring) costs per worker in the homogeneous-good sector are identical across all countries, whereas matching costs per worker in the differentiated-good sector are country specific.

Job-finding rate ζ_0 and hiring cost per worker c_0 are given by

$$\zeta_0 = (2\mu_0)^{-1/\gamma}, \qquad c_0 = 1/2, \tag{24}$$

and we assume that $\mu_0 > 1/2$ to ensure that the job-finding rate is less than one (see Appendix A for the proof). Equation (24) implies that expected worker income in the homogeneous sector is equal to $\zeta_0 c_0 = \zeta_0/2$. Ex-ante labor mobility across sectors implies that expected worker income must be equal across both sectors, that is, $\zeta_0/2 = \zeta_i w_i(h_i/n_i)$, where $w_i(h_i/n_i) = c_i$ is the expected wage of a matched worker and ζ_i is the probability that a worker searching in the differentiated-good sector will be matched with an entrepreneur as a trainee. The probability of becoming a trainee ζ_i and matching costs per worker c_i are exogenous parameters given by

$$\zeta_i = \zeta_0 \left(\frac{\mu_0}{\mu_i}\right)^{\frac{1}{1+\gamma}}, \qquad c_i = \frac{1}{2}\left(\frac{\mu_i}{\mu_0}\right)^{\frac{1}{1+\gamma}}. \tag{25}$$

One can show that the rate of unemployment in country i is

$$u_i = (1-\zeta_0)(1-a_{ii}^{-k}) + \frac{(\zeta_0 + 2f_{ii})}{2} F(a_{ii}) a_{ii}^{-k} + \sum_{j \neq i} \mathbb{I}_j f_{ij} F(a_{ij}) a_{ij}^{-k}, \tag{26}$$

where

$$F(a_{ij}) = \frac{k}{\phi}\left(\frac{\rho}{1+\rho}\right)^{\sigma}\left[\frac{2}{(1+k-\sigma)} - \frac{\xi_i a_{ij}^{-\lambda_i}}{c_i(1+k+\lambda_i-\sigma)}\right].$$

3.5 Equilibrium

In equilibrium, each country's aggregate expenditure E_i must be equal to aggregate income Y_i. Because θE_i is spent on differentiated goods consumed in country i, the budget constraint can be written as

$$R_{ii} + \sum_{j \neq i} R_{ji} = \theta Y_i, \tag{27}$$

where R_{ii} is aggregate revenue generated by varieties produced and consumed in country i; and R_{ji} denotes revenue generated by varieties produced in country j and consumed in country i. Aggregating over all trade partners, the second term of the LHS is revenue spent by consumers of country i on all imported varieties.

One can show that

$$R_{ii} = \int_{a_{ii}}^{\infty} r_{ii}(a) M_i \psi_i(a) da = \frac{k(1+\rho)(\zeta_0 + 2f_{ii}) a_{ii}^{-k} L_i}{2(1-\rho)(k+1-\sigma)}, \tag{28a}$$

$$R_{ji} = \int_{a_{ji}}^{\infty} r_{ji}(a) M_j \psi_j(a) da = \frac{k(1+\rho) f_{ji} a_{ji}^{-k} L_j}{(1-\rho)(k+1-\sigma)}, \tag{28b}$$

where M_i is the supply of entrepreneurs and $\psi_i(a)$ is the ex-post distribution of ability. Aggregate tariff revenue collected by country i's government is given by

$$R_i^{\tau} = \frac{k(1+\rho)}{(1-\rho)(k+1-\sigma)} \sum_{j \neq i} \tau_{ji} f_{ji} a_{ji}^{-k} L_j. \tag{29}$$

Aggregate income Y_i equals aggregate wage income W_i plus aggregate entrepreneurial profit Π_i plus tariff revenue R_i^{τ}. Denote with N_{0i} and N_i the measure of workers searching for jobs in the homogeneous-good and differentiated-good sectors, respectively. This notation implies that $G(a_{ii})L_i = N_{0i} + N_i$, where $G(a_{ii})L_i$ is the endogenous supply of workers. Aggregate wage income is equal to expected wage income of all employed workers in the homogeneous-good sector $(\zeta_0/2)N_{0i}$ plus the wage of all workers employed in the differentiated-good sector $w_i H_i$:

$$W_i = \frac{\zeta_0}{2} N_{0i} + c_i \zeta_i N_i = \frac{\zeta_0}{2}(1 - a_{ii}^{-k}) L_i, \tag{30}$$

where the second equality follows from $c_i \zeta_i = \zeta_0/2$ and $N_{0i} + N_i = G(a_{ii})L_i$.

Aggregate profit is given by

$$\Pi_i = \left[\frac{k(\zeta_0 + 2f_{ii})}{2f_{ii}(k+1-\sigma)} - 1 \right] f_{ii} L_i a_{ii}^{-k} + \sum_{j \neq i} \left[\frac{k}{(k+1-\sigma)} - 1 \right] f_{ij} L_i a_{ij}^{-k}. \tag{31}$$

Thus, aggregate income is

$$Y_i = R_i^{\tau} + W_i + \Pi_i, \tag{32}$$

where each of the three components is given by (29), (30) and (31), respectively.

Substituting (22) in each component of aggregate income and in (28b), one can write the budget constraint for country i expressed by equation (27) as a function of only the I domestic talent cutoffs. Because the budget constraint must hold for each country, equation (27) generates a system of I simultaneous equations in I unknown domestic cutoffs a_{ii}. This system of equations is linear in a_{ii}^{-k} and thus has unique solution as long as the matrix of coefficients which depends on model parameters is invertible.

Table 1: Parameter Choices for the Quantitative Analysis

Parameter	Restriction	Description	Value
ρ	$0 < \rho < 1$	CES Utility Parameter	0.50
σ	$\sigma = \frac{1}{1-\rho}$	Elasticity of Substitution	2.00
ζ_0	$\zeta_0 < 1$	Job-Finding Rate (Outside-Good Sector)	0.98
ζ	$\zeta < 1$	Job-Finding Rate (Differentiated-Good Sector)	0.98
c_0	$c_0 > 0$	Expected Wage (Outside-Good Sector)	0.50
c	$c > 0$	Expected Wage (Differentiated-Good Sector)	0.50
f_d	$f_d \geqslant 0$	Fixed Domestic Cost	0.17
f_x	$f_x \geqslant 0$	Fixed Export Cost	0.31
k	$k > 1$	Pareto Shape Parameter	2.00
θ	$0 < \theta < 1$	Expenditure Share (Differentiated-Good Sector)	0.90

Notes: Country-specific subscripts are omitted for expositional purposes.

4 Quantitative Analysis

We bring the model to the data by performing a quantitative analysis with 4 countries (regions): The United States (U.S.), the European Union (EU), China (CHN), and the rest of the world (ROW). We choose these countries based on their economic significance and their active role in the 2018 global tariff war.

4.1 Baseline Calibration

In the baseline calibration we follow the standard practice and choose parameters that are either commonly used in the literature, stem directly from the data, or allow us to match several data-based targeted moments. Table 1 provides a summary of the baseline-specification parameters that are common across all trading countries.

The CES utility parameter ρ is chosen to match previous estimates of the elasticity of substitution. In particular, Broda and Weinstein (2006) estimate median elasticities between 2 and 4 depending on the level of aggregation. Since we use aggregate-level data we choose a value at the lower end of this range and set $\rho = 0.5$ in order to generate an elasticity of substitution of $\sigma = 2$.[16]

Given our choice of σ, we set the Pareto shape parameter of the entrepreneurial ability dis-

[16] The choice of the same σ across varieties is based on the absence of significant tariff variation across imported products during the 2018 global trade war. For example, in 2018 the U.S. imposed a uniform tariff of 25 percent on 2,850 imported products and another uniform tariff of 10 percent on 9,076 imported Chinese products (Fajgelbaum et al. 2020).

tribution to $k = 2$ in order to match estimates by Chaney (2008) which imply that $k/(\sigma - 1)$ is approximately equal to 2 for the median U.S. industry. Since the ability distribution determines the distribution of firm productivity, our model delivers the same relationship between rank and size as Chaney (2008). As a result, the size-rank regressions used in his study suffice to identify k in this context. Furthermore, $k = 2$ is also in line with recent estimates of 2.3 by Fernandes et al. (2019) and close to Eaton, Kortum, and Kramarz's (2011) estimate of $k = 1.75$ for France.

