The US–China Phase One trade deal: An economic analysis of the managed trade agreement

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Abstract. In light of the recent tit-for-tat trade dispute between China and the US, interest in quantifying the effects of the so-called Phase One agreement has risen. To this end, this paper quantifies the impact of the asymmetric managed trade agreement using such a multi-country open-economy dynamic general equilibrium model. Besides assessing the direct implications for China and the US, this paper analyzes trade diversion effects. The model-based analysis finds noticeable positive (negative) impacts of the agreement for the US (China) as well as negative spillover effects for countries not directly affected by the managed trade deal due to trade diversion. The impact of possible future trade agreements is also examined.

Résumé. La première phase de l'accord commercial entre les États-Unis et la Chine : une analyse économique de l'accord de commerce administré. À la lumière de l'escalade du récent différend commercial entre la Chine et les États-Unis, la quantification des effets de la dénommée première phase de l'accord suscite un intérêt croissant. À cette fin, l'article quantifie l'incidence de l'accord asymétrique de commerce administré à l'aide d'un modèle d'équilibre général dynamique multinational d'économie ouverte. En plus d'évaluer les répercussions directes pour la Chine et les États-Unis, les effets du détournement de commerce ont également été analysés. L'analyse fondée sur ce modèle révèle des répercussions positives (négatives) notables de l'accord pour les États-Unis (la Chine) ainsi que des réactions en chaîne négatives pour des pays qui ne sont pas touchés directement par l'accord de commerce administré en raison du détournement de commerce. La portée des futurs accords commerciaux possibles est également examinée.

JEL classification: F13, F41, F42

1. Introduction

After three years of tariffs and tensions whilst the US and China have grown more hostile to one another, the US and the Chinese government signed the "Economic and Trade Agreement," also referred to as the US–China Phase One trade agreement, on January

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15, 2020.[1] The centerpiece of the trade deal consists of the introduction of a voluntary import expansion (VIE) opening up the Chinese markets.[2] In detail, the managed trade agreement contains the following provisions: (i) Chinese commitments to purchase more agricultural, energy and manufactured goods and services, (ii) Chinese commitments to reform investment policies and enforce intellectual property rights and (iii) abstention from currency manipulation. In addition, the trade deal comprises provisions to monitor the implementation of the pact, settle disputes and pursue additional policy reforms in Phase Two.

To gauge the macroeconomic effects of the VIE agreement between the US and China, we develop an open-economy dynamic general equilibrium model in the spirit of Melitz (2003) and Ghironi and Melitz (2005). Recently, more considerations have been given to transitions following new trade agreements. While comparative statics are a natural starting point for understanding the steady-state effects of trade policies, knowledge of the transitions is important with respect to capturing the full picture of trade policy impacts. For example, Ravikumar et al. (2019) have shown the importance of distinguishing between static and dynamic gains resulting from tariff reductions. The model proposed by Ghironi and Melitz (2005) embeds the steady-state version of the Melitz (2003) model into a two-country dynamic model, which, together with Bernard et al. (2003), was the breakthrough in the modelling of international trade by heterogeneous firms. This is the motivation for designing a multi-country dynamic model with Chinese characteristics in the tradition of Ghironi and Melitz (2005) below. A special feature of our model is the distinction between privately owned enterprises (POEs) and state-owned enterprises (SOEs) in China because this is of key importance for the implementation of the agreement. The Chinese government thus has two options for implementing the Phase One agreement. On the one hand, the contractually agreed VIE can be achieved via unilateral tariff reduction. On the other hand, the import surge can be achieved by instructing the SOEs to import more American products. The latter could be implemented through an import subsidy, or a market share VIE (Greaney 1996).

Our analysis yields five main results. First, the model simulations show positive (negative) GDP effects for the US (China) with the order of magnitude depending on the extent to which the agreement is implemented. Second, we find negative trade diversion effects for the rest of the world. The reason is that the trade agreement incentivizes China to shift imports away from other suppliers and towards the US. Third, we uncover positive (negative) welfare effects for the US (the rest of the world) throughout, while the welfare effects for China depend on the degree of compliance and the type of implementation. Fourth, an SOE import subsidy to implement the Phase One deal is more efficient than a market share VIE if both achieve the same volume of imports. In the short run, however, a market share VIE might be more beneficial to China, at least if the import volume is not too high. The reason for this result is the production linkages in our model: Unlike the market share VIE, a subsidy relieves not only the SOEs but also the POEs via lower SOE prices. Finally, the quantitative model evaluation yields a permanent improvement in the US–China bilateral trade balance, but no lasting improvement in the overall US trade balance.

1 For the text of the Phase One trade agreement between the US government and the Chinese government, see Office of the United States Trade Representative (2020).

2 VIEs entered the lexicon of trade policy after Bhagwati's (1987) pioneering article. On the one hand, the earlier VIE literature has analyzed the trade and welfare effects of managed trade quotas on the countries being directly involved in various competitive environments. Furthermore, the literature has demonstrated significant trade diversion effects.

To our knowledge, this is the first study that attempts to quantify the global impact of the US−China managed trade agreement using such a multi-country open-economy dynamic general equilibrium model with China-specific model components. A partial list of other recent contributions includes Amiti et al. (2019), Cerutti et al. (2019), Chowdhry and Felbermayr (2020a, 2020b), Freund et al. (2020) and Handley et al. (2020). Chowdhry and Felbermayr (2020a, 2020b) employ an empirical gravity model disaggregated by sector to analyze the impact of the trade agreement on third countries. On the contrary, Freund et al. (2020) use a calibrated computable general equilibrium model under the assumption of perfect competition to analyze the resulting trade patterns. From a methodological point of view, the paper by Bolt et al. (2019), using the multiregional general equilibrium Euro Area and Global Economy (EAGLE) model, is closer to our exercise, but the outcome-based Phase One trade agreement is not evaluated. Finally, Cerutti et al. (2019) examine potential follow-up effects of the managed trade agreement, which were still unknown at the time of writing and thus hypothetical, by means of empirical modelling approaches. In general, one may say that our study fits into this emerging literature on the re-emergence of discriminatory protectionism shaking the foundations of the global trading system.

The remainder of this paper is structured as follows. Section 2 explains the contents of the agreement and analyzes its implementation to date. Section 3 lays out the modelling framework and research design. Section 4 presents the model calibration, and section 5 presents the various numerical trade policy scenarios. The modelling allows to examine different ways of implementing the agreement. Furthermore, the model makes it possible to analyze not only trade policy effects on the US and China but also trade diversion effects on the rest of the world. Finally, alternative possible future trade arrangements of the Biden administration will also be examined. All in all, the modelling framework provides a rich laboratory for the analysis of Sino-American trade policies. Supplementing this, section 6 provides a welfare analysis. The last section contains a summary and conclusions.

2. The asymmetric Phase One trade agreement and its implementation to date

Chapter 6 of the Phase One trade deal contains legal commitments for China to make additional purchases of US exports that would total USD 200 billion above its baseline purchases in 2017, split into $76.7 billion in 2020 and $123.3 billion in 2021. Those 2017 purchases were about USD 130 billion of US merchandize exports and USD 50 billion of US service exports. Thus, the VIE agreement commits China to increase its imports from the US by nearly 43% in 2020 and 68.5% in 2021 both compared with 2017. Within the overall target there are four explicit sub-targets for covered products in the manufacturing, agricultural, energy, and services sectors.[3]

For the implementation of the ambitious commitments, the Chinese government has a variety of enforcement mechanism options from which to choose. In particular, it could pressure its SOEs by persuasion to allow greater imports of US products. In 2019, however, Chinese SOEs purchased only 26% of Chinese total imports. The managed

3 Among the various types of VIE agreements (content VIE, market-share VIE and total value VIE), market-share VIEs have proven to be the most popular in practice. An important reason for this is that this form of VIE is susceptible to the rent-seeking of certain stakeholders (see, e.g., Rodrik 2018).

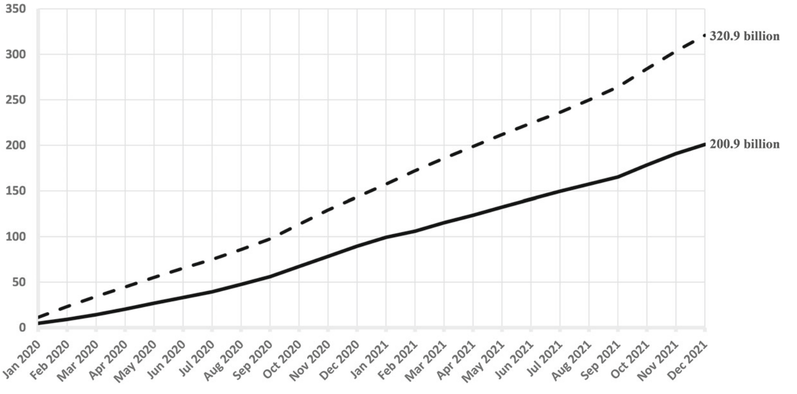

FIGURE 1 US–China Phase One deal monitoring

NOTES: The black dashed line is the accumulated purchase commitment with even monthly targets and the solid black line represents actual accumulated US exports of covered goods.

SOURCES: Author's calculation, US Census Bureau, US International Trade in Goods and Services

trade targets could, therefore, be met only if the Chinese government somehow directs its SOEs to shift their 26% of imports entirely toward American suppliers. Ultimately, one inconsistency of the agreement thus is that the special role of the SOEs, which has been repeatedly criticized by the American authorities, is even strengthened by the trade agreement.

As regards tariffs, the high level of tariffs achieved will largely be maintained. The US will cut by half the tariff rate it imposed on September 1, 2019, on a USD 120 billion list of Chinese goods to 7.5%. US tariffs of 25% USD 250 billion-worth of Chinese goods put in place earlier will remain unchanged. Tariffs that were scheduled to go into effect on December 15, 2019, on nearly USD 160 billion-worth of Chinese goods, including cellphones, laptop computers, toys and clothing, are suspended indefinitely. China's retaliatory December 15, 2019, tariffs, including a 25% tariff on US cars have also been suspended. Overall, however, reciprocal average tariffs will remain at a very elevated level for the foreseeable future.[4] Finally, on October 4, 2021, the Biden administration announced that it will continue to enforce the Phase One agreement with China for the time being.

A target-performance comparison since the beginning of 2020 is shown in figure 1. The figure shows the actual and committed accumulated exports of the product groups covered in the Phase One deal. These are the yardstick for the degree of fulfillment of the target. What does the compliance with the managed trade deal obligations look like until December 2020? The target-performance comparison for the covered goods reveals a degree of fulfillment of 63% (USD 200.9 billion/USD 320.9 billion) in December 2021. This provides a quantitative underpinning for the model simulations.

For several reasons, the target achievement level in figure 1 must be understood as an approximation. To begin with, trade in services is not taken into account. Most importantly, the impacts of the pandemic, which has led to an unprecedented disruption to world trade,

4 After the Phase One trade deal went into effect, the average US (Chinese) tariffs on Chinese (US) exports are 19.3% (20.3%). The empirical evidence shows throughout that the higher tariffs raised prices and punished American consumers (Amiti et al. 2019; Fajgelbaum et al. 2020).

are left unconsidered.[5] For a hypothetical accounting of the pandemic on implementation, see figure A1 in the online appendix. If we assume that the pandemic tacitly led to a six-month delay in implementation, the achievement rate would increase by 10 percentage points.

