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Keywords

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Abstract

The recent rise of populism and authoritarian politics has seen a turn from multilateralism and toward international disputes like that between the US and China. This paper uses a calibrated global macro model to assess the potential economic consequences of this conflict under explicit assumptions about monetary and fiscal policy. US unilateral protection emerges as "beggar thy neighbor" policy, the more so if new tariff revenue affords capital tax relief. China's proportional losses are comparatively large and little mitigated by retaliation, which nonetheless constrains US net gains. Avoiding leakage by protecting against all sources causes substantial losses in third regions trading with China and the US.

1. Introduction

A decade ago serious international trade conflicts seemed to be relegated to history, yet with the rise of authoritarian regimes and of populism in the democratic West they have once again become prominent. That between China and the US is amongst the most controversial and it began with the announcement on March 1st 2018 that the US would impose tariffs on all imports of steel and aluminium, with many trading partners other than China eventually exempted. On April 3rd 2018, 25 per cent tariffs were announced on $US50 billion in Chinese imported electronics, aerospace products, and machinery. China retaliated hours later and announced 25 percent tariffs on $US50 billion of imports from the US.

On May 21st 2018, the two countries announced the outline of a trade deal to avoid the tariffs. But the deal did not prevent further conflict. The US moved forward with the first tranche of tariffs on $US34 billion of Chinese imports on July 6th 2018 and the second tranche of tariffs on $US16 billion of Chinese imports on August 23rd 2018. Further tariffs were then threatened by the US were China not to change some of its trade and intellectual property practices, with the possibility that protection could spread to the half-trillion dollars of Chinese exports as well as to the smaller flow from the US to China. Other prominent trade conflicts underlie the renegotiation of North America Free Trade Area (NAFTA), European retaliation against surviving US steel and aluminium tariffs and a US threat to impose a 25% duty on motor vehicle imports from the EU, pending the outcome of continuing negotiations.

Against this background, this study briefly reviews the drivers of the particular trade conflict between the US and China and applies a macroeconomic approach to the estimation of its

implications. An elemental six-region global macro model is used that captures trade in final and intermediate goods as well as financial flows, with some attention to household heterogeneity, and which makes monetary and fiscal policy responses explicit. Key features of the model include that capital owning households manage global portfolios of variably differentiated regional assets, and monetary policies target inflation in the US, Europe and Japan, as well as in smaller advanced regions like Australia, "anchoring" inflation expectations. In China, on the other hand, we see monetary policy targeting its US exchange rate, creating a mismatch between actual and expected inflation. Two types of solutions are obtained, one under short run assumptions, with varying unemployment levels and fiscal deficits but fixed capital use, and another in which time is allowed for financial flows to redistribute productive capacity across countries, for labor markets to adjust and for fiscal balance to be retained via changes in tax rates or government expenditure.

At either length of run trade distortions alter the relativities between consumer, producer and GDP prices, wage rates and capital returns. Since all regions are characterized as "large", unilateral increases in protection by any one region can raise domestic "welfare" at the expense of other regions, though such protection can shrink the volume of its own, and of global, output. We offer several policy scenarios to reflect alternative trajectories of the trade conflict, depending on the actions taken by the US and China and on whether there is further escalation. These include unilateral protection by the US against Chinese imports, protection by the US with bilateral retaliation by China, and the avoidance of leakage via protection against all imports by both the US and China.

Several conclusions emerge. First, US real wage rates and welfare more generally are indeed raised by unilateral protection against China, by most when the additional revenue from tariffs affords capital income tax relief but far less substantially if there is retaliation from China or elsewhere. Second, while the economic losses from the trade conflict are comparable across regions outside the US on a "dollars per capita" basis, the losses to China are much larger as a proportion of initial disposable income. This is also true for effects on China's real GDP and its real low-skill wages, suggesting that it has the strongest motive to renegotiate trade arrangements. Third, trade wars can be significantly damaging not only for at least one of the protagonists, but also for third regions, reducing both output and welfare globally. And finally, since trade could leak around new protectionist barriers, if the two protagonists in the conflict

were to impose protection on imports from all sources, global losses would be very much larger than in the bilateral cases and they would be borne primarily by third regions, including Europe and small traders with China, such as Australia. Indeed, these losses are so large as to justify considerable effort in avoiding this outcome.

We caution that these experiments with a calibrated model should be thought of as numerical theory rather than fully fledged empirical analysis. Nonetheless, the results are more than illustrative, by virtue of the model's calibration to data that is representative of the global economy. Section 2 of the paper reviews the drivers of the US-China trade conflict while Section 3 offers a brief summary of the relevant literature. Section 4 is a summary of the modelling method used, Section 5 presents results and Section 6 concludes.

2. Genesis

The underlying drivers of the US-China trade conflict stem from a number of inter-related trends. Intensified strategic competition is clearly one, related to which are concessions over trade, investment and intellectual property protection in both goods and services sectors, some of which stem from special conditions granted to developing countries in the Uruguay Round of trade negotiations. Then there are the negative effects of globalization, which the surge of Chinese growth in the 2000s exacerbated. These contributed to the growth of inequality in the advanced economies that has led to a political backlash against the associated decline in the labour market performance of low-skill workers. Finally, there has been an associated change in the patterns of international trade that has seen outsourcing of stages of production and the rise of "value chains". These cause a mismatch between the balances of trade and value added content that give the superficial impression of unjust behavior.