Finally, parameters $\zeta_0 = \zeta = 0.98$ imply that the expected wage in each sector is the same and equal to $c_0 = c = 0.5$ in all countries according to equations (24) and $\zeta_0/2 = \zeta c$. We set the value of parameter θ equal to 0.9 to highlight our focus on the differentiated-good sector which depicts a more realistic variation of personal income by incorporating firm heterogeneity and the employer size-wage premium.

4.2 Model Fit

The remaining parameters were calibrated to match several moments in the data, which are shown in Table 2. First, the fixed export cost f_x is set to 0.31 for all countries in order to match the share of exporters in U.S. manufacturing of 18 percent (see Bernard et al. (2007)). The second data-based moment is the share of entrepreneurs. We use the share of self-employed individuals, both incorporated and non-incorporated, as measure of the fraction of entrepreneurs. In the U.S., the number of entrepreneurs as share of total employment is regularly reported by the Bureau of Labor Statistics (BLS) and was equal to 10.1 percent in 2015. The parameter which most directly affects this moment is the fixed domestic entry cost f_d, and a value of $f_d = 0.17$ delivers the desired share of U.S. entrepreneurs. In the absence of reliable data on the number of entrepreneurs and exporters in the other countries, we assume that f_d and f_x are the same across countries.

Data on unemployment rates and country-specific, income-based Gini coefficients are taken from the World Bank.[17] These targeted moments are particularly sensitive to the choices of parameters λ and ξ. For instance, the fraction of retained workers in the differentiated sector, which affects the rate of technological unemployment and the firm-size wage premium, decreases with parameter λ and increases with parameter ξ, as indicated by equation (8). We therefore choose the combination

[17] The dataset is available at https://data.worldbank.org/indicator/SI.PV.GINI/ and provides estimates by the World Bank Development Research Group of the Gini coefficient by country and year. We use information for the year 2015 for each country whenever available and otherwise the most recent year in the dataset.

Table 2: Targeted Data-Based Moments

Moment	Model	Data	Source
Unemployment Rate	[5.28, 9.38, 4.60, 5.53]	[5.28, 9.38, 4.60, 5.53]	World Bank
Gini Coefficient	[41.0, 32.8, 42.2, 38.3]	[41.0, 32.8, 42.2, 38.3]	World Bank
Domestic Shares	[77.3, 83.0, 86.1, 71.7]	[77.3, 83.0, 86.1, 71.7]	GTAP 8, Ossa (2014)
Share of Entrps	10.1	10.1	BLS (2015)
Share of Exporters	18.0	18.0	Bernard et al. (2007)

Notes: Values reported in square brackets refer to the individual region values in the order of the U.S., EU, CHN, and ROW.

of these parameters that best matches these two moments jointly. This choice allows us to capture country-specific differences in unemployment and the income distribution.

Intuitively, ξ determines how selective firms hire in general in a country, while λ governs to which extent larger and more productive firms are more selective than smaller firms. Further, as evident from Equation (18), λ also shapes the degree to which wages vary with managerial talent, which has important implications for the share of top income earners that are workers as opposed to firm owners. Specifically, we find that in practice, a greater λ translates into larger shares of workers among a country's top income earners.

For example, the EU has a comparably equal income distribution compared to the U.S. and China. The model is able to generate this feature with a relatively high value of λ, which implies that firms hire more selectively but also that firms pass on a greater share of profits to workers. Hence, the difference between wages and manager income is less pronounced in the EU than in the U.S., where most top income earners are business owners.[18] Finally, conditional on λ, differences in ξ rationalize the observed variation in unemployment, with ξ taking on greater values in the EU and the rest of the world than in the U.S. and China. This for example implies that hiring tends to be less selective in the U.S. overall and that frictional unemployment is low as a consequence.

Table 3 summarizes the values for λ and ξ that best fit the relevant targeted moments shown in Table 2. In addition, we choose each country's economic size L according to its nominal GDP.

[18] In the case of China, the zero value of λ reflects the absence of the employer size-wage premium as indicated by equation (18). One possible reason might be the extensive state intervention in the determination of wages, which are not based solely on worker-productivity, especially in larger state-owned Chinese firms. Li et al. (2019) report that in 2013 among the top 5 percent income earners in China two thirds were employed by the state and collective sectors. They also argue that communist party membership accounts for 33 percent income hike of large company owners belonging to top 5 percent income earners.

Table 3: Country-Specific Parameter Values

Region	λ	ξ	L	δ	τ
U.S.	0.0040	0.9037	1.025	4.320	0.030
EU	0.0961	0.9954	0.935	4.430	0.080
CHN	0.0000	0.9247	0.675	6.550	0.100
ROW	0.0238	0.9296	1.000	3.350	0.070

Specifically, we normalize the size of ROW to 1, and then assign each country a value of L in proportion to its relative GDP. This results in moderate differences with the U.S. being the largest country with $L = 1.025$ and China being the smallest one with $L = 0.675$. We also match the domestic expenditure shares in each country which take values between 72 percent and 86 percent. These shares are particularly sensitive to trade costs and we obtain values for δ between 3.4 and 6.6.[19] The final column of Table 3 reports the factual tariff for each country used in the calibration analysis. The U.S. factual tariff is the lowest at 3 percent and China's factual tariff is the highest at 10 percent.[20]

Using these parameters and relevant model equations we calculate the domestic talent cutoffs, and the other endogenous variables including export cutoffs, unemployment rates, prices and wages for each of the four countries. For each country, we draw a random sample of 200,000 individuals differing in entrepreneurial talent. Specifically, each individual is assigned a talent level drawn from a Pareto distribution with shape parameter $k = 2$ based on equation (6). Each individual in the sample is assigned to an occupational status and matched with the corresponding nominal and real income. For instance, individuals with managerial talent higher than the equilibrium domestic talent cutoff become entrepreneurs and receive income equal to firm profit (which increases linearly with talent for $\sigma = k = 2$) plus a fraction of the tariff revenue. The latter is distributed in proportion to each individual's income share under free trade reflecting the neutrality of tariff policies.[21] The

[19]For the purpose of the calibration we assume that each country imposes the same tariff against all other countries. The derived values of transport costs in Table 5 are high compared to most other studies. However, Eaton and Kortum (2002, Table 7) infer bilateral iceberg trade costs in the range of 4 to 5 in the case of distant countries. Since our four countries cover the whole globe, we infer substantial iceberg costs in order to match the observed domestic expenditure shares.

[20]Factual tariffs for the U.S., EU, and China are taken from Ossa (2014). Factual tariffs for ROW are computed based on the MacMap database (http://www.macmap.org).

[21]The tariff revenue is distributed to each individual according to the following algorithm. First we solve the model under free trade and calculate the income share of each individual. This share determines what fraction of

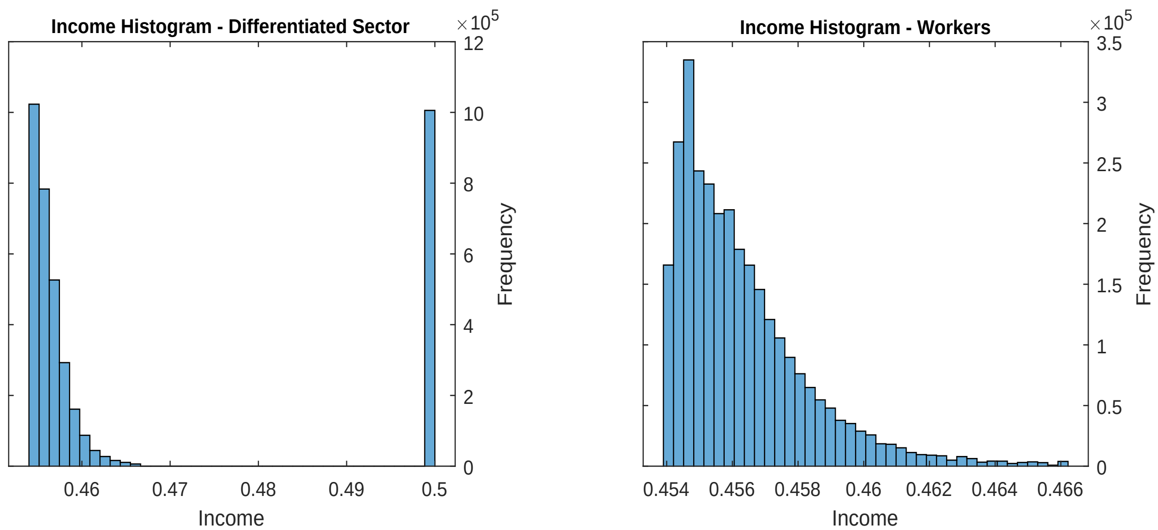

Figure 1: Income Distribution Histograms: Both histograms show the predicted income distribution in the differentiated sector at factual tariffs. The figure on the left includes entrepreneurs while the right one excludes them. Top incomes are capped at 0.5.

information on income for each individual is used to describe the distributional properties of the model for any set of parameters including different tariff regimes.