3. Model

The theoretical model is designed to investigate the underlying questions in a coherent multi-country framework rigorously, yet still be tractable to obtain intuitive results. The modelling setup is reminiscent of the approaches by Melitz (2003) and Ghironi and Melitz (2005) featuring heterogeneous firms that decide not only how much they produce and export but also whether they enter the market or export at all. The Ghironi and Melitz (2005) model comprises several recent advances in the theory of international trade. Notable among them are the assumptions that firms within each sector are heterogeneous in their productivity as in Melitz (2003), and that international trade evolves dynamically over time. Furthermore, the model produces an array of empirical regularities, including persistent trade deficits, the dynamics of firm entry and exit, and an environment in which only the most productive firms become exporters.

For the research question at hand, however, the baseline model is modified in several ways. First, the model is extended by a third country and calibrated to represent the US, China and the rest of the world (RW) to consider the effects of trade deflection. Second, the China module of the model also contains a state-owned enterprise sector operating under the authority of the government. Third, tariffs are introduced as a policy instrument in all economies. Fourth, we adopt the nested constant elasticity of substitution CES preferences proposed by Feenstra et al. (2018) to distinguish between micro and macro trade elasticities. The distinction between micro and macro trade elasticities is a possible solution to the so-called international elasticity puzzle (Ruhl 2008). In international macroeconomics, which works with highly aggregated data, lower trade elasticities are estimated than with micro data, as they are used in international economics. Finally, we include international production linkages through a model structure like that of Caliendo et al. (2015). They have extended a model in the spirit of Melitz (2003) by adding international input-output structures and thus global supply chains. A feature of, and used by, the model is that the same good can be used as both a consumption good and an intermediate good. This leads to a substantial streamlining of the model structure.

For an overview, figure 2 sketches the general structure of the model. The model presumes a two-stage production process. In the first stage, heterogeneous firms use labour, capital and final goods to produce tradable intermediate goods (see section 3.1.2). These firms are differentially productive, drawing their productivity from a Pareto distribution at their birth. Only the most productive of them export their products abroad. The tradable goods from the first stage are bought by the firms in the second stage. As a China-specific feature, a distinction between POEs and SOEs is introduced in the China submodule. In the model, SOEs differ from POEs in two respects. First, they are less productive and second, they can be instructed by the Chinese government to purchase, for example, a higher share of tradable goods from the US (see section 3.1.1). Firms in the second stage produce a homogeneous final

5 As with all trade agreements, the Phase One trade deal includes a force majeure provision allowing for exceptions in crises. The “disaster clause” in article 7.6 stipulates that the parties shall consult with each other in the event of a natural disaster or other unforeseeable event outside of their control. However, neither party has made use of this option.

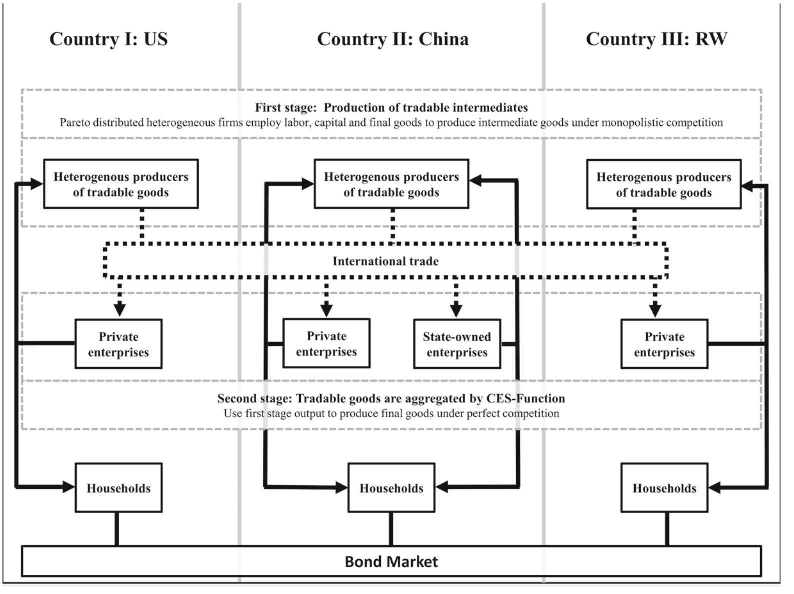

FIGURE 2 The general structure of the modelling framework

product, which they in turn sell to households as consumption and capital goods and to firms in the first stage as material inputs. The households of the three countries are connected via the bond market. They smooth their consumption over time, accumulate capital and supply a fixed amount of labour (see section 3.2). For the sake of clarity, the governments that pursue trade policy VIEs, tariffs, directives and possibly subsidies are not shown (see section 3.3). The details of the model are described next.

3.1. Firms

The structure of the production sector is similar to that of Caliendo et al. (2015). Deviating from this multi-good modelling framework, however, the model presented here incorporates a special three-country-four-sector structure. The three countries are the United States (US), China (CN) and the rest of the world (RW). Each of these countries has privately owned enterprises (POEs). In addition, and exclusively, China also has a state-owned enterprise (SOE) sector.

3.1.1. Final goods production and managed trade policy

The economy is populated by final goods firms, indexed by sector $s \in \{POE, SOE\}$ and country $i \in \{US; CN; RW\}$. Using the Dixit–Stiglitz aggregator the production of final goods in period t is given by

$$Q^i_{s,t} = Z^i_s\left(\left(1-\alpha^i\right)^{\frac{1}{\omega}}\left(Q^i_{Ds,t}\right)^{\frac{\omega-1}{\omega}} + \left(\alpha^i\right)^{\frac{1}{\omega}}\left(Q^i_{Xs,t}\right)^{\frac{\omega-1}{\omega}}\right)^{\frac{\omega}{\omega-1}}, \tag{1}$$

where Z^i_s is the productivity of final goods firms in country i and sector s, α^i is the degree of openness, and ω is the macro elasticity, i.e., the elasticity of substitution between the domestically produced bundle of intermediate varieties and that produced abroad. The former is given by

$$Q^i_{Ds,t} = \left(\int_{\varphi\in\Phi}\left(Q^i_{Ds,t}(\varphi)\right)^{\frac{\theta-1}{\theta}} d\varphi\right)^{\frac{\theta}{\theta-1}}, \tag{2}$$

where $Q^{i}_{Ds,t}(\varphi)$ represent the demand for variety φ, and the foreign produced bundle $Q^{i}_{Xs,t}$. We normalize the productivity of POEs to 1, while the Chinese SOEs have lower productivity. The foreign bundle is given by

$$Q^{i}_{Xs,t}=\left(\sum_{j\neq i}\left(\kappa^{ij}\right)^{\frac{1}{\theta}}\left(Q^{ij}_{Xs,t}\right)^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}}, \tag{3}$$

where κ^{ij} denotes the utility weight of the CES index, the bundle of varieties imported from country j is $Q^{ij}_{Xs,t}=\left(\int_{\varphi\in\Phi}\left(Q^{ij}_{Xs,t}(\varphi)\right)^{(\theta-1)/\theta}d\varphi\right)^{\theta/(\theta-1)}$ and θ is the micro elasticity of substitution, which is the same for all goods. As mentioned above, the introduction of these two distinct substitution elasticities follows Feenstra et al. (2018). The economic motivation is that substitution between domestic and foreign goods may be more difficult than between different foreign goods.

For privately owned firms the CES-based final price index is given by

$$P^{i}_{POE,t}=\frac{1}{Z^{i}_{POE}}\left[\left(1-\alpha^{i}\right)\left(P^{i,n}_{DPOE,t}\right)^{1-\omega}+a^{i}\left(P^{i,n}_{XPOE,t}\right)^{1-\omega}\right]^{\frac{1}{1-\omega}}, \tag{4}$$

where $P^{i,n}_{DPOE,t}=\left(\int_{\varphi\in\Phi}\left(p^{i,n}_{DPOE,t}(\varphi)\right)^{1-\theta}d\varphi\right)^{1/(1-\theta)}$ and $P^{i,n}_{XPOE,t}=\left(\sum_{j\neq i}\kappa^{ij}\left(P^{ij,n}_{XPOE,t}\right)^{1-\theta}\right)^{1/(1-\theta)}$ are the nominal price indices of the domestic varieties and of imported intermediates, respectively.[6] $P^{ij,n}_{XPOE,t}=\left(\int_{\varphi\in\Phi}\left((1+\tau^{ij}_{t})p^{ij,n}_{XPOE,t}(\varphi)\right)^{1-\theta}d\varphi\right)^{1/(1-\theta)}$ is the nominal price index of varieties from country j, which also depends on the trade tariff τ^{ij}_{t} levied by country i on products of country j. In the US and the rest of the world the final product of the POE sector is used as a numeraire. In other words, the numeraire price index $P^{i}_{t}=P^{i}_{POE,t}\forall i\,\epsilon\,\{US;RW\}$ is the private firm price index according to equation (4). For China, we use the composite of SOEs and POEs as the numeraire. Therefore, the Chinese numeraire price index is based on the price indices of POEs and SOEs according to $P^{CN}_{t}=\left(P^{CN,n}_{POE,t}\right)^{\chi}\left(P^{CN,n}_{SOE,t}\right)^{1-\chi}$ (see also section 3.2). Dividing equation (4) by P^{i}_{t}, the following relationship between real domestic and import price indices can be obtained:

$$1=\left(1-\alpha^{i}\right)\left(\frac{P^{i}_{DPOE,t}}{Z^{i}_{POE}}\right)^{1-\omega}+a^{i}\left(\frac{P^{i}_{XPOE,t}}{Z^{i}_{POE}}\right)^{1-\omega}. \tag{5}$$

Consequently, for China, a similar relationship between the real price indices of POEs and SOEs holds:

$$1=\left(P^{CN}_{POE,t}\right)^{\chi}\left(P^{CN}_{SOE,t}\right)^{1-\chi}. \tag{6}$$

We define the relative demand for US products by the Chinese SOEs as

$$\Psi_{\mathrm{t}}=\frac{P^{CNUS}_{XSOE,t}\,Q^{CNUS}_{XSOE,t}}{P^{CN}_{DSOE,t}\,Q^{CN}_{DSOE,t}+P^{CNUS}_{XSOE,t}\,Q^{CNUS}_{XSOE,t}+P^{CNRW}_{XSOE,t}\,Q^{CNRW}_{XSOE,t}}=\frac{P^{CNUS}_{XSOE,t}\,Q^{CNUS}_{XSOE,t}}{P^{CN}_{SOE,t}\,Q^{CN}_{SOE,t}}. \tag{7}$$

6 The superscript n denotes nominal variables.

Without government intervention, the SOEs act exactly like the POEs, i.e., Ψ_t is endogenously determined by the price indices as described above for private firms. But sbecause the Chinese SOEs are less productive than POEs, the SOEs receive a government subsidy for compensation. They get this subsidy, $\tau^{CN}_{DSOE,t}$, for domestic market purchases, allowing the Chinese government to simultaneously promote SOEs and domestic producers of tradable intermediates while discriminating against the corresponding foreign producers. Thus, the price index of Chinese domestic varieties sold to SOEs is given by

$$P^{CN}_{DSOE,t} = \left(\int_{\varphi \in \Phi} \left(\left(1 - \tau^{CN}_{DSOE,t}\right) P^{CN}_{DSOE,t}(\varphi) \right)^{1-\theta} d\varphi \right)^{1/1-\theta}. \tag{8}$$

Moreover, we introduce a subsidy $\tau^{CNUS}_{XSOE,t}$ to SOEs for importing US goods. Using this import subsidy is one way to fulfill China's commitments under the Phase One Deal.[7] The price index of varieties from the US exported to China is thus given by

$$P^{CNUS}_{XSOE,t} = \left(\int_{\varphi \in \Phi} \left(\left(1 + \tau^{CNUS}_{t} - \tau^{CNUS}_{XSOE,t}\right) P^{CNUS}_{XSOE,t}(\varphi) \right)^{1-\theta} d\varphi \right)^{1/1-\theta}. \tag{9}$$

Both subsidies are modelled symmetrically to tariffs, i.e., Chinese households receive the difference between tariff revenues and subsidy expenditures as a lump sum payment. $P^{CNRW}_{XSOE,t}$ is defined analogously.

Our main theoretical contribution is that we also consider the case where the Chinese government instructs SOEs to increase Ψ_t to a minimum level rather than just providing the appropriate incentive via a subsidy. Let's assume for the moment that the relative SOE demand for US goods, Ψ_t, is simply set exogenously by the Chinese authorities. From standard profit maximization, the demand function of SOEs for domestic goods is obtained as

$$\frac{Q^{CN}_{DSOE,t}}{Q^{CN}_{SOE,t}} = \left(1 - \alpha^{CN}\right) \left(\mathrm{Z}^{CN}_{\mathrm{SOE}}\right)^{\omega-1} \left(\frac{P^{CN}_{DSOE,t}}{P^{CN}_{SOE,t}} \right)^{-\omega} \Xi_t^{-\omega}, \tag{10}$$

and the demand for goods from the rest of the world is given by

$$\frac{Q^{CNRW}_{XSOE,t}}{Q^{CN}_{SOE,t}} = \alpha^{CN} \kappa^{CNEU} \left(\mathrm{Z}^{CN}_{\mathrm{SOE}}\right)^{\frac{(\omega-1)\theta_{SOE}}{\omega}} \left(\frac{P^{CNRW}_{XSOE,t}}{P^{CN}_{SOE,t}} \right)^{-\theta} \left(\frac{Q^{CN}_{XSOE,t}}{\alpha^{CN} Q^{CN}_{SOE,t}} \right)^{\frac{\omega-\theta}{\omega}} \Xi_t^{-\theta}, \tag{11}$$

where Ξ_t is defined as

$$\Xi_t = \frac{1}{(1-\Psi_t)} - \frac{\Psi_t}{(1-\Psi_t)} \left(\kappa^{CNUS}\right)^{\frac{1}{\theta}} \left(\mathrm{Z}^{CN}_{\mathrm{SOE}}\right)^{\frac{\omega-1}{\omega}} \left(\frac{Q^{CNUS}_{XSOE,t}}{Q^{CN}_{XSOE,t}} \right)^{-\frac{1}{\theta}} \left(\frac{Q^{CN}_{XSOE,t}}{\alpha^{CN} Q^{F}_{SOE,t}} \right)^{-\frac{1}{\omega}} \frac{P^{CN}_{SOE,t}}{P^{CNUS}_{XSOE,t}}. \tag{12}$$

If the Chinese government exogenously sets the demand of SOEs for US goods, then this leads to a distortion in relative demands, this distortion is represented by Ξ_t. The higher the Chinese government sets the minimum import quota for US goods above the competitive level, the more Ξ_t increases. In addition, the CES price indices for final and for imported goods can no longer be represented as a function of only

7 The modelling illustrates an important issue. The Phase One deal worsens rather than resolves one of the frictions underlying this trade conflict. The counterproductive trade agreement pushes China even farther away from markets and toward a state-driven economy. In practical terms, the Chinese authorities could promise to rebate the tariffs it collects on SOE purchases.

price subindices, as in equation (4). Instead, we use the demand functions given by equations (10) and (11) as equilibrium conditions to close the model. They are still tractable and easy to interpret. Notice that the above-described term Ξ_t equals 1 if the relative demand Ψ_t exactly matches the unconstrained CES demand function of the SOEs without government interventions. Therefore, we write the demand policy of the Chinese government as

$$\Psi_t = \max\left(\alpha^{CN}\kappa^{CNUS}\left(Z^{CN}_{SOE}\right)^{\frac{(\omega-1)\theta_{SOE}}{\omega}} \left(\frac{P^{CNUS}_{XSOE,t}}{P^{CN}_{SOE,t}}\right)^{1-\theta} \left(\frac{Q^{CN}_{XSOE,t}}{\alpha^{CN}Q^{CN}_{SOE,t}}\right)^{\frac{\omega-\theta}{\omega}}, \underline{\Psi}_t \right). \quad (13)$$

The first term in parentheses is the unconstrained CES-based demand function and $\underline{\Psi}_t$ is the market share VIE for US goods set by the Chinese authorities. Thus, we model the voluntary import expansion as a constraint exogenously set by the Chinese government. If the latter is not binding, then Ψ_t is exactly the endogenously determined unrestricted SOE demand for US goods.

3.1.2. Intermediate goods production

Intermediate goods are produced in monopolistically competitive markets, described below in more detail. The production function of a firm indexed by its relative productivity z is given by the Cobb−Douglas function

$$Y^i_{D,t}(z) = zZ^i\left(L^i_t(z)\right)^{\varrho^i_L}\left(K^i_t(z)\right)^{\varrho^i_K}\left(M^i_t(z)\right)^{\varrho^i_M}, \quad (14)$$

where $L^i_t(z)$, $K^i_t(z)$ and $M^i_t(z)$ are labour, capital and raw materials used by firm z, respectively. ϱ^i_L, ϱ^i_K and ϱ^i_M are the respective factor weights and Z^i is aggregate productivity in country i. Unlike the other two countries, SOEs and POEs coexist in China. The intermediate goods firms thus buy materials and rent capital from companies of both ownership structures and thus we define the aggregate Cobb−Douglas-weighted input bundle as

$$M^{CN}_t(z) = \check{\chi}\left(M^{CN}_{POE,t}(z)\right)^{\chi}\left(M^{CN}_{SOE,t}(z)\right)^{1-\chi}, \quad (15)$$

$$K^{CN}_t(z) = \check{\chi}\left(K^{CN}_{POE,t}(z)\right)^{\chi}\left(K^{CN}_{SOE,t}(z)\right)^{1-\chi}, \quad (16)$$

where χ is the weighting factor and $\check{\chi} = 1/\left(\chi^{\chi}(1-\chi)^{(1-\chi)}\right)$ ensures that the coexistence of the two sectors does not lead to any losses. Profit maximization leads to an expression for marginal cost in the US and the RW given by

$$MC^i_t = \left(\frac{w^i_t}{\varrho^i_L}\right)^{\varrho^i_L}\left(\frac{R^i_{K,t}}{\varrho^i_K}\right)^{\varrho^i_K}\left(\frac{1}{\varrho^i_M}\right)^{\varrho^i_M}, \quad (17)$$

where $i \in \{US, RW\}$. Given the dissimilar corporate structure, marginal cost in China can be written as

$$MC^{CN}_t = \left(\frac{w^{CN}_t}{\varrho^{CN}_L}\right)^{\varrho^{CN}_L}\left(\frac{R^{CN}_{KPOE,t}}{\check{\chi}\chi\varrho^{CN}_K}\right)^{\varrho^{CN}_K\chi}\left(\frac{R^{CN}_{KSOE,t}}{\check{\chi}(1-\chi)\varrho^{CN}_K}\right)^{\varrho^{CN}_K(1-\chi)}$$
$$\times\left(\frac{P^{CN}_{POE,t}}{\check{\chi}\chi\varrho^{CN}_M}\right)^{\varrho^{CN}_M\chi}\left(\frac{P^{CN}_{SOE,t}}{\check{\chi}(1-\chi)\varrho^{CN}_M}\right)^{\varrho^{CN}_M(1-\chi)}, \quad (18)$$

where w_t^i denotes the real wage in country i, $R_{K,t}^{CN}$ is the rental price of physical capital and $P_{SOE,t}^{CN}$ is the price of the homogeneous final product produced by the state-owned enterprises in China and used as raw material input by the intermediate firms. Note that MC_t^i is the marginal cost of buying an additional unit of the factor input bundle, which is the same for all firms in country i, and not the marginal cost of producing an additional unit of output, which varies across firms depending on their relative productivity z. Price setting under imperfect competition leads to the first-order condition in which firms choose the output price as a mark-up on marginal costs as

$$p_{D,t}^{i}(z) = \frac{p_{D,t}^{i,n}(z)}{P_t^i} = \frac{\theta}{\theta - 1}\frac{MC_t^i}{Z^i z}. \tag{19}$$

If firm z exports to country j, its price in terms of the price index of the destination market is given by

$$p_{X,t}^{ji}(z) = \frac{p_{X,t}^{ji,n}(z)}{P_t^j} = \frac{1}{\varepsilon_t^{ij}}\tau_{IB,t}^{ij}\, p_{D,t}^{i}(z), \tag{20}$$

where $\tau_{IB,t}^{ji}$ are iceberg trade costs from exporting from country j to country i and ε_t^{ij} is the real exchange rate defined as $\varepsilon_t^{ij} = \varepsilon_t^{ij,n} P_t^j / P_t^i$. The existence of iceberg costs implies that $\tau_{IB,t}^{ji} > 1$ units of goods must be shipped for 1 unit to arrive at the destination. We assume a flexible exchange rate throughout our paper. Note that $p_{X,t}^{ji}(z)$ is the price received by firm z. The trade tariff is levied on the final price and is therefore not considered a cost by the firm, unlike the iceberg trade cost (for the economic meaning of this distinction see Caliendo et al. 2015).

In the Chinese sub-model, real profits of firm z from domestic sales to SOEs are

$$\begin{aligned} d_{DSOE,t}^{CN}(z) = {} & \frac{1}{\theta}\left(1 - \tau_{DSOE,t}^{CN}\right)^{-\theta}\left(Z_{SOE}^{CN}\right)^{\omega-1}\left[p_{D,t}^{CN}(z)\right]^{1-\theta}\left(P_{DSOE,t}^{CN,n}\right)^{\theta-\omega} \\ & \times \left(\frac{P_{SOE,t}^{CN}}{\Xi_t}\right)^{\omega}(1-\alpha)Q_{SOE,t}^{CN}. \end{aligned} \tag{21}$$

If a firm in country i decides to export to country j, it has to pay fixed costs of exporting $f_{X,t}^{ij}$ in terms of effective units of its input bundle.[8] Consequently, the export profits are given by

$$d_{Xs,t}^{ij}(z) = \begin{cases} \frac{\varepsilon_t^{ij}}{\theta}\left(1 + \tau_t^{ji}\right)^{-\theta}\left[p_{X,t}^{ji}(z)\right]^{1-\theta}\left(P_{Xs,t}^{ji}\right)^{\theta} Q_{s,t}^{ji} - MC_t^i \frac{f_{X,t}^{ij}}{Z^i}, & \text{if firm } z \text{ exports to } j \\ 0 & \text{otherwise.} \end{cases} \tag{22}$$

Notice that, in China, intermediate firms make domestic profits from selling to the POE and the SOE sector. In the US and the RW a firm z decides separately whether and if so to which Chinese sectors it exports. Hence, the total profits of firm z, the sum of its domestic and export profits, also have to be summed across sectors, i.e., $d_t^i(z) = \sum_s \sum_{j \neq i}\left(d_{Ds,t}^i(z) + d_{Xs,t}^{ij}(z)\right)$.