Figure 1 plots histograms of the simulated U.S. personal income distribution. Both histograms illustrate the income distribution in the differentiated-good sector, which incorporates the employer size-wage premium, with the left figure including entrepreneurs while the right one excluding them. Note that the income distribution among workers is consistent with a log-normal distribution which is in line with the empirical distribution of household income in the U.S. (Donovan et al. 2016).

Figure 2 plots the predicted Lorenz curve for the overall U.S. economy (on the left) as well as for the differentiated-good sector (on the right).[22] Both curves reveal a significant amount of inequality within the U.S. economy. The extent of inequality in the differentiated sector is larger than that in the economy as a whole. This feature stems from the property that workers in the outside sector receive very similar income and tariff revenue. Specifically, the horizontal intercept of the aggregate Lorenz curve equals the predicted aggregate U.S. unemployment rate; the vertical

tariff revenue each individual receives under positive tariffs. For instance, we calculate the income of each individual under factual tariffs and aggregate tariff revenue. We then distribute the tariff revenue as follows: the individual with the highest income under factual tariffs receives the same fraction of tariff revenue as the richest individual under free trade, and so on. Distributing the tariff revenue in proportion to each individual's income in autarky does not change our results significantly and neither does a uniform tariff revenue distribution.

[22]The Lorenz curve plots the cumulative percentage of total income as a function of the cumulative percentage of the corresponding income earners (ranked by income from lowest to highest).

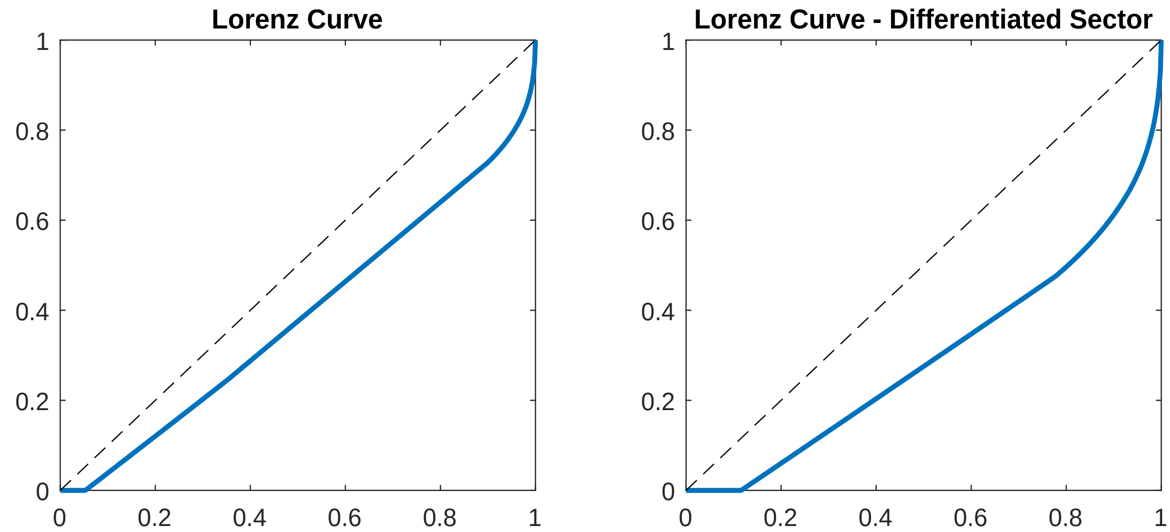

Figure 2: Income Distribution Lorenz Curve: Both plots show the Lorenz curve of the predicted income distribution at factual tariffs. The figure on the left includes all incomes while the right one only those in the differentiated sector.

distance between the diagonal and the Lorenz curve evaluated at 99 percent of population equals the share of income going to top 1 percent income earners; and half the area below the diagonal and above the Lorenz curve equals the Gini coefficient.

The model matches the targeted moments with reasonable parameter values as illustrated in Table 2. In addition, the model predicts that the top 1 percent income share of U.S. is 11.1 percent for the overall economy and 15.2 percent for the differentiated sector, which are close to empirical estimates.[23]

Encouraged by the model fit, we also investigate welfare and distributional effects of tariffs. We have two main findings from this analysis (see Appendix B for details). First, tariffs "export" jobs from the tariff-imposing country to its trade partners. For example, a U.S. tariff that increases the rate of unemployment in the U.S. by 1.5 percent lowers the rate of unemployment in China by about a third of that amount. Second, tariffs have ambiguous income distributional effects on the tariff imposing country: they hurt high-income exporters and low-income workers, and benefit middle-income domestic entrepreneurs (and their workers).

[23]For the year 2014, estimated top 1 percent income shares are 13.1 percent for Auten and Splinter (2019), 16.7 percent for the Congressional Budget Office (2018) and 21.5 percent for Piketty et al. (2019).

Table 4: Optimal Tariffs (percent)

	(1) All countries	(2) U.S.	(3) EU	(4) CHN	(5) ROW
U.S.	16.1	–	12.4	11.8	12.1
EU	16.0	14.3	–	14.2	14.3
CHN	16.2	15.1	15.2	–	15.0
ROW	16.0	12.4	12.6	12.2	-

Notes: Each value in column (1) represents the optimal tariff when each country sets the same tariff against all other countries. For columns (2)–(5), each value (i, j) represents the optimal tariff set by country i against country j, when all other tariffs are held at factual levels.

4.3 Optimal Tariffs

We now proceed with the characterization of government's optimal behavior. We start our analysis by assuming that the government in each country maximizes national welfare. We first compute each country's optimal (welfare-maximizing) tariff assuming that all other countries keep their tariffs fixed at factual levels. In the context of a multi-country model, we need to distinguish between a non-discriminatory tariff imposed against imports from all trade partners and a discriminatory tariff applied to imports from only one trade partner with all other tariffs kept at factual levels. We refer to the former as multilateral tariff and the latter as bilateral tariff.

Table 4 presents each country's optimal tariffs. These tariffs are computed by finding a country's tariff that maximizes aggregate welfare, keeping tariffs of other countries at their factual levels. Column (1) presents each country's optimal multilateral tariff which has an average value of about 16 percent. Optimal tariffs are throughout higher than factual levels, which are 3 percent for the United States, 8 percent for the European Union, 10 percent for China, and 7 percent for the Rest of the World. This is expected because factual tariffs are largely the outcome of a long history of trade negotiations. Columns (2)-(5) summarize the set of optimal bilateral tariffs, i.e. when countries do not follow a most-favored-nation clause. The average bilateral optimal tariff is close to 14 percent and varies from 11.8 percent to 15.2 percent.

Figure 3 provides economic intuition behind these optimal tariffs. In particular, start with equation (5) which can be written in logs as $\ln V = \ln Y - \theta \ln P$. Hence, the optimal tariff maximizes the difference between $\ln Y$ and $\theta \ln P$. As shown in the left plot of Figure 3 for the

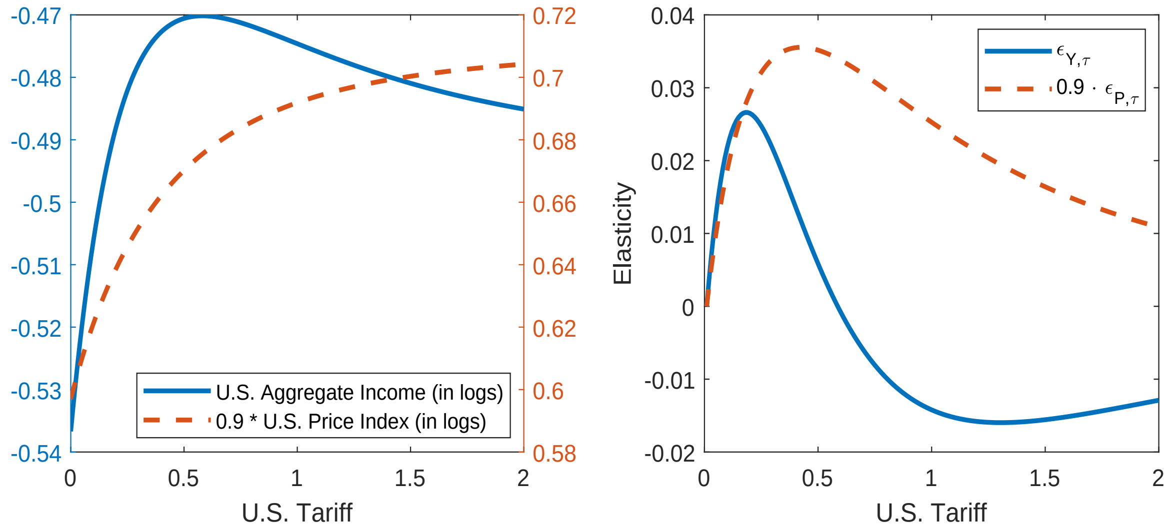

Figure 3: U.S. income and price level as function of U.S. tariffs. The figure on the left plots log income and log prices in the baseline specification, while the right figure shows the elasticity of income and prices with respect to U.S. tariffs.

U.S., while both income and price index initially increase with the multilateral tariff, the former increases more than the latter. This implies that the economy benefits from moving away from free trade. At some point however, a higher multilateral tariff lowers welfare. Aggregate income has in fact a unique maximum which occurs at the strictly positive tariff of 16 percent that maximizes the vertical distance between the two curves.[24]

Equation (5) can also be expressed in terms of elasticities as $\varepsilon_{V,\tau} = \varepsilon_{Y,\tau} - \theta\varepsilon_{P,\tau}$ and so the tariff elasticity of income must equal θ times the tariff elasticity of the price index at the optimal tariff.[25] The right plot of Figure 3 shows that at lower tariff values the tariff elasticity of income is initially higher than the tariff elasticity of the price index but it becomes negative for large values of τ which again implies that the optimal tariff is strictly positive and given by the intersection of the two elasticity curves.

As Table 4 shows, bilateral (discriminatory) tariffs are smaller than multilateral (non discriminatory) tariffs, with the U.S., for example, imposing optimal bilateral tariffs ranging form 11.8 percent to 12.4 percent.[26] For any given tariff, the revenue collected under a bilateral tariff is less

[24]As evident from Figure B7 in the appendix, this occurs in part because tariff revenue is an inverted U-shaped function of the tariff, while income from other sources monotonically increases with the tariff and flattens out at high tariff values. Consequently, the presence of tariff revenue generates a finite optimal tariff.

[25]Formally, these elasticities are defined as follows: $\varepsilon_{V\tau} = d\ln V/d\ln\tau$, $\varepsilon_{Y\tau} = d\ln Y/d\ln\tau$, and $\varepsilon_{P\tau} = d\ln P/d\ln\tau$.

[26]Ossa (2011, Figure 2) plots tariff reaction curves of U.S. and ROW which imply a U.S. bilateral optimal tariff

than the revenue corresponding to the same multilateral tariff.[27,28]

As opposed to previous findings, e.g. by Felbermayr et al. (2013) for the two-country Melitz model, we also find that optimal tariffs are strategic complements in the current framework: As shown in Appendix Figure B9 for the U.S.-China case, an increase in China's tariff increases the bilateral U.S. optimal tariff.[29]

Group-Specific Optimal Tariffs. There is considerable variation in the tariffs that maximize welfare of various income groups within each economy as evident from the left plot in Figure 4. This plot illustrates the distribution of U.S. multilateral tariffs that maximize welfare (real income) of an individual according to her/his talent rank in the absence of tariff retaliation from other trade partners. Individuals at the bottom of the ability distribution, who tend to be workers, generally prefer free trade (zero-tariff) because the increase in the aggregate price index exceeds the nominal income increase due to tariff revenue. Individuals at the top of the ability distribution, who tend to be entrepreneurs, benefit from a strictly positive tariff. In addition, within the group of entrepreneurs, those with lower levels of ability favor a higher tariff than those at the top: For example, an individual at the 95th percentile of the ability distribution, maximizes her real income with a tariff of approximately 70 percemt, while a person at the 99th percentile prefers a 46 percent tariff.

The right plot in Figure 4 shows the relationship between income, prices, and tariffs for an individual at the top 1 percent and the top 5 percent income brackets in more detail, and compares it to the aggregate (100 percent income bracket) optimal tariff. At the optimal tariff, the elasticity of income with respect to the tariff, $\varepsilon_{Y,\tau}$, must equal θ times the elasticity of the price index $\varepsilon_{P,\tau}$. In general, the $\varepsilon_{Y,\tau}$-curve intersects the $\theta\varepsilon_{P,\tau}$-curve at a higher tariff for the top 5 percent income share group, followed by the top 1 percent income group and the 100 percent (aggregate income) group.

between 12 percent and 14 percent.

[27] Figure B8 in the appendix shows that this difference stems from the property that income gains from less competition in the U.S. become flat at lower levels of bilateral (as opposed to multilateral) tariffs.

[28] When k increases, i.e. the talent distribution becomes less dispersed, optimal bilateral tariffs converge to multilateral tariffs.

[29] The strategic complementarity of optimal tariffs is consistent with recent developments in the U.S.-China trade war. In August 2019, China announced new tariffs on \$75 billion U.S. goods starting at 5 percent on September 2019 and increasing to 10 percent on December 2019. In response, the U.S. increased tariffs from 25 percent to 30 percent on \$250 billion Chinese imports and from 10 percent to 15 percent on another \$250 billion Chinese products starting in October 2019.

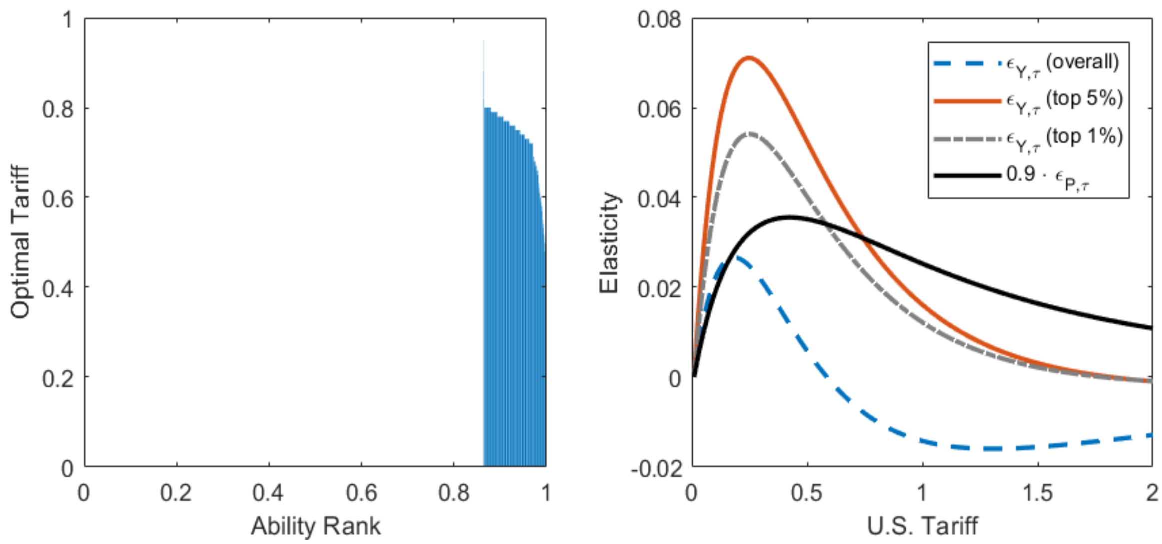

Figure 4: Optimal tariff by ability group: The left plot shows the welfare-maximizing tariffs for individuals with varying levels of ability. The values on the x-axis reflect ability percentiles with 0 representing the lowest possible ability level and 1 the highest one. The right plot shows the elasticity of income of various income groups and prices with respect to the U.S. tariff. Tariffs in other countries are held at factual levels.

This implies that entrepreneurs serving the domestic market have the highest optimal tariff and benefit most from tariff protection compared to exporters, who earn part of their income abroad, or to the group of all individuals, including workers whose real income declines with the tariff.

4.4 Tariff Wars and Cooperative Tariffs

4.4.1 Tariff Wars

In this subsection, we begin by assuming that the government objective consists of aggregate national welfare maximization. In the presence of income inequality this objective is equivalent to the government weighing each (real) dollar equally no matters who earns it. Table 5 summarizes trade-war (Nash-equilibrium) as well as cooperative tariffs for all four countries along with factual and counterfactual implications of each tariff regime for welfare, unemployment and income inequality. Nash-equilibrium tariffs are computed by finding the set of tariffs from which no country would individually want to deviate, given the tariff choices of other countries. These tariffs can be found numerically by starting at an initial set of tariffs and then successively updating each country's tariff. This procedure quickly converges to the unique Nash equilibrium.