8 There are persuasive reasons that there are not only trade costs but also fixed costs of exporting. These include, among others, learning about new markets, regulatory costs and costs for distribution networks.

3.1.3. Equilibrium price indices and aggregation

The aggregate domestic and import equilibrium prices from country i and sector s are given by

$$P^i_{Ds,t} = \left\{ \int_{z_{min}}^{\infty} \left[p^i_{Ds,t}(z) \right]^{1-\theta} N^i_{D,t} g(z)\ dz \right\}^{\frac{1}{1-\theta}} \tag{23}$$

and

$$P^{ij}_{Xs,t} = \left\{ \int_{z^{ji}_{Xs,t}}^{\infty} \left[\left(1 + \tau^{ij}_t\right) p^{ij}_{Xs,t}(z) \right]^{1-\theta} N^j_{D,t} g(z)\ dz \right\}^{\frac{1}{1-\theta}}, \tag{24}$$

respectively. $N^i_{D,t}$ is the number of intermediate firms in country i. Every individual firm produces one variety, and hence the number of firms equals the number of available varieties. Only firms with a productivity cut-off value of at least $z^{ji}_{Xs,t}$ will also export to country i and sector s.

Given this export productivity cut-off value and a minimum productivity of firms in country i, z_{min}, we define the average productivity of all firms as

$$\tilde{z}^i_{Ds,t} = \left[\int_{z_{min}}^{\infty} z^{\theta-1} g(z)\ dz \right]^{1/(\theta-1)}$$

and of all exporters to country j and sector s as

$$\tilde{z}^{ij}_{Xs,t} = \left[1/\left(1 - G\left(z^{ij}_{Xs,t}\right)\right) \int_{z^{ij}_{Xs,t}}^{\infty} z^{\theta-1} g(z)\ dz \right]^{1/(\theta-1)}.$$

$G(z)$ is the cumulative distribution function of firm productivity and thus $G\left(z^{ij}_{Xs,t}\right)$ is the probability that a firm will not export to sector s in country j. $\tilde{z}^i_{Ds,t}$ and $\tilde{z}^{ij}_{Xs,t}$ are weighted means of the firms' productivity values z, where the weighting is based on the firms' output shares. These average values defined here summarize the information in the distribution of productivity levels relevant for all aggregated variables (Melitz 2003). For example, it can be shown that the aggregated prices described above can be written as a price index of the destination market as

$$P^i_{Ds,t} = \frac{P^{i,n}_{D,t}}{P^i_t} = \left(N^i_{D,t}\right)^{\frac{1}{1-\theta}} p^i_{D,t}\left(\tilde{z}^i_{D,t}\right), \tag{25}$$

$$P^{ij}_{Xs,t} = \frac{P^{ij,n}_{Xs,t}}{P^i_t} = \left(1 + \tau^{ij}_s\right) \left(N^{ji}_{Xs,t}\right)^{\frac{1}{1-\theta}} p^{ij}_{X,t}\left(\tilde{z}^{ji}_{Xs,t}\right). \tag{26}$$

$N^{ji}_{Xs,t}$ is the number of firms in country j that decide to export to sector s in country i.

3.1.4. Distributional assumptions and firm averages

We assume the firm productivity z to be Pareto distributed.[9] The cumulative distribution function is then given by $G(z) = 1 - (z_{min}/z)^k$ with lower bound z_{min} and shape parameter k, which must be greater than $\theta - 1$ so that the average of the firm size does not become infinite. Given the Pareto distribution, the average productivities are as follows:

9 The Pareto distribution has two well-known advantages. (i) Combined with CES, it delivers closed-form solutions, and (ii) the Pareto distribution is scale-free and thus the degree of heterogeneity is summarized only by the shape parameter κ. The homogeneous firm model corresponds to the limit case in which the $\kappa \to \infty$.

$$\tilde{z}^{i}_{D,t} = \left[\frac{k}{k-\theta+1}\right]^{\frac{1}{\theta-1}} z_{min}; \quad \tilde{z}^{ij}_{Xs,t} = \left[\frac{k}{k-\theta+1}\right]^{\frac{1}{\theta-1}} z^{ij}_{Xs,t}. \tag{27}$$

We now combine the above and equation (21) to solve for the productivity cut-offs that distinguish profitable from nonprofitable exporters. Firms that draw a productivity above the cut-off will supply the market, and this therefore determines the set of varieties supplied to the market.[10]

In the interest of a space-saving presentation, only the productivity cut-off value of US firms exporting to Chinese state-owned enterprises is presented here:[11]

$$z^{USCN}_{XSOE,t} = \left(\frac{\theta}{\theta-1}\right) \frac{\left(1+\tau^{CNUS}_{t} - \tau^{CNUS}_{XSOE,t}\right)\tau^{USCN}_{IB,t}}{P^{CNUS}_{XSOE,t}} \times \left(\frac{\Psi_t Q^{CN}_{SOE,t} P^{CN}_{SOE,t}}{\theta\left(1+\tau^{CNUS}_{t} - \tau^{CNUS}_{XSOE,t}\right) f^{USCN}_{X,t}}\right)^{\frac{1}{1-\theta}} \left(\frac{MC^{US}_{t}}{\varepsilon^{USCN}_{t} Z^{US}}\right)^{\frac{\theta}{\theta-1}}. \tag{28}$$

A higher (relative) demand of the Chinese SOEs for US goods leads to a lower productivity cut-off value and thus to lower average productivity of the respective US exporters, as firms that are less productive self-select into the export market. The reason for this selection effect, as Caliendo et al. (2015) call it, is that US exporters can spread their fixed costs over higher sales.

There are $N^{i}_{D,t}$ companies in country i, but only $N^{ij}_{Xs,t}$ companies decide to export to sector s of country j.[12] The share of the latter can be expressed by

$$\frac{N^{ij}_{Xs,t}}{N^{i}_{D,t}} = \left(\frac{z_{min}}{\tilde{z}^{ij}_{Xs,t}}\right)^{k} \left(\frac{k}{k-\theta+1}\right)^{\frac{k}{\theta-1}}. \tag{29}$$

The associated average profits are $\tilde{d}^{i}_{D,t} = d^{i}_{D,t}(z_{min})\,[k/(k-\theta+1)]$ and $\tilde{d}^{ij}_{Xs,t} = [(\theta-1)/(k-\theta+1)]MC^{i}_{t} f^{ij}_{X}/Z^{i}_{t}$, respectively. Average total profits of Chinese intermediate firms are

$$\tilde{d}^{CN}_{t} = \tilde{d}^{CN}_{D,t} + \tilde{d}^{CN}_{SOE,t} + \sum_{j\neq CN} \frac{N^{CNj}_{XPOE,t}}{N^{CN}_{D,t}} \tilde{d}^{CNj}_{XPOE,t}, \tag{30}$$

and for all $i \neq CN$,

$$\tilde{d}^{i}_{t} = \tilde{d}^{i}_{D,t} + \frac{N^{iCN}_{SOE,t}}{N^{i}_{D,t}} \tilde{d}^{iCN}_{SOE,t} + \sum_{j\neq i} \frac{N^{ij}_{XPOE,t}}{N^{i}_{D,t}} \tilde{d}^{ij}_{XPOE,t}. \tag{31}$$

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10 How does foreign trade affect the distribution of firms and average productivity? With foreign trade, exporting provides new opportunities for profits only to the most productive firms with productivities above the cut-off. The most productive firms increase labour demand. This increases the real wage and forces less productive firms to exit. In other words, foreign trade leads to intra-industry reallocation across firms. For exporting firms, profits due to export opportunities increase, but decrease due to the entry of foreign firms in the domestic market. For non-exporting firms, only the negative second effect is active. The normative implication is that exposure to trade increases average productivity and thus leads to gains from trade.

11 The remaining export cut-off values are available upon request.

12 Since the firm draws its productivity and then decides whether or not it exports, all exporting firms must sell domestically (but the converse is not true).

3.1.5. Firm entry and exit decisions

There is a large (unbounded) pool of prospective entrants into the industry. Prior to entry, firms are identical. However, the entry decision undertaken by each firm is risky. When entering the market, identical firms must pay sunk entry costs amounting to f_E^i effective units of the input bundle. After the market entry, the firm draws its productivity level z from the Pareto distribution described above. Prior to entry, firms think about their expected profits and calculate the present value of the expected stream of average profits starting in period $t+1$:

$$\tilde{\nu}_t^i = E_t\left(\sum_{h=t+1}^{\infty}[\beta(1-\delta)]^{h-t}\left(\frac{\lambda_h^i}{\lambda_t^i}\right)\tilde{d}_h^i\right). \tag{32}$$

The expected stream of profits must be equal to the costs of entry, which implies

$$\tilde{\nu}_t^i = \frac{MC_t^i f_E^i}{Z_t^i}. \tag{33}$$

As in Ghironi and Melitz (2005), new entrants in period t start to produce in period $t+1$ and survive every period with a probability $(1-\delta)$. Let the number of new entrants in period t be $N_{E,t}^i$, then the stock of firms is given by

$$N_{D,t}^i = (1-\delta)\left(N_{D,t-t}^i + N_{E,t-1}^i\right). \tag{34}$$

3.2. The representative household

The representative household h in country $i \in \{US; CN; RW\}$ acts competitively, taking prices and policy as given, and maximizes its utility

$$V_0 = E_0\left(\sum_{t=0}^{\infty}\beta^t\frac{\left(C_{h,t}^i\right)^{1-\gamma}}{1-\gamma}\right), \tag{35}$$

where E_0 is the rational expectations operator, β is the discount factor and γ is the inverse elasticity of intertemporal substitution with regard to consumption $C_{h,t}^i$. In the US and the RW, households consume POE-produced goods, i.e., $C_{h,t}^i = C_{h,POE,t}^i$ for $i \neq CN$. In contrast, Chinese households consume a bundle of POE-produced and SOE-produced goods $C_{h,t}^{CN} = \check{\chi}\left(C_{h,POE,t}^{CN}\right)^{\chi}\left(C_{h,SOE,t}^{CN}\right)^{1-\chi}$. Consumption of every country has a mass relative to the size of the US economy ξ^{US}. Therefore, all absolute quantities represent aggregates relative to the US. Due to symmetry, consumption and labour supply are the same for every household and, thus, $C_{h,s,t}^i = \frac{\xi^{US}}{\xi^i}C_{s,t}^i$. The aggregated budget constraint of all households in country i is given by

$$\begin{aligned}\sum_{j\neq i}B_{i,t}^i &+ \sum_{j\neq i}\varepsilon_t^{ij}B_{j,t}^i + \tilde{v}_t^i\, N_t^i\, x_t^i + \sum_s\frac{P_{s,t}^{i,n}}{P_t^i}I_{s,t}^i + C_{h,t}^i\\ &= \sum_{j\neq i}R_{t-1}^i B_{i,t-1}^i + \sum_{j\neq i}R_{j,t-1}^i\varepsilon_t^{ij}B_{j,t-1}^i + R_{Ks,t}^i\, K_{s,t-1}^i\\ &\quad + \left(\tilde{d}_t^i + \tilde{v}_t^i\right)\, N_t^i x_{t-1}^i + w_t^i\, L^i + \Gamma_t^i,\end{aligned} \tag{36}$$