Because optimal tariffs are higher than factual tariffs, strategic complementarity of tariffs implies that Nash tariffs are generally higher than the optimal tariffs displayed in Table 4. However,

Table 5: Aggregate Tariffs and Counterfactuals

	Factual (1)	Optimal (2)	Nash (3)	Coop. (4)	Factual (5)	Optimal (6)	Nash (7)	Coop. (8)
	U.S.				**EU**			
Tariffs (%)	3.00	16.09	16.14	0.00	5.00	16.04	16.13	0.00
Welfare	0.322	0.324	0.321	0.325	0.298	0.298	0.294	0.299
Unemployment	0.053	0.056	0.054	0.054	0.093	0.095	0.090	0.093
Gini Coef.	0.233	0.250	0.242	0.237	0.274	0.279	0.270	0.275
-Diff. Sector	0.410	0.405	0.403	0.412	0.320	0.318	0.316	0.326
Share Top 1%	0.111	0.115	0.111	0.115	0.101	0.102	0.097	0.102
-Diff. Sector	0.152	0.150	0.146	0.155	0.114	0.113	0.110	0.116
Share Top 5%	0.209	0.218	0.211	0.214	0.188	0.191	0.184	0.190
Share Top 10%	0.272	0.284	0.278	0.275	0.254	0.257	0.250	0.254
	CHN				**ROW**			
Tariffs (%)	10.00	16.19	16.25	0.00	7.00	16.04	16.12	0.00
Welfare	0.149	0.149	0.147	0.149	0.328	0.329	0.325	0.329
Unemployment	0.047	0.048	0.046	0.047	0.055	0.058	0.056	0.054
Gini Coef.	0.244	0.249	0.238	0.241	0.208	0.222	0.212	0.202
-Diff. Sector	0.382	0.381	0.377	0.384	0.383	0.378	0.374	0.387
Share Top 1%	0.119	0.120	0.114	0.121	0.104	0.107	0.102	0.105
-Diff. Sector	0.150	0.150	0.146	0.154	0.144	0.142	0.138	0.148
Share Top 5%	0.222	0.224	0.215	0.223	0.194	0.201	0.194	0.192
Share Top 10%	0.287	0.290	0.281	0.285	0.252	0.263	0.255	0.247

Notes: Optimal, Nash, and cooperative tariffs refer to the case when each country maximizes aggregate welfare. Unless stated otherwise, unemployment, the Gini coefficient and the income shares are computed for the overall economy. Share Top 1%, Share Top 5%, and Share Top 10% refer to the share of income earned by the top 1 percent, the top 5 percent and the top 10 percent of income earners in a country.

we find that optimal tariffs tend to be only moderately sensitive to other countries' tariffs. As a result, optimal and Nash-equilibrium tariffs are numerically quite close. Specifically, we find Nash-equilibrium tariffs that average 16 percent and are fairly similar across countries. This is consistent with both the data and previous results. Ossa (2011) for example calculates bilateral Nash-equilibrium tariffs in a multi-country version of Krugman's (1980) model of intra-industry trade with homogeneous firms and reports that Nash-equilibrium tariffs range between 10 percent and 13 percent when the elasticity of substitution is set at 9.28 and between 25 percent and 29 perent when the elasticity of substitution is 4.60. Our tariff results are also close to those reported by Felbermayr et al. (2013), who find Nash-equilibrium tariffs between 23.1 percent and 29.3

percent depending on the relative country size in a two-country Melitz (2003) model.[30]

4.4.2 Trade Talks and Cooperative Tariffs

The previous analysis highlights the incentives of each country to move from factual to optimal tariffs without paying attention to the behavior of its trade partners. We therefore ask the following natural questions: Starting at Nash-equilibrium tariffs, can countries reach a lower tariff through cooperation and trade negotiations, i.e. is there any scope for mutually beneficial trade negotiations? Further, what are the implications of cooperation for the income distribution and unemployment across countries?[31]

We define cooperative tariffs as the tariffs that would prevail if national welfare maximizing governments can jointly agree to lower tariffs. Specifically, starting at Nash equilibrium tariffs, we ask whether or not all countries would obtain higher national welfare levels and thus prefer lowering all tariffs by 1 percent. If so, we set the cooperative tariff to this new level and check if all countries would favor an additional tariff reduction by 1 percent. We continue with consecutive 1 percent tariff reductions and stop when we reach a point at which at least one country would not be in favor of a further tariff reduction.

As summarized in the top rows of Table 5, when countries maximize aggregate welfare, trade negotiations would result in zero tariffs.[32] This implies that the overall welfare gain from a small decline in tariffs of other countries always dominates the welfare loss from a similarly large reduction in tariffs of one country. As a consequence, under perfect cooperation, negotiated tariffs lead to free trade.

[30] Ossa (2014) uses a more disaggregated version of Ossa (2011) with 33 (instead of 2) industries within each country to analyze the effects of optimal and Nash-equilibrium tariffs. He reports higher median optimal tariffs in the range of 54 percent to 62 percent and median Nash equilibrium tariffs in the range of 55 percent to 60 percent. Possible reasons for Ossa's higher tariffs is the use of 33 (as opposed to one) industries and the fact that, in his case, tariffs do not affect the number of imported varieties. For example, in the case of uniform optimal tariff in each country Ossa reports a median optimal tariff of 44 percent. In this case, a move from factual tariffs to the optimal tariff raises welfare in the tariff imposing country by 1.5 percent (Ossa 2014, footnote 30). As in the present paper, Ossa finds that the average Nash-equilibrium tariff (63 percent) is only slightly higher than the corresponding average optimal tariff (62 percent).

[31] During the tariff war of 2018, the U.S. has invoked national-defense and intellectual property protection arguments for the imposition of tariffs against China. These considerations are absent from the present analysis.

[32] This result is in line with Ossa (2014) who predicts that cooperation frequently leads to a full removal of tariffs or even the introduction of import subsidies.

4.4.3 Counterfactuals

The remainder of Table 5 summarizes the implications of each tariff regime for welfare, unemployment and inequality in each of the four countries. First, columns (2) for the U.S. and (6) for the EU highlight that countries can indeed benefit from imposing an optimal tariff when all other countries maintaining their factual tariffs. For example, in the U.S. case, this hypothetical move would increase long-run welfare moderately by 0.6 percent, so the U.S. benefits from a tariff at the expense of its trade partners. But, this welfare gain comes at the cost of rising unemployment and inequality. In particular, it increases unemployment, the overall Gini coefficient and overall income shares earned by each of the top income brackets at the expense of workers and exporters.[33]

Columns (3) for the U.S. and (7) for the EU illustrate the equilibrium of a global trade war in which each country imposes the respective Nash tariff. In this case, U.S. welfare reaches its minimum level and falls below its level under a U.S. optimal unilateral tariff by about 1 percent, below its factual tariff by about 0.3 percent, and below its zero cooperative tariff by 1.2 percent. The U.S. hence cannot win a global tariff war because retaliation by other countries matters! These welfare results complement the findings of Amiti et al. (2019) and Fajgelbaum et al. (2020), who analyze the short-run impact of actual (as opposed to optimal and Nash-equilibrium) tariffs which were implemented by the U.S. and other countries in 2018. They find that these tariffs resulted in a complete pass-through of foreign prices and reduced slightly U.S. and global welfare.[34]. They also complement the results obtained by Ossa (2014) who finds that relative to factual tariffs, a Nash-equilibrium tariff results in a U.S. welfare loss of 2.2 percent. A move from a U.S. multilateral optimal tariff to a global trade war has however beneficial employment and income distributional effects: higher retaliatory foreign tariffs reduce U.S. unemployment slightly and improve its income distribution by reducing top income shares and the Gini coefficients in the overall economy and the

[33] It also reduces the top 1 percent income share and the Gini coefficient in the differentiated-good sector which incorporates more variation in personal incomes stemming from the employer size-wage premium. The negative relationship between tariffs and income inequalitly is consistent with one finding of Helpman et al. (2017), who also embed an employer size-wage premium in their model, and report that a 10 percent increase in Brazilian tariffs reduce Brazilian wage inequality by about 2 percent.

[34] Amiti et al. (2019) and Fajgelbaum et al. (2020) estimate a short-run annual U.S. welfare loss between \$7 and \$8 billion (0.04 percent of GDP) caused by U.S. tariffs implemented during 2018. In contrast, we calculate long-run welfare effects which incorporate general-equilibrium adjustments. Although we share the same welfare conclusion with these two studies, the reasons differ. They argue that, in the short run, there are no beneficial terms-of-trade welfare effects, especially for the U.S. Our analysis recognizes the presence of (long-run) welfare gains for the U.S. resulting in a positive optimal U.S. tariff as in Broda et al. (2008). These U.S. welfare gains are transformed into substantial losses because of optimal retaliatory tariffs imposed by its trade partners.

differentiated-good sector.