where $B_{i,t}^i$ are bonds denoted in domestic currency, $B_{j,t}^i$ are bonds denoted in a foreign currency, and $\varepsilon_t^{ij} = \varepsilon_t^{ij,n}P_t^j/P_t^i$ is the real exchange rate. R_{t-1}^i is the interest rate of bonds denoted in domestic currency and $R_{j,t-1}^i$ is the interest rate of bonds denoted in the currency of country j. w_t^i is the real wage, L^i is labour supply, and Γ_t^i is a lump-sum rebate of the import tariff revenue (see section 3.3). During period t, households buy x_t^i shares in an investment fund from $N_t^i \equiv N_{D,t}^i + N_{E,t}^i$ domestic firms and in this way invest at the extensive margin. The price of the shares is equal to the above-mentioned present value of the expected stream of average profits of the domestic firms $\tilde{\nu}_t^i$. The dividends paid to the shareholders in period t are again equal to average profits $\tilde{d}_t^i$. Moreover, households can consume $C_{POE,t}^i$ or invest $I_{POE,t}^i$ of the final private sector good (at the intensive margin). Chinese households can also consume $C_{SOE,t}^{CN}$ goods or invest $I_{SOE,t}^{CN}$ capital goods produced by state-owned enterprises by paying the real price $P_{SOE,t}^{CN}$. In previous periods accumulated capital, $K_{s,t-1}^i$ provides a real return $R_{Ks,t}^i$ to the household. Furthermore, we assume convex investment adjustment costs. Therefore, the utility maximization problem of the household is also subject to

$$K_{s,t}^i = (1-\delta_K)\, K_{s,t-1}^i + I_{s,t}^i \left(1 - \frac{\phi}{2}\left(\frac{I_{s,t}^i}{I_{s,t-1}^i} - 1\right)^2\right), \tag{37}$$

where ϕ is an investment adjustment cost parameter and δ_K is the depreciation rate of capital. The aggregate marginal value of consumption is given as

$$\lambda_t^i = \left(\frac{\xi^{US}}{\xi^i} C_{h,t}^i\right)^{-\gamma}, \tag{38}$$

where λ_t^i is the Lagrangian multiplier of the budget constraint. In contrast to the US and the RW, Chinese households consume POE-produced and SOE-produced goods. Therefore, the corresponding relative demand is given by

$$\frac{C_{POE,t}^{CN}}{C_{SOE,t}^{CN}} = \frac{\chi}{(1-\chi)} \frac{P_{SOE,t}^{CN}}{P_{POE,t}^{CN}}. \tag{39}$$

The remaining first-order conditions common to all countries are

$$R_t^i = \frac{1}{\beta}\, E_t\left(\frac{\lambda_t^i}{\lambda_{t+1}^i}\right), \tag{40}$$

$$R_{j,t}^i = \frac{1}{\beta} E_t\left(\frac{\varepsilon_t^{ij}}{\varepsilon_{t+1}^{ij}} \frac{\lambda_t^i}{\lambda_{t+1}^i}\right), \tag{41}$$

$$q_{s,t}^i = \beta\, E_t\left(\frac{\lambda_{t+1}^i}{\lambda_t^i}\, \left(R_{Ks,t+1}^i + q_{s,t+1}^i (1-\delta_K)\right)\right), \tag{42}$$

$$\begin{aligned} q_{s,t}^i = {} & \frac{P_{s,t}^{i,n}}{P_t^i} + q_{s,t}^i \frac{\phi}{2}\left(\frac{I_{s,t}^i}{I_{s,t-1}^i} - 1\right)^2 + \phi\, q_{s,t}^i \left(\frac{I_{s,t}^i}{I_{s,t-1}^i} - 1\right) \frac{I_{s,t}^i}{I_{s,t-1}^i} \\ & - \beta\phi\, E_t\left(q_{s,t+1}^i \frac{\lambda_{t+1}^i}{\lambda_t^i} \left(\frac{I_{s,t+1}^i}{I_{s,t}^i} - 1\right)\left(\frac{I_{s,t+1}^i}{I_{s,t}^i}\right)^2\right), \end{aligned} \tag{43}$$

$$\tilde{v}_t^i = \beta(1-\delta)\, E_t\left(\frac{\lambda_{t+1}^i}{\lambda_t^i}\left(\tilde{d}_{t+1}^i + \tilde{v}_{t+1}^i\right)\right). \tag{44}$$

Equations (40) and (41) are the usual Euler equations for trading in domestic and foreign bonds. The ratio of the Lagrange multipliers is denoted q_t^i, which corresponds to the marginal value of a unit of installed capital (marginal Tobin's q). Its development is determined by equations (42) and (43). Finally, equation (44) is the Euler equation for shareholdings. The above equations summarize the optimal behaviour of the household.

3.3. Government

We model the operations of the government in a simplified way to maintain the focus of our paper on trade policy. Consequently, the government is responsible for trade policy, collecting tariffs and transferring all revenues to households in the form of lump-sum transfers. The aggregate government tariff revenues in the US and the RW are

$$\Gamma_t^i = \sum_s \sum_{j \neq i} \tau_t^{ij} \varepsilon_t^{ij} N_{Xs,t}^{ji} \tilde{r}_{Xs,t}^{ji}, \tag{45}$$

where $\tilde{r}_{X,t}^{ji} = \theta \left(\tilde{d}_{Xs,t}^{ji} + MC_t^j \left[f_X^{ji} / Z^j \right] \right)$ are average export revenues from intermediate firms in country j exporting to sector s in country i. In each period, the lump-sum transfers follow residually to satisfy the government budget constraint. In China, the corresponding term is

$$\Gamma_t^{CN} = \left(\sum_{j \neq CN} \tau_t^{CNj} \varepsilon_t^{CNj} N_{XPOE,t}^{jCN} \tilde{r}_{XPOE,t}^{jCN} \right) - \tau_{XSOE,t}^{CNUS} \varepsilon_t^{CNUS} N_{XSOE,t}^{USCN} \tilde{r}_{XSOE,t}^{USCN} - \tau_{DSOE,t}^{CN} N_{D,t}^{CN} \tilde{r}_{DSOE,t}^{CN}, \tag{46}$$

where $\tilde{r}_{DSOE,t}^{CN} = \theta \, \tilde{d}_{DSOE,t}^{CN}$ are average revenues of Chinese intermediate firms from domestic sales to SOEs.

3.4. Market clearing

The model is completed by conditions for clearing in bond and goods markets. Market clearing is defined as a sequence of allocations such that households maximize utility, firms maximize profits, all constraints are satisfied, and all markets clear. Demand and supply in the market for bonds denominated in the currency of country i are equated for

$$B_{i,t}^{US} + B_{i,t}^{CN} + B_{i,t}^{RW} = 0. \tag{47}$$

In order to obtain a unique steady state, we follow Schmitt-Grohé and Uribe (2003) and assume a convex risk premium that depends upon the difference between the actual bond holdings $B_{i,t}^j$ and their steady state $\overline{B}_i^j$:

$$R_{i,t}^j = R_t^i + \Upsilon \, e^{\overline{B}_i^j - B_{i,t}^j} \tag{48}$$

Since we choose Υ to be very small, our quantitative results do not depend on the existence of the risk premium; they are as if there were no risk premium. Market clearing in the sector of tradable intermediates requires

$$\left(L^i\right)^{\varrho_L^i} \left(K_t^i\right)^{\varrho_K^i} \left(M_t^i\right)^{\varrho_M^i} = \frac{(\theta - 1)}{MC_t^i} \left(N_{D,t}^i \tilde{d}_{D,t}^i + \sum_s \sum_{j \neq i} N_{Xs,t}^{ij} \tilde{d}_{Xs,t}^{ij} + \frac{1}{Z_t^i} \left(\theta \left[\sum_s \sum_{j \neq i} N_{Xs,t}^{ij} f_X^{ij} \right] + N_{E,t}^i f_E^i \right) \right). \tag{49}$$

In the POE and the SOE goods markets, the aggregate resource constraints are

$$Q^i_{POE,t} = C^i_{POE,t} + M^i_{POE,t} + I^i_{POE,t} \tag{50}$$

and

$$Q^{CN}_{SOE,t} = C^{CN}_{SOE,t} + M^{CN}_{SOE,t} + I^{CN}_{SOE,t}, \tag{51}$$

respectively. Moreover, the net assets of two out of the three countries must be considered. In the case of the US, market clearing requires

$$\begin{aligned}
&B^{US}_{US,t} + \varepsilon^{USCN}_t B^{US}_{CN,t} + \varepsilon^{USRW}_t B^{US}_{RW,t} \\
&\quad = \frac{1}{2}\Bigg[R^{US}_{US,t-1}B^{US}_{US,t-1} - \sum_{j\neq US} R^j_{US,t-1}B^j_{US,t-1} \\
&\qquad + \varepsilon^{USCN}_t \left(R^{US}_{CN,t-1}B^{US}_{CN,t-1} - \sum_{j\neq US} R^j_{CN,t-1}B^j_{CN,t-1}\right) \\
&\qquad + \varepsilon^{USRW}_t \left(R^{US}_{RW,t-1}B^{US}_{RW,t-1} - \sum_{j\neq US} R^j_{RW,t-1}B^j_{RW,t-1}\right) + w^{US}_t L^{US} \\
&\qquad + \Gamma^{US}_t + R^{US}_{KPOE,t}K^{US}_{POE,t-1} + N^{US}_{D,t}\tilde{d}^{US}_t - N^{US}_{E,t}\tilde{\nu}^{US}_t - I^{US}_{k,t} - C^{US}_{h,t} \\
&\qquad - \sum_{j\neq US} \varepsilon^{USj}_t \left(w^j_t L^j + \Gamma^j_t + \sum_s R^j_{Ks,t}K^j_{s,t-1} + N^j_{D,t}\tilde{d}^j_t - N^j_{E,t}\tilde{\nu}^j_t - \sum_s \frac{P^{j,n}_{s,t}}{P^j_t} I^j_{s,t} - C^j_{h,t}\right)\Bigg].
\end{aligned} \tag{52}$$

3.5. Numerical model evaluation

Before proceeding with the calibration, we briefly discuss the solution method providing the before-and-after comparison. The standard approach to solve a model starts with log-linearization around its steady state. Since the policies studied in this paper take some model variables far from their steady state and because parts of the model are highly non-linear, we employ a perfect foresight rational expectations solution method. The basic idea is that agents have perfect foresight until an arbitrary point in time. Therefore, the system can be solved backwards from this point. The algorithm takes into consideration the special structure of the Jacobian matrix in dynamic models with forward-looking agents. The details of the algorithm can be found in Juillard (1996).

4. Calibration

Calibration of the model parameters is done in two steps. First, we fix the values of several structural parameters either to conventional values found in the literature, or to values derived from observed data. Second, we choose a number of other parameters to match selected steady-state model moments in accordance with the corresponding moments in the data. The parameters and steady-state ratios implied by the calibration are reported in tables 1, 2 and 3.