We find that trade negotiations increase overall national welfare: As evident from columns (3) and (4) as well as (7) and (8), each country experiences welfare gains when moving from a trade war to cooperative tariffs and these gains range from 1.2 percent for the U.S. and EU to 1.4 percent for China.[35] This implies that the U.S. (and any other country) cannot "win" a global tariff war: retaliatory tariffs render the optimal-tariff equilibrium unfeasible and force the global economy in a prisoner's dilemma situation.[36] However, trade talks have also important implications for inequality. First, income becomes more concentrated with the share of income earned by the top 1 percent, 5 percent, and 10 percent income earners increasing in each economy.[37] This result is largely due to significant increases in profits of very talented entrepreneurs who either increase their exports or now find it profitable to become exporters. Second, inequality in the differentiated sector, as measured by the Gini coefficient, increases as well in all countries. For instance, the U.S. Gini coefficient in the differentiated sector rises from 40.3 percent to 41.2 percent. Third, the implications of trade talks for unemployment and overall inequality measured by the Gini coefficient are country-specific. Trade liberalization in the larger economies, such as the U.S. and ROW, comes with the additional benefit of lower unemployment and inequality, while both increase in the EU and China. Hence, all else equal, larger economies might have an additional interest in cooperation when policy makers are concerned about unemployment and the distribution of income.

Figure 5 plots the implications for U.S. inequality when moving from Nash to cooperative tariffs. Note that workers benefit from the move to cooperative tariffs whereas the impact on entrepreneurs is ability-specific. While the most productive entrepreneurs benefit from cooperation, entrepreneurs with lower talent levels are worse off. The right plot in Figure 5 shows the corresponding Lorenz curve in the two cases for the differentiated sector. The Lorenz curve is closer to the origin in the non-cooperative case, implying a lower level of inequality. The largest differences occur at the top of the income distribution. Since lower tariffs imply gains for entrepreneurs managing the most productive firms and losses for the least talented ones, inequality across firms is greater under

[35] Ossa (2014) reports that a move from Nash-equilibrium to cooperative tariffs raises U.S. welfare by 3.6 percent.

[36] The most likely reason for this result is that all countries have similar labor endowments. Kennan and Riezman (1988) and Syropoulos (2002) analyze formally the role of country size in winning a trade war.

[37] The one exception being the top 10 percent share in the U.S. and the top 5 percent and top 10 percent in the ROW which experience a moderate decline.

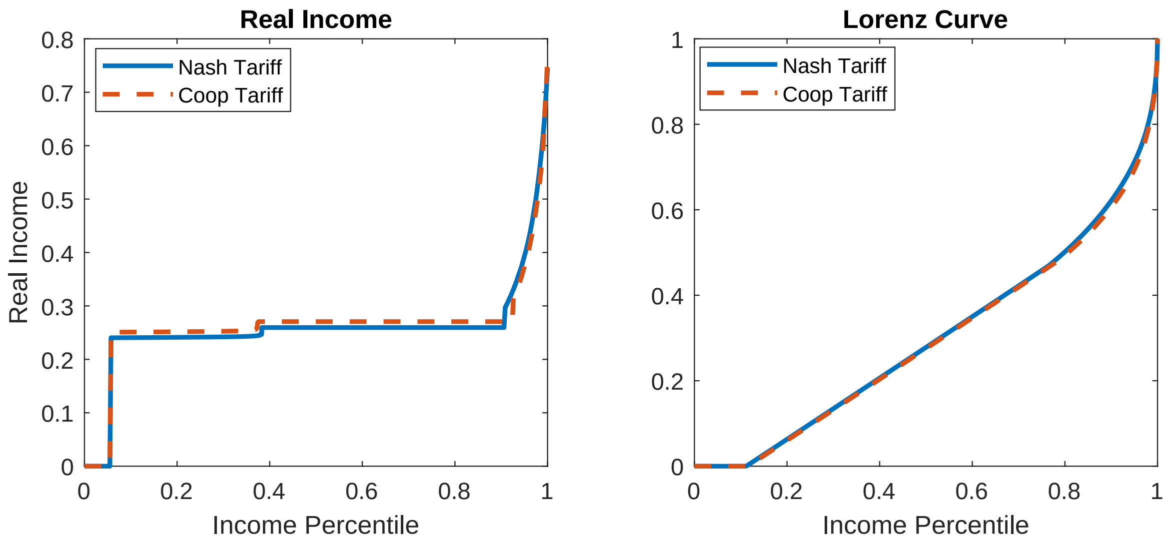

Figure 5: Nash versus Cooperative Tariffs: The left figure plots real income across the ability distribution in the U.S. for aggregate Nash as well as cooperative tariffs. The right figure plots the Lorenz curve in the U.S. both tariff equilibria.

cooperative tariffs, which translates into a more unequal income distribution.

In sum, there is a scope for trade talks and tariff reductions leading to cooperative tariffs, but we predict the resulting trade liberalization also to have sizable and asymmetric consequences for unemployment and inequality across countries. While cooperation can lower unemployment and inequality in larger economies it actually increases both in smaller ones. Further, a move to cooperative tariffs raises the top 1 percent income shares.

4.5 Political-Economy Perspectives

4.5.1 Elite Trade Wars

The previous analysis and results suggest that the U.S., who initiated the 2018 trade war, did not achieve its main objective, if the latter was based on national welfare maximization. Optimal tariffs increase U.S. welfare by a moderate amount, whereas retaliation by its trading partners results in a net U.S. welfare loss. In other words, from a perspective of U.S. aggregate welfare, the 2018 trade war looks like a policy mistake which can be fixed through global trade talks leading to universal free trade.

The adoption of aggregate-welfare maximization as a government objective implies that the government places the same weight on the real dollar of each individual in an economy. In reality however, governments might not weight the interest of each individual equally, for instance, because of lobbying or the interests of the respective government constituency. Given that our model explicitly features individuals with different talent, occupational status, and real income, we can readily extend our analysis and allow for a government objective that places different weights on each individual.

In this section we compute Nash and cooperative tariffs that would prevail when each government cares only about the top 10 percent income earners who are are predominantly entrepreneurs (business owners). We also assume that the government views the top 10 percent income earners as a political constituency and is interested in gaining the approval of their majority by adopting a median-voter approach as in Mayer (1984).[38] We denote the welfare of the median top 10 percent income earner in country i by W_i^E and define a Nash equilibrium as a set of tariffs which maximize W_i^E for each country, given the tariffs imposed by all other countries. In order to compute cooperative tariffs, we start at Nash tariffs and ask if in each country a majority of individuals within the top 10 percent income earners would favor a worldwide 1 percent reduction in tariffs. If so, we set the cooperative tariff to this new level and continue with consecutive 1 percent tariff reductions until we reach a point at which the majority within the top 10 percent income earners in at least one country would not be in favor of a further tariff reduction.

We find that the Nash-equilibrium tariff preferred by the top 10 percent income earners is substantially higher than the Nash-equilibrium tariff under aggregate welfare maximization. This is expected given the results for the optimal tariffs illustrated in Figure 4. In the case of the U.S., for example, the Nash-equilibrium tariff equals 74 percent compared to Europe's 60 percent and China's 74 percent.[39]

In contrast to the aggregate welfare maximization case, a move to free trade is generally not optimal when governments maximize the welfare of the median top 10 percent income earner. Figure 6 illustrates the main trade-off between changing U.S. and Chinese tariffs on real income of individuals residing in the U.S. and the role of income inequality in this process. Starting from free

[38]Individual preferences are Cobb-Douglas and thus are "single-peaked" and satisfy the condition for a unique voting equilbrium. The latter is defined as the tariff rate that cannot be altered by a majority of voters and equals the tariff rate preferred by the median voter. We focus on the top 10 percent income earners instead of just entrepreneurs because the occupational status of an individual is endogenous in the present model.

[39]Furthermore, the sensitivity of optimal U.S. tariffs to tariffs set by other countries is low as shown in Appendix Figure B9, which again implies that the resulting Nash-equilibrium tariffs are close to the optimal ones found when other countries' tariffs were held at factual levels.