The time unit is measured in quarters. We calibrate our model to reflect the relative size of the US, China and the RW. Following the estimates in the IMF (2021, p. 12), the average productivity of Chinese SOEs compared with the Chinese POEs is assumed to be

TABLE 1
Baseline parameters

Parameter	Definition	Value
Trade elasticities		
θ	Micro elasticity	3.8
ω	Macro elasticity	1.9
Production, costs and capital		
ϱ_L	Labour, capital and material share in the production function	0.5
ϱ_K		0.2
ϱ_M		0.3
Z^i_{POE}, Z^{CN}_{SOE}	Productivities of final goods firms	1.0, 0.8
δ	Exit probability of firms	0.025
δ_K	Capital depreciation	0.025
f^i_E	Entry cost	1
$\tau^{CN}_{DSOE,t}$	SOE subsidy	0.05
ξ^{US}		0.043
ξ^{CN}	Country weights	0.183
$\xi^{RW} = 1 - \xi^{US} - \xi^{CN}$		0.774
Households		
β	Discount factor	0.99
γ	Coefficient of relative risk aversion	2
L^i	Labour	$0.33\xi^i/\xi^{US}$
Firm distribution and other structural parameters		
z_{min}	Minimum relative productivity	1
k	Pareto shape parameter	3.4
ϕ	Investment adjustment cost parameter	8
Υ	Risk premium parameter	0.001

TABLE 2
Parameters targeting moments

Parameter	Definition	Value
Z^{US}, Z^{CN}, Z^{RW}	Aggregate productivity	1, 0.46, 0.28
α^{US}, α^{CN}, α^{RW}	Degree of openness	0.2079, 0.2720, 0.1201
κ^{ij}	Country weights	$GDP^i/\sum_{j\neq i}GDP^j$
$\tau^{USCN}_{IB,t}$, $\tau^{USRW}_{IB,t}$	Iceberg trade costs of the US	2.2, 1.4
$\tau^{CNUS}_{IB,t}$, $\tau^{CNRW}_{IB,t}$	Iceberg trade costs of China	1.5, 1.3
$\tau^{RWUS}_{IB,t}$, $\tau^{RWCN}_{IB,t}$	Iceberg trade costs of RW	1.7, 1.5
f^{ij}_X	Fixed costs of exporting	0.0032
χ	POE weight	0.68
$\overline{B}^{US}_{US,t} + \overline{B}^{CN}_{US,t} + \overline{B}^{RW}_{US,t} = 0$	Steady state bond holdings in US dollar	$-0.6648 + 0.124 + 0.5408 = 0$
$\overline{B}^{US}_{CN,t} + \overline{B}^{CN}_{CN,t} + \overline{B}^{RW}_{CN,t} = 0$	Steady state bond holdings in yuan	$-0.031 + 0.031 + 0 = 0$
$\overline{B}^{US}_{RW,t} + \overline{B}^{CN}_{RW,t} + \overline{B}^{RW}_{RW,t} = 0$	Steady state bond holdings in RW currency	$-0.1352 + 0 + 0.1352 = 0$

TABLE 3
Selected steady-state ratios implied by the baseline calibration

Ratio	US	China	RW
GDP as ratio of world GDP	24.4 (24.4)	16.4 (16.3)	59.1 (59.3)
Trade as ratio of GDP	26.6 (26.4)	35.1 (35.7)	18.2
US–China-trade as ratio of overall US trade	11.7 (11.3)	—	—
Ratio of US imports from China to exports to China	2.9 (2.9)		—
Ratio of exporting firms	22.5	24.6	7.9
Output of state-owned enterprises to GDP	—	25.6 (23–28)	—
Net claims (+) or net debt (–) to GDP	–51.6 (–51.6)	14.8 (14.8)	17.2

NOTES: The model GDP ratio of country i is defined by $\mathrm{GDP}^i \big/ \left(\mathrm{GDP}^i + \sum_{j \neq i} \varepsilon^{ij} \mathrm{GD}P^j\right)$. The actual numbers are taken from the World Bank, World Development Indicators, the US Census Bureau, US International Trade in Goods and Services and the IMF, Balance of Payments and International Investment Position. The actual rations are in parentheses.

0.8, while the SOE subsidy $\tau^{CN}_{DSOE,t}$ is 0.05. Fixed labour is set to $0.33\xi^i/\xi^{US}$. The discount factor is set to $\beta = 0.99$, the coefficient of relative risk aversion is set to $\gamma = 2$, and the depreciation rate as well as the exit rate are set at $\delta_K = \delta = 0.025$. As in Bilbiie et al. (2012), this exit rate can be justified with an annual production destruction rate of 10 per cent in line with the results of Bernard et al. (2010). The Cobb–Douglas exponents of capital and labour, ϱ_K and ϱ_L, are set equal to 0.2 and 0.5, respectively, so that the exponent of materials follows residually and is equal to 0.3.[13] Regarding the Pareto distribution, we set the Pareto shape parameter for firm productivity $k = 3.4$, which ensures a Pareto shape parameter for firm revenue close to one in accordance with the empirical estimates in Axtell (2001). The investment cost adjustment parameter is set to $\phi = 8$ and the risk premium parameter is set to $\Upsilon = 0.001$, both in line with estimates by Hoffmann et al. (2019). We set the minimum relative productivity, the productivity of the final goods firms and the market entry costs to 1. The latter can be normalized because only the ratio of fixed export costs and entry costs is relevant for calibrating the share of exporting firms (Jaef and Lopez 2014). Alternatively, the productivity of second-stage POEs could be set equal to the productivity of the first stage, which would imply a loss in the second stage in China and the rest of the world. Productivity disadvantages of both stages would be multiplied up (see the online appendix). The tabular summary of the baseline parameters is given in table 1.

The next step is to determine the remaining parameters that affect the steady state of the model. The tariff rates between China and the US $\tau_t^{USCN} = 0.193$ and $\tau_t^{CNUS} = 0.212$ are taken from Bown (2021), and the remaining tariff rates $\tau_t^{RWUS} = \tau_t^{RWCN} = 0.0434$, $\tau_t^{CNRW} = 0.0751$ and $\tau_t^{USRW} = 0.0347$ are taken from the WTO Integrated Database (IDB). We use the EU tariff rates for the rest of the world, as they are a major trading partner for both the US and China. For the micro elasticity, θ, we assume the value of 3.8, which is usual in the literature and was recently found to be the median estimate in a meta-analysis based on 3524 estimates of the Armington elasticity (Bajzik et al. 2020). This value also falls within the range estimated by Feenstra et al. (2018), whose median estimates are 3.22 and 4.05, depending on the method. For the macro elasticity, ω, we assume that it is 1.9, half as large as the micro elasticity, the so-called rule of two (see also Feenstra et al. 2018).

13 The calibration implies labour ratios of 50.8% and 53.2% for the US and China, respectively. This is very close to the corresponding actual values of 58.6% and 59.7% (Feenstra et al. 2015).

Steady-state bond holdings are calibrated according to the net international investment position reported by the IMF. For the sake of simplicity, we assume that China has only claims denominated in the US dollar and in yuan and the rest of the world has only claims denominated in the US dollar and in its own currency. Furthermore, we assume that 80% of the debt is denominated in US dollars. The parameters targeting moments are given in table 2.

We set the country weights to the population shares, i.e., $\xi^{US} = 0.043$, $\xi^{US} = 0.183$ and $\xi^{RW} = 0.774$. Given the latter, we then use aggregate productivities to match the countries' share of world GDP. To match key trade figures, we use the degree of openness, α^i, as well as the iceberg trade costs, τ_{IB}^{ij}. Moreover, the fixed costs of exporting are calibrated such that somewhat more than 21% of firms export to match the US ratio of exporters reported by Bernard et al. (2003) and the weight of private enterprises in China is used to match the output of state-owned enterprises as ratio to GDP (Zhang 2019). Given these parameter values, we solve for the open-economy equilibrium of the heterogeneous firm model. The comparison of the selected steady-state ratios implied by the calibration with the actual values is shown in table 3.

5. Model dynamics

The modelling framework provides a rich laboratory for the analysis of trade policies. Below we explore numerically the properties of the model. In doing so we cast a special focus on facilitating trade through the Phase One agreement. We also conduct various policy experiments.

5.1. Quantifying the trade and income effects of the phase one deal

In simulating the impact of the asymmetric trade agreement, an assumption must be made about its implementation by the Chinese government. This requires an assumption about the degree of compliance with the contractual voluntary import expansions (VIEs). As per the text of the agreement, Chinese imports of goods and services from the US are supposed to increase by 41% in 2020 and even by 66% in 2021 compared with the trade deal benchmark year 2017. When compared with the lower imports in 2019, this even amounts to increases of 47% and 75% in 2020 and 2021, respectively. The trade agreement does not specify how the targets should be met by China. In what follows, we therefore present model simulations for four different policy scenarios regarding the actual implementation of the Phase One trade deal. Furthermore, given the absence of a follow-on agreement, all numerical model simulations assume that the Phase One deal is a permanent trading arrangement for the time being.

First, the Chinese government "guides" the SOEs to increase imports from the US.[14] More precisely, the government commits the SOE sector to increase its share of imports from the US by 155% in 2020 and once again by 92% in 2021 compared with the steady state calibrated for 2019. These quantitative targets would just imply a complete fulfillment of the contractual obligations. Second, the Chinese government again implements the required increase in imports by means of the SOEs. Notwithstanding the contractual agreement, however, this time only by up to 65%. This corresponds to the current achievement level. In quantitative terms, this corresponds to an increase of total US exports to China by

14 "Guiding" is a widely used policy tool in China. For a theoretical modelling analysis of this approach in a different context, see Chen et al. (2020).

15% in 2020 and by 29% in 2021 compared with 2019. To achieve this increase in total imports SOE imports from the US have to increase by 49% in 2020 and once again by 46% in 2021. In the simulations, it is assumed that tariff rates remain unchanged even if the additional SOE imports cannot fully meet the contractual obligations. In the third scenario, the import increase is again by means of the SOEs and the degree of contract fulfillment is again 65%. In contrast to the previous scenarios, however, the SOE imports from the USA are subsidized by the government. The needed subsidy for the 65% fulfillment of the deal is 14.5% in the first year and 23% in the second year. Finally, we consider the case that China fulfills the trade agreement by means of a unilateral import tariff cut to 7.51 percentage points for US imports. This hypothetical import tariff rate corresponds to the current most-favored-nation tariff rate, which also applies to RW countries. In other words, China meets the VIE import targets from the US by means of a non-discriminatory reduction of import tariffs rather than through a preferential access of US producers to the Chinese market. The non-discriminatory tariff reduction to this extent achieves about the same gains in US exports to China as targeted under the agreement for the year 2020. In the subsequent year 2021, this reduced tariff rate will be adhered to, although the import obligations from the US will not be fully met.

Figure 3 shows simulations of the impact of import targets in the US−China agreement on the trade and income of these two countries as well as on third countries under these different implementation scenarios. These are our central scenarios. The horizontal axis shows the elapsed time in quarters. Trade balances (as a percentage of the corresponding GDP) are calculated as absolute deviations from their steady state, all other variables are calculated as percentage deviations from their steady states. The solid (dashed) black line shows the responses for the first and second simulation whereby the Chinese SOEs are committed to a market share VIE that meets 100% or 65% of the contractual managed trade deal obligations. The solid grey line shows the third simulation, i.e., a SOE subsidy to import US goods in order to meet 65% of the agreement. Finally, the dotted grey line denotes the fourth simulation and thus the hypothetical unilateral tariff cut for US imports to 7.51 percentage points.