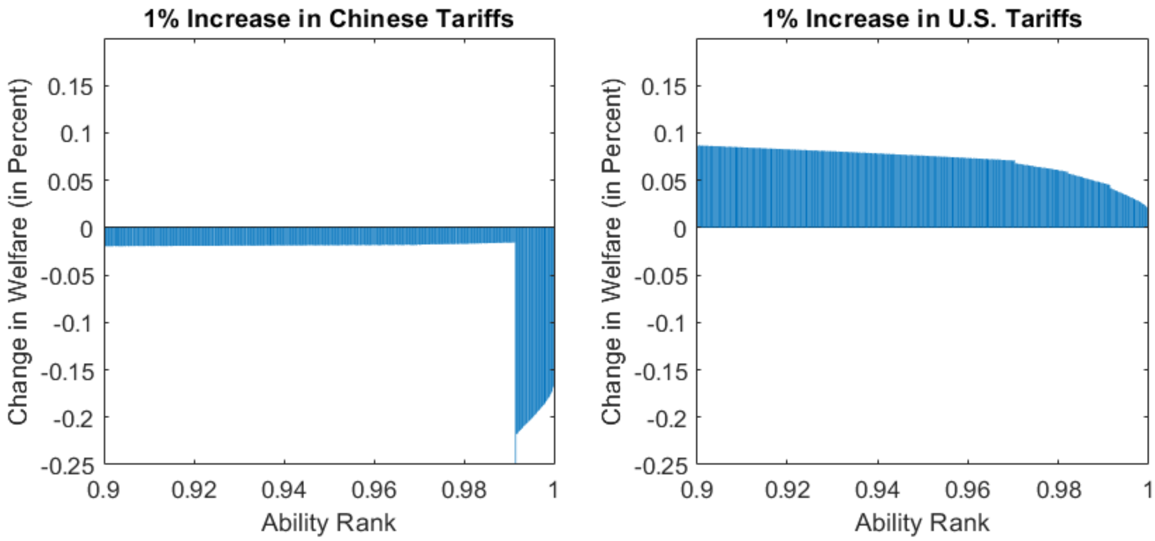

Figure 6: Counterfactual increase in U.S.-China tariffs: The left plot shows the percentage change in welfare on individuals across the ability distribution in the U.S. following a 1 percent tariff increase in China. The plot on the right shows the impact of a 1 percent increase in the United States.

trade, a 1 percentage point increase in Chinese tariffs leads to a sizable decline in welfare for most talented entrepreneurs located in the top 1 percent in the ability scale, but only moderate declines in the real incomes of other entrepreneurs. In particular, for the U.S. median entrepreneur (located close to the 95 percentage point on the ability scale), the losses from a higher Chinese tariff are smaller than the gains associated with a higher U.S. tariff. Hence, the median U.S. entrepreneur would be in favor of a move away from free trade. In other words, in the top 10 percent income case, the Nash or cooperative tariffs cannot be zero.

While cooperative tariffs are somewhat lower than non-cooperative ones, they still range from 50 percent for the EU to 60 percent for the ROW, as shown in Table 6. Entrepreneurs managing very large exporting firms would actually prefer to move to a zero cooperative tariff in all four countries, but this cannot be achieved since the median voter among the top 10 percent income earners is typically an entrepreneur with a moderate level of talent serving the domestic market. This entrepreneur benefits more from tariff protection provided by her own government compared to the real income decline from foreign retaliatory tariffs.

A move from Nash-equilibrium to cooperative tariffs raises aggregate welfare and the median real income among top 10 percent income earners (W_i^E) in each country. Consequently, each government has an incentive to engage in trade talks, although this incentive is smaller when

Table 6: Elite Trade Wars: Tariffs and Counterfactuals

	Nash (1)	Coop. (2)	Nash (3)	Coop. (4)	Nash (5)	Coop. (6)	Nash (7)	Coop. (8)
	U.S.		**EU**		**CHN**		**ROW**	
Tariffs (%)	74.00	61.75	59.60	49.74	73.60	61.42	75.70	63.17
Agg. Welfare	0.303	0.306	0.278	0.280	0.138	0.140	0.304	0.308
W_i^E	0.509	0.509	0.491	0.494	0.346	0.347	0.498	0.499
Unemployment	0.054	0.055	0.082	0.083	0.045	0.045	0.058	0.058
Gini Coef.	0.242	0.243	0.253	0.255	0.226	0.228	0.225	0.225
-Diff. Sector	0.389	0.390	0.305	0.306	0.363	0.365	0.360	0.361
Share Top 1%	0.098	0.100	0.084	0.085	0.097	0.099	0.094	0.095
-Diff. Sector	0.127	0.130	0.096	0.098	0.125	0.129	0.118	0.121
Share Top 5%	0.203	0.205	0.172	0.173	0.199	0.201	0.195	0.195
Share Top 10%	0.276	0.277	0.241	0.241	0.270	0.271	0.264	0.264

Notes: Nash and cooperative tariffs refer to the case when each country maximizes welfare of the median top 10% income earner. Unless stated otherwise, unemployment, the Gini coefficient and the income shares are computed for the overall economy. Share Top 1%, Share Top 5%, and Share Top 10% refer to the share of income earned by the top 1 percent, the top 5 percent and the top 10 percent of income earners in a country.

measured by gains in W_i^E. For example, cooperation raises U.S. aggregate welfare by 1 percent without affecting at all the median real income of the top 10 percent U.S. income earners. In other words, traditional economists focusing on aggregate welfare would support trade talks more enthusiastically, whereas U.S politicians interested in the support of (in particular small) business owners would be indifferent between a trade war and trade talks.

The rest of Table 6 summarizes the counterfactual implications of moving from the elite Nash to cooperative tariffs. One aspect that distinguishes the impact of trade liberalization in the aggregate and top 10 percent income case has to do with the tariff implications for unemployment and overall inequality. As established previously, when countries maximize aggregate welfare, moving to cooperative tariffs lowered the unemployment rate and the Gini coefficient in some countries, particularly in the U.S.. This does not hold in the top 10 percent income case where trade liberalization comes at the cost of rising unemployment and inequality in the U.S., the EU and China.[40]

In sum, when governments are interested in serving the interests of business owners only, elite trade wars result in substantially higher tariffs in the range of about 50 percent to 75 percent. These

[40]This result is an immediate consequence of the non-monotonic relationship between global tariffs and unemployment as shown in Figure B3 in Appendix B. Since the Nash tariffs that maximize the welfare of the median entrepreneur are above the 30 percent, the economy is above the threshold in this case and a move from elite Nash to cooperative tariffs increases unemployment and income inequality.

predicted tariffs exceed by far the vast majority of tariffs implemented during 2018. In addition, trade talks cannot lead to global free trade as in the case of aggregate welfare maximization. Instead, the model predicts high cooperative tariffs in the range of about 50 percent to 60 percent and very low incentives (if any) of governments serving the interests of the top 10 percent income earners to pursue global trade talks. Thus cooperation does not have any teeth in a sense that it fails to eliminate tariff protection in this case, and adversely affects unemployment and income inequality.

4.5.2 A Calibrated Government Objective

Finally, we allow the government to place different weights on firm interests and workers and aim at shedding light at how the objective of policy makers in each country shapes the resulting equilibrium tariff regimes. We do this for essentially two reasons. First, governments frequently emphasize the uneven and asymmetric benefits and costs of trade for firms and workers. American and European politicians frequently point out the different consequences of trade for small businesses and blue-collar workers from consequences for exporters and their employees. This indicates a more nuanced government policy objective than national aggregate welfare maximization.

Second, none of the previous set of estimates is fully satisfying in terms of matching existing tariff data. On the one hand, our results for Nash equilibrium tariffs (of about 16 percent) are lower than the 25 percent tariff imposed by the U.S. on 2,850 imported products in 2018 (Table 1 in Fajgelbaum et al. 2020), and on $200 billion imports from China in May 2019. They are lower than the 30 percent U.S. tariffs imposed on solar panels and 25 percent on steel imports. They are also lower than the factual average non-cooperative tariffs reported by Ossa (2014), referred to as "autonomous rate" average tariffs, which are equal to 25 percent for the EU and 69 percent for China. On the other hand, in a scenario in which the government maximizes the welfare of the median entrepreneur, the resulting Nash-equilibrium tariffs are significantly higher and exceed the autonomous tariff rates with the possible exception of China. Thus, our goal is to infer a government objective that is consistent with the data on autonomous average tariffs. These tariffs can be interpreted as long-run Nash-equilibrium tariffs for each country.[41]

[41]The interpretation of autonomous tariffs as optimal (as opposed to Nash-equilibrium) tariffs does not change our results because the model predicts almost identical optimal and Nash-equilbrium tariffs.