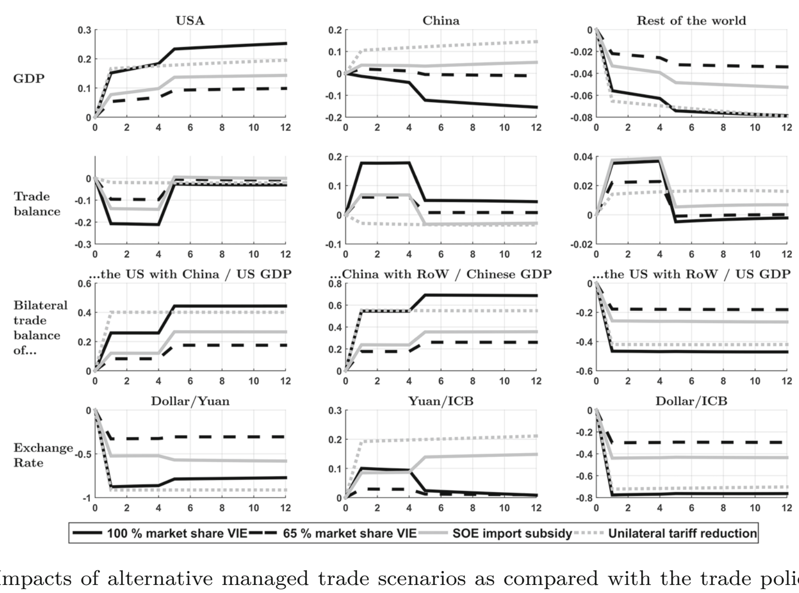

FIGURE 3 Impacts of alternative managed trade scenarios as compared with the trade policy status quo scenario

The first impression is that the implications of the agreement depend on how China implements it. For the US, there is an increase in GDP in all four scenarios. As expected, the discriminatory VIE with 100% compliance (black solid line) leads to the largest effect. In this case, the GDP increase amounts to 0.17% in the first year and 0.24% in the second year. This magnitude is comparable to other estimates in the literature. Examples include the size of the export demand shock impact as examined in Backus et al. (1992) based on the international real business cycle model or Lubik and Schorfheide (2005) based on the two-country new open economy macroeconomics model.[15]

In the remaining three scenarios the GDP increase is smaller due to the merely 65% compliance, but still positive. The four policy scenarios deliver different effects on Chinese GDP. Marked effects arise above all in the first and fourth scenarios. The first scenario with 100% contract fulfillment via VIE leads to a persistent GDP loss. In the other three scenarios, the exchange rate depreciation against the US dollar plays a role. In particular, the unilateral tariff reduction and subsequent devaluation of the Chinese currency results in an expansionary effect due to China's increased price competitiveness in both foreign countries/markets. What are the associated impacts for China? The impact on China's welfare would be negative if the market were under free trade and ambiguous in the case of products in protected industries, as in our simulation. The ambiguity for China depends on the fact that increased imports from the US may drive out less efficient Chinese producers or more efficient producers from the RW. This efficiency gain is particularly evident in the case of the across-the-board tariff reduction to the most-favored-nation rate. A follow-up set of effects may result from the distortions created by the VIE in China. Chinese producers, seeing the domestic price decline, may sell part of their production abroad. This form of trade deflection will have negative consequences for producers in the RW, which will suffer from the increased competition from Chinese exporters, and a positive effect on RW consumers who will benefit from lower prices.[16] It is also instructive to compare the market share VIE and the SOE import subsidy to understand the underlying mechanisms. Both have a trade-creating effect that is welfare enhancing. However, as Greaney (1996) has already shown, an import subsidy reduces domestic prices, while a market share VIE increases the marginal costs of the affected importers, in our case the SOEs, and thus their prices. Without the subsidy, domestic producers are facing import tariffs and the commitment to increase imports from the US. The subsidy reduces this strain.

These different effects show up very clearly in numerical results. The considerations also explain why 65% (100%) contract fulfillment has positive (negative) effects for China. Moreover, in the RW countries there is a negative GDP impact, which is a mirror image of that in the US. The underlying mechanism is again clear. The trade deal incentivizes China to shift imports away from other suppliers and towards the US and thus leads to

15 In contrast, qualitatively equivalent but quantitatively larger effects are found in the dynamic computable general equilibrium (CGE) modelling framework in Freund et al. (2020). Each country contains multiple sectors linked through an input−output structure to other domestic and foreign sectors. In this setup, a tariff introduces an inefficiency in the allocation of resources across sectors. Unlike CGE, there is limited sectoral disaggregation in the open-economy macro model. On the other hand, emphasis is on dynamics, stock-flow consistency, and forward-looking expectations. As a result, both approaches highlight different implications of the distortions brought about by trade policies.

16 This mechanism has been referred to as trade deflection by Bown and Crowley (2007) in the context of US anti-dumping duties against Japan.

international trade diversion. In political terms: the discriminatory trade agreement follows a nationalist, not a globalist approach.[17]

Finally, the temporary trade balance effects result from consumption smoothing of forward-looking agents with assumed perfect foresight of the lasting nature of the trade deal. Beyond these temporary effects, there is a permanent improvement in the US−China bilateral trade balance, but no lasting improvement in the overall US trade balance.

5.2. Future US−China trade agreements: Some policy experiments

Much of the current trade policy debate, in the US as well as internationally, revolves around the future US trade policy towards China. The broad bipartisan consensus in the US comprises the belief of the need to stand up to China. Signs are already emerging that elements of the Trump approach will remain in place. But when a simple "reset" in trade relations is unlikely to happen, what might a future trade agreement look like? To get closer to an answer to this question, we conduct several policy experiments in the next step. In doing so, however, we assume that the 65% market share VIE remains in place, i.e., that both parties agree to reduce the commitment to this same 65%.

In our simulations, we assume that a possible Phase Two deal takes effect in the seventh quarter after the start of the implementation of the Phase One deal and is not anticipated by the households. First, because China has not yet met the quantitative targets in the Phase One deal in full, the follow-up Phase Two deal could set the lower level of fulfillment achieved so far as a new target. In other words, the 65% Chinese VIE surge from the US achieved to date is assumed to be the new Phase Two contractual import requirement. Second, the two parties agree on a mutual 5 percentage point bilateral import tariff reduction. This can be understood as a goodwill gesture by the Biden administration offering to rescind Donald Trump's tariffs on condition that China reciprocates. Perhaps this would enable the Chinese American rivalry to proceed along less confrontational lines in the future.

As noted above, structural changes to the current Chinese economic model relying on deep-rooted industrial policy and a long-term strategy of import substitution in ever more sophisticated products are a particular priority in the US. The Biden administration may thus seek to use the tariffs as a bargaining chip to extract concessions. Two possible structural concessions by the Chinese government in a prospective Phase Two deal will be numerically simulated. First, the eventual reduction of SOE subsidies encouraging the purchase of domestic goods and thus discriminating against foreign firms is examined. Specifically, the impact of reducing $\tau^{CN}_{DSOE,t}$ from 5% to 3% is simulated. In other words, China would have to reduce its favoritism for SOEs and hence improve market access for foreign exports. The final model simulation attempts to quantify Chinese concessions on existing non-tariff trade barriers. In the theoretical model, these are approximated by lowering the iceberg costs for US exports to China from 2.2 to 2.1, which has about the same effect on total Chinese imports from the US as the bilateral tariff reduction.[18]

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17 Our results complement other studies. Model-based analyses have found noticeable spillover effects for countries not directly affected by protectionist policies in relation to the trade conflict between the US and China. See, for example, Bolt et al. (2019) and the IMF (2018, pp. 33−35). The evidence of significant trade diversion effects is also consistent with the IMF's empirical analyses (Huidrom et al. 2019). The IMF estimates based on granular trade data reveal a substantial "exports-at-risk" for the EU, Japan and Korea.

18 Due to the growth-reducing effects of entry barriers, such a contractual provision could represent a mutual win-win situation. See Jiang et al. (2021).

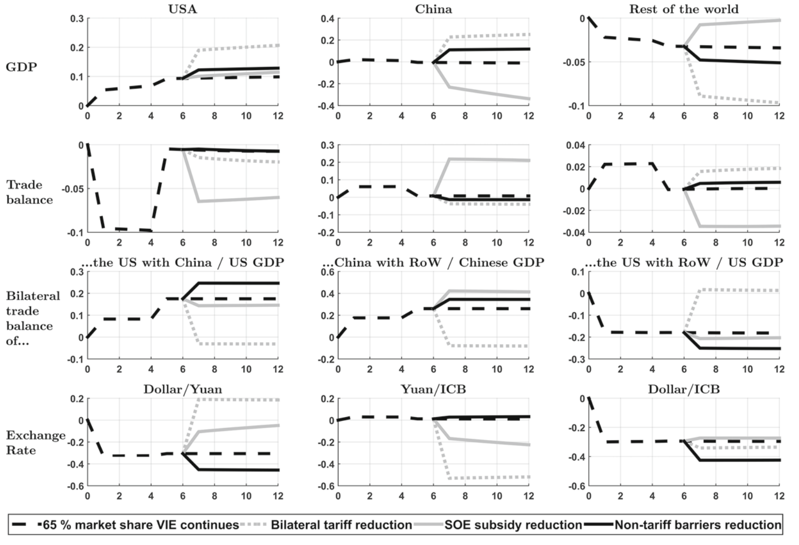

FIGURE 4 The impact of alternative phase two deal scenarios

The numerical results are shown in figure 4. In all cases, the figure shows the change compared with the Phase One deal. The dashed black line shows the effect of the future VIE pledge reduced to 65%. The dotted grey line shows the impact of the symmetric bilateral tariff reduction, the solid grey line shows the SOE subsidy reduction impact, and the solid black line indicates the iceberg cost reduction impact.

The analysis, stylized as it is, yields some important policy conclusions. First, it is noticeable that both the reciprocal tariff reduction and the reduction of non-tariff trade barriers, approximated by reduced iceberg costs for US exports to China, are win-win outcomes in terms of GDP for the US and China. The flip side of the coin is that the RW countries lose even more. Put another way: The trade diversion effect is more pronounced, and the updated bilateral managed trade deal is reshaping the global economic relationships further.

A further takeaway of this simulation is that a different winner−loser constellation emerges for the simulated cut in SOE subsidies. The impact on Chinese GDP is surprising at first glance. Although SOEs are less productive, a reduction in the subsidy has a contractionary effect. The rationale is that the elasticity of substitution of POE and SOE goods is comparatively difficult. This counteracts the positive effect that a smaller share of production now takes place through the less productive SOEs. In light of the institutional and legal framework, we consider this to be realistic, at least in the short term. As expected, the rest of the world benefits as Chinese SOEs now buy their products to a greater extent. In contrast, no noticeable effect is seen for the US. The reason is that Chinese SOEs must import an exogenously specified VIE commitment regardless of the subsidy level. In addition, another important insight for future trade negotiations emerges from the simulations. The Chinese GDP impact illustrates why the Chinese government would want to avoid SOE subsidy cuts in the face of decreasing GDP growth rates.

Both policy variants, the bilateral tariff cut and the SOE subsidy reduction, lead to a further deterioration of the overall and bilateral US−China trade balance. Only a reduction in iceberg trade costs can improve the bilateral US−China trade balance to a lesser extent. Finally, exchange rate effects are also worth highlighting. In particular, the exchange rate effect of the reciprocal tariff reduction is noteworthy. Although symmetrical, the tariff reduction leads to a depreciation of the US dollar against the renminbi. The reason for this is that despite the symmetric design, China benefits more from the tariff cut because of China's export surplus in bilateral US–China trade.