We assume that each country i maximizes a government objective $\overline{V}_i$ with

$$\overline{V}_i = \beta_i W_i^E + (1 - \beta_i) W_i^L, \tag{33}$$

where W_i^E and W_i^L denote entrepreneurial and worker welfare and $\beta_i \in (0, 1)$ is the weight that the government of country i places on entrepreneurial welfare. Specifically W_i^E equals the median real income of the top 10 percent income earners and W_i^L is the aggregate real income of workers. Replacing the aggregate real income of workers with the median worker income does not change our results since all workers prefer free trade as indicated in Figure 4. To identify these weights, we solve for Nash and cooperative tariffs as before but add the restriction that the Nash tariffs predicted by the model must equal the average autonomous tariffs in the data for each country.

We find that the weight β_i which rationalizes the non-cooperative tariffs in the data is 0.31 for the U.S., 0.50 for the EU, and 0.93 for China. The magnitude of these weights largely reflects the size of the non-cooperative (Nash-equilibrium) tariffs which equal 22.6 percent in the U.S., 25 percent in the EU and 68.6 percent in China.[42] Since entrepreneurs benefit more from tariffs than workers do, a larger weight β_i tends to translate into higher Nash tariffs. In addition, the ranking of these weights could in part reflect the relative scarcity of entrepreneurs in each country which translates into a higher government encouragement of entrepreneurship reflected on pro-business policies. As Table 7 shows, cooperation lowers tariffs to values between 14.1 percent for the U.S. and 42.8 percent for China. Hence in this hybrid and more realistic setting trade negotiations would not lead to global free trade.

A move from Nash-equilibrium to cooperative tariffs increases aggregate welfare and the government objective $\overline{V}_i$ throughout although the latter increases by less than the former. However, cooperation in trade tends to increase inequality and unemployment, although the results vary largely by country: While top income shares increase in all economies, unemployment and the Gini coefficient see sizable increases in the EU and China, but not in the U.S. where unemployment and the overall Gini coefficient remain the same.[43] We also find that trade talks increase worker welfare

[42]Since we do not have information on non-cooperative tariffs for the rest of the world we are unable to infer a β for this country. In order to still be able to compute weights for the other countries we set $\beta = 0.5$ for ROW. We found that other values of β for ROW change the results only marginally. This is due to the small sensitivity of optimal tariffs to tariffs of other countries (see Figure B9).

[43]The intuition for this results goes back to the non-monotonic effects of global tariffs as shown in Figures B3, B4, and B5 in Appendix B. For instance, China's Nash-equilibrium tariff is higher than the tariffs which maximize each measure of inequality. As a result, a move from Nash to cooperative tariffs increases China's income inequality.

Table 7: Results and Counterfactuals: Calibrated Government Objective

	Nash (1)	Coop. (2)	Nash (3)	Coop. (4)	Nash (5)	Coop. (6)
	U.S.		**EU**		**CHN**	
Tariffs (%)	22.6	14.1	25.0	15.6	68.6	42.8
Agg. Welfare	0.316	0.319	0.288	0.292	0.142	0.145
$\overline{V}_i$	0.329	0.330	0.392	0.394	0.338	0.339
W_i^E	0.499	0.493	0.497	0.495	0.354	0.355
W_i^L	0.256	0.260	0.287	0.292	0.166	0.169
Unemployment	0.053	0.053	0.086	0.088	0.046	0.047
Gini Coef.	0.234	0.234	0.260	0.264	0.242	0.247
Share Top 1%	0.103	0.106	0.091	0.094	0.111	0.115
Share Top 5%	0.203	0.206	0.177	0.180	0.213	0.219
Share Top 10%	0.271	0.272	0.244	0.247	0.283	0.288

Notes: Nash, and cooperative tariffs refer to the case when each country maximizes welfare of the median top 10% income earner. Unless stated otherwise, unemployment, the Gini coefficient and the income shares are computed for the overall economy. Share Top 1%, Share Top 5%, and Share Top 10% refer to the share of income earned by the top 1 percent, the top 5 percent and the top 10 percent of income earners in a country.

in all three economies, but not necessarily that of entrepreneurs. While in China, which places a high weight on firms, both groups benefit, this is not the case for the U.S. and the EU, where trade talks make the median top 10 percent income earner worse off . Hence, even if governments place a disproportionate weight on firms, the median entrepreneur might still be harmed by trade liberalization.

We also found that cross-country heterogeneity in the government objective can have important implications for the success of global cooperation. In particular, we find that cooperation will result in a move to free trade only if no country places a disproportionately high weight on firms. If a single country assigns a high value β_i on firms, the cooperative tariff is strictly positive, even if all other economies maximize aggregate welfare. Misaligned interests of even a small group of trade partners can hence be detrimental to trade negotiations leading to global free trade.

4.6 Robustness Analysis

We investigate sensitivity of our quantitative results to various alternative parameterizations. In particular, we examine the sensitivity of the results to (1) lower trade costs, (2) a greater Pareto dispersion parameter k, and (3) changes in the elasticity of substitution σ.

The results are generally robust in most dimensions, as shown in Tables C1 to C9 in Appendix C. Neither country can win a tariff war and unilateral increases in tariffs are accompanied by rising unemployment and inequality. Further, a move from aggregate Nash to cooperative tariffs (1) increases total welfare, (2) lowers unemployment, and (3) results in more income inequality in the differentiated sector but less overall income inequality.[44] As in the main case, optimal top 10 percent income tariffs are substantially higher than those that maximize aggregate welfare and the relationship between a global tariff and unemployment as well as income inequality continues to be inverse U-shaped.[45]

5 Concluding Remarks

Motivated by the 2018 global tariff war, this paper developed a multi-country, computable, general-equilibrium model of trade with revenue-generating tariffs to analyze the welfare, unemployment, and distributional effects of tariffs. The aggregate welfare effects of multilateral (as opposed to bilateral) tariffs can be summarized as follows. The average optimal tariff and the average Nash-equilibrium tariff equal 16 percent, and the cooperative tariffs supported by trade negotiations are zero leading to global free trade. In the case of the U.S., who started the global trade war, a move from a factual tariff to its optimal tariff raises national welfare, but retaliation by other countries leads to a greater welfare loss bringing U.S. welfare below its level under global cooperative tariffs and even under factual tariffs. That is, from a perspective of national welfare, the U.S. cannot win the 2018 global war.

The complex distributional effects of tariffs open the door to alternative government objectives. When governments care only about political support of the top 10 percent income earners, the U.S. and China choose a Nash equilibrium tariff of 74 percent and Europe chooses a 60 percent Nash equilibrium tariff. In this case, a move from a trade-war equilibrium to cooperative tariffs raises unemployment in the U.S. and the EU withour affecting unemployment in China. It also raises inequality in all these countries. When the government objective is a weighted sum of

[44]The EU is an exception with increases in unemployment and the Gini coefficient in response to a move from Nash-equilibrium to cooperative tariffs.

[45]As a consequence, a move from Nash-equilibrium to cooperative tariffs in the top 10 percent income case is accompanied by declines in unemployment and the Gini coefficient (See Tables C3, C6, and C9).

entrepreneurial and worker interests with weights incorporating factual, non-cooperative tariffs, trade talks lead to more realistic tariffs of 14 percent for the U.S., 16 percent for Europe and 43 percent for China; and successful trade talks tend to increase unemployment and income inequality.

In sum, aggregate-welfare maximization perspective suggests that the 2018 trade war has generated excessive tariffs with net welfare, distributional, and employment costs. These costs can be reversed through trade talks leading to global free trade. This suggestion seems unrealistic because it predicts low optimal and Nash-equilibrium tariffs and therefore raises doubts about the rationality of U.S. government behavior. The political-economy perspective, which places different weights on workers and firms and information on autonomous tariffs in the government objective, delivers a more realistic and, at the same time, more pessimistic scenario about the role of cooperation and trade talks. In this case, predicted tariffs are closer to factual tariffs; but cooperation does not lead to free trade, and tends to increase unemployment and income inequality.

The political-economy perspective on trade policy raises serious concerns about the ability of global institutions, such as the WTO, to prevent trade wars and their role to promote free trade. Our analysis indicates that in a global economy, where governments care differently about entrepreneurs and workers, trade talks will result in free trade only if no country places a disproportionately high weight on firm profits and entrepreneurs. This suggests that the deterioration of personal income distribution might have acted as a major driver behind the 2018 trade war and thus might have severely undermined the goals and even the existence of WTO. As a result, bilateral and regional trade agreements might constitute the only feasible mechanisms to lower trade barriers.

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