5.3. Robustness

In this subsection, we conduct robustness tests on our baseline model calibration. As expected, the results are sensitive to the underlying trade elasticities, while other parameter variations have little bearing on the results. Consequently, the focus is on these parameters playing a pivotal role in the context of the open-economy macroeconomic model. To save space, additional robustness tests are presented in the online appendix to the paper. In line with the Chinese import expansion achieved so far, all subsequent robustness tests assume that China maintains the 65% VIE henceforth.

Uncertainty continues to prevail regarding the responsiveness of demand to international prices. The overall uncertainty is reflected in uncertainty about the upper-level macro elasticity as well as uncertainty about the lower-level micro elasticity. The macro elasticity determines the degree of interchangeability in demand between domestic and foreign good varieties. Goods with a high macro elasticity are goods for which consumers will substitute relatively easily between domestic and foreign varieties, given a relative change in domestic and foreign prices. On the other hand, goods with a low macro elasticity imply that consumers stay with their preferred variety more firmly and are less willing to substitute between the two. The micro elasticity reflects the second-tier choices between suppliers of the imported good at the country level. Figure 5 displays the change in GDP and the trade balances for alternative macro and micro elasticities.

In the benchmark calibration, the macro elasticity is assumed to be $\omega = 1.9$. First of all, the two calibrations $\omega = 1.6$ (dashed grey lines) and $\omega = 2.2$ (dotted grey lines) are shown in figure 5. As expected, the comparison with the baseline calibration (dashed black lines) shows that a smaller macro elasticity leads to a larger positive (negative) effect on US GDP (RW GDP) as substitution between domestic and foreign goods is more difficult. The corresponding mechanism via changes in the trade balances are evident in the second row of figure 5. In addition, we also show model simulations for $\omega = 0.95$ (solid black lines) and

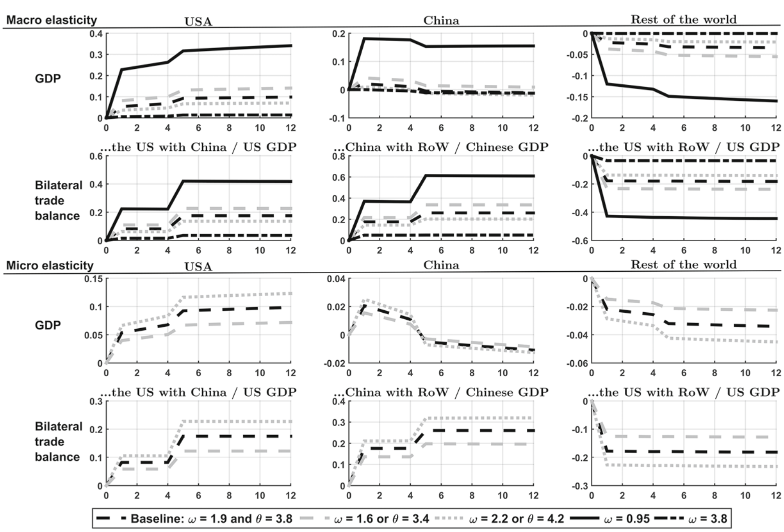

FIGURE 5 Sensitivity to the macro elasticity and the micro elasticity

$\omega = 3.8$ (dotted-dashed black lines), respectively. The first value resembles calibrations in the RBC literature, while the second value corresponds to the use in trade analyses (see, i.e., Yilmazkuday 2019). One may also claim that both alternative calibrations represent extreme values. In the case of $\omega = 3.8$, the impact on US GDP decreases to almost zero, while the GDP effect for $\omega = 0.95$ increases to 0.32 in the second year. For $\omega = 0.95$, the interesting finding is that China's GDP is also rising. In other words, the low macro elasticity leads to internationally correlated business cycles.[19] Again the trade response is decreasing in the macro elasticity of substitution.

For the micro elasticity, alternative model solutions for $\theta = 3.4$ (dashed grey lines) and $\theta = 4.2$ (dotted grey lines) are given in figure 5. The baseline calibration is $\theta = 3.8$ (dashed black lines). As can be seen, the higher the micro elasticity, the greater the positive effect on US GDP and the negative trade diversion effect upon the RW GDP. By way of comparison, the results for China are quite robust with respect to the changes in the micro elasticity.

We introduced the distinction between micro and macro elasticity to address the international elasticity puzzle. Another possible solution to the international elasticity puzzle is that short-term trade elasticities are lower than long-term ones. The latter could be due to slow adjustment on the extensive margin, e.g., due to sunk costs of exporting. In the online appendix, we present a second variant of our model incorporating sunk costs of exporting. This leads to a gradual increase or decrease in the quantity of exporters after e.g., a tariff change.

6. Welfare

In this section we briefly touch upon welfare. Following Schmitt-Grohé and Uribe (2007), the welfare effects of the Phase One agreement and hypothetical Phase Two agreements are calculated relative to a reference policy scenario. In case of the Phase One agreement, the reference policy scenario is the continuation of the status quo of 2019 (equal to the model steady state). In the case of eventual phase agreements, we take the continuation of the 65% market share VIE as the reference policy scenario. Throughout, the welfare difference is expressed as the percentage of consumption that households are willing to give up in order to be as well off under the corresponding trade policy as under the reference policy. Given the representative household's objective function, the consumption-equivalent total welfare gain is given by

$$\Delta_{TOT} = \left(\frac{V_0^a}{V_0^r}\right)^{\frac{1}{1-\gamma}} - 1, \tag{53}$$

where V_0^a is the welfare of the respective policy alternative, and V_0^r is the welfare of the respective reference policy. The welfare of both policies, that is their net present value of utility, is calculated according to equation (35) for a time frame of 1,000 quarters. Moreover, in accordance with Cacciatore and Fiori (2016) we decompose the welfare gain into a short-run and a medium- to long-run component, denoted by Δ_{SR} and Δ_{LR}, respectively. In a first step, we calculate Δ_{TOT} as described above. Then, for the short-term welfare effects, we perform the same calculation but only until the 8th quarter ($t = 8$), thus only the effects within the first two years are considered. Finally, for the medium- to long-term welfare effects, we simply calculate $\Delta_{LR} = \Delta_{TOT} - \Delta_{SR}$. The results are given in table 4.

19 That is why such an elasticity is typically used in the international RBC literature. See, e.g., Heathcote and Perri (2002).

TABLE 4
Welfare analysis

	USA	China	Rest of the World
	$\Delta_{SR} + \Delta_{LR} = \Delta_{TOT}$ (errors due to rounding)		
Welfare gains and losses of the Phase One agreement compared with a continuation of the status quo at the end of 2019			
100% market share VIE	0.22 + 0.06 = 0.28	−0.04 − 0.09 = −0.14	−0.06 − 0.03 = −0.10
65% market share VIE	0.09 + 0.02 = 0.11	0.02 − 0.01 = 0.01	−0.03 − 0.01 = −0.04
SOE import subsidy to reach 65% fulfillment	0.12 + 0.04 = 0.16	0.00 + 0.05 = 0.05	−0.045 − 0.01 = −0.055
Unilateral tariff reduction	0.17 + 0.07 = 0.25	0.08 + 0.06 = 0.14	−0.07 − 0.02 = −0.09
Welfare gains and losses of potential Phase Two agreement elements compared with only a continuation of the 65% market share VIE			
5% bilateral import tariff reduction	0.04 + 0.10 = 0.14	0.13 + 0.21 = 0.34	−0.04 − 0.04 = −0.08
Reduced SOE subsidies	0.02 − 0.01 = 0.01	−0.03 − 0.31 = −0.33	0.02 − 0.005 = 0.02
Reduction of Chinese non-tariff trade barriers with the US	0.02 + 0.03 = 0.04	0.07 + 0.10 = 0.17	−0.01 − 0.01 = −0.02

Four results should be highlighted from the multitude of findings. First, the welfare effects for the US are positive across the board. However, the magnitude of the welfare effects depends—as expected—on the extent of managed trade achieved. Second, China's welfare would decline in the event of full compliance with the Phase One agreement. Likewise, a reduction in SOE subsidies in a potential Phase Two agreement would lead to a negative welfare effect. Third, an import subsidy is more efficient from a Chinese (and US) perspective than the market share VIE. This is consistent with Feenstra and Hong (2022), who show that the most efficient way for China to increase its agricultural imports from the US is to mimic the effect of an import subsidy. In our simulation, both the VIE and the import subsidy can increase total welfare if the Phase One deal is only 65% fulfilled. However, our dynamic analysis also shows that the short-term welfare effect of the VIE is higher, it has a negative effect only in the medium to long term, making its overall welfare effect lower than that of the import subsidy. Finally, the trade diversion effects lead to negative welfare effects for the RW countries, the magnitude of which depends on the degree of implementation of the Phase One agreement. The results confirm previous welfare estimates. Felbermayr et al. (2013) have shown that unilateral protectionist policies by a dominant country may increase welfare in its economy, at the expense of the rest of the economies. However, when the rest of the economies retaliate, the global equilibrium is characterised by lower welfare for all economies. The losses from pursuing protectionist policies, in fact, are further amplified when there is more than one dominant country.

7. Conclusions

The build-up of US–China trade disputes and the shift away from a multilateral, rules-based trading system has led to a growing interest in quantifying the effects of protectionist trade policies. Besides assessing the impacts on the US and the Chinese economy, both researchers and policymakers are also interested in the effects on third countries. In a nutshell, the paper considers a new open-economy macroeconomics model split between three large trading partners, the US, China, and the rest of the world. We have illustrated noticeable positive (negative) of the agreement for the US (China) as well as negative spillover effects for countries not directly affected by the managed trade deal due to trade diversion. An important by-product of our approach is that it can be used to provide quantitative evaluations of potential future trade agreements. To the best of our knowledge, we are the first to analyze the Phase One Sino−American managed trade agreement in such a state-of-the-art modelling framework.

We invite the reader to cautiously interpret our results, with three caveats that should be kept in mind. One impact not accounted for in the model is the COVID-19 pandemic. The pandemic may leave a lasting imprint on the world economy that goes beyond a short-term recession, causing changes away from global just-in-time supply chains.[20] Furthermore, unresolved US−China trade policy disputes create uncertainty about the future. The knock-on effects of this uncertainty on strategic company decisions dampening global economic growth have likewise not been considered in the model.[21] Further research on these aspects will provide a better understanding of the effects of trade disputes. Finally, the further continuation of the Phase One deal is unclear. As the agreement expired in December 2021, questions arise to its future. On the one hand, the Biden administration has stated its adherence to the agreement just in October 2021. On the other hand, the awaited new round of talks between China's chief trade negotiator, Vice-Premier Liu He, and US Trade Representative Katherine Tai and US Treasury Secretary Janet Yellen has not yet been scheduled. This can be understood as meaning that both governments are tacitly adhering to the agreement and its partial implementation to date. One rationale for the US could be that there are few, if any, alternative venues to force China to abide by its trade obligations.[22]

Supporting information

Additional supporting information accompanies this article. The data and code that support the findings of this study are available in the Canadian Journal of Economics Dataverse at https://doi.org/10.5683/SP3/NWV8W7.

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20 Antras (2020) offers some thoughts worth reading on hyper-globalization running out of steam and the future of global value chains in the post COVID-19 world.

21 See Caldara et al. (2020) and Handley and Limão (2017).

22 In the meantime, a further managed trade agreement has been signed. Under the EU-American managed trade agreement signed in October 2021, the EU can export 4.4 million metric tons of steel and aluminum to the US duty free in 2022. Beyond that 25% import tariffs on steel and 10% import tariffs on aluminum kick in.

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