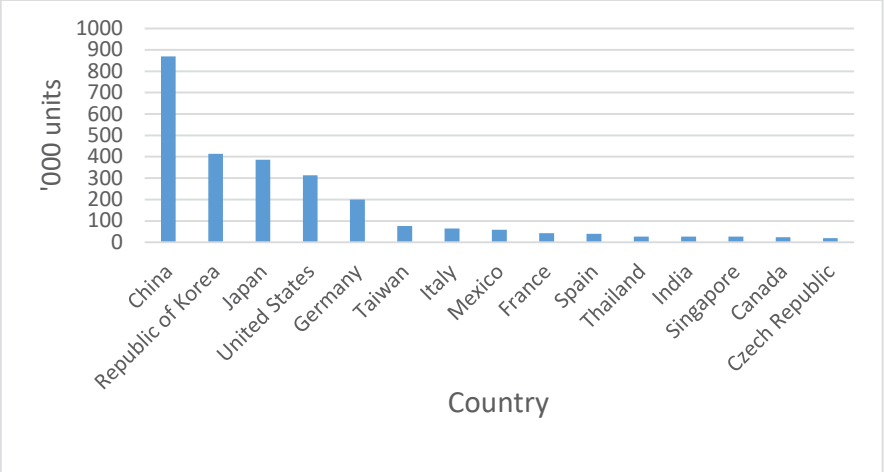
2.1 Intensified competition between US and China

While a key focus of expressed US concern is the bilateral trade imbalance with China, most economists agree that in today's world of private financial flows and flexible exchange rates bilateral trade imbalances are not appropriate targets for policy. The key underlying cause of US concern would appear to be China's threat to US leadership in the markets for hi-tech goods and services and the implications this has for military sophistication and the strategic relationship

between the two countries. The threat arises due to the continuing rapid expansion of the Chinese economy, the requirement that entry into the large and growing Chinese market requires US firms to relinquish intellectual property and the wider transition of Chinese production toward sophisticated manufactures and services under the "Made in China 2025" plan (State Council, 2015).

High-tech goods with growing domestic supply in China include robotic machinery that embodies sophisticated artificial intelligence (Figure 1). They also include electric cars, of which China is now the largest global supplier by numbers.[1] As hi-tech competition from abroad has grown, US net receipts of payments for the foreign use of its intellectual property have slowed and fallen (Figure 2). Other countries in global value chains have been catching up and so increasingly rely on home grown technologies and frontier products. But China is the largest

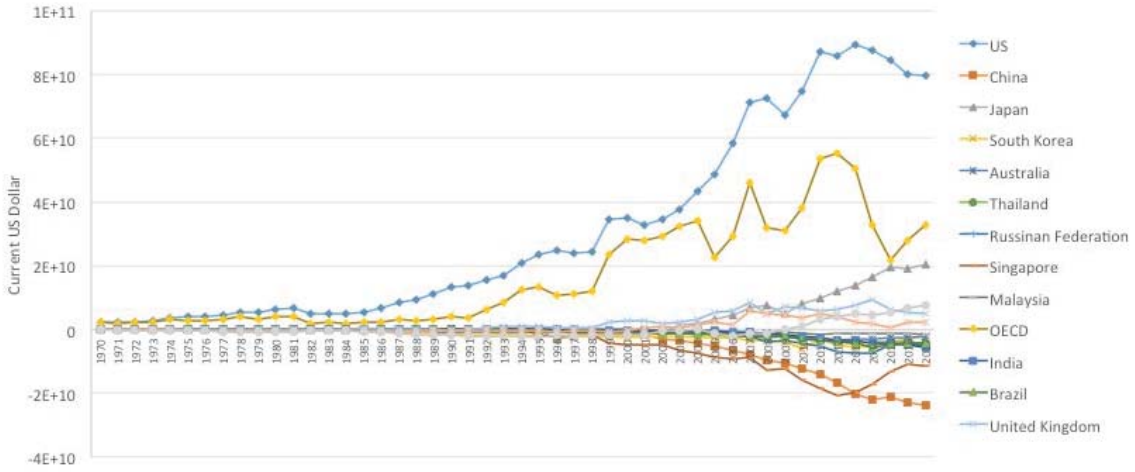
Figure 1. Annual supply of industrial robots in the fifteen largest markets in 2016



Source: International Federation of Robots.

[1] Market updates for electric vehicles are available from: https://qz.com/1102552/ladies-and-gentlemen-the-winners-and-losers-of-the-electric-car-race-so-far/

Figure 2. Net receipts from use of intellectual property, current USD



Source: Authors' calculations based on data from the World Bank's *World Development Indicators*.

of these growing economies and the second largest economy in the world, with strategic ambitions to match. The recent imposition of bilateral trade controls may indeed represent the beginning of a strategically driven trend in restricted commerce between the two countries and their close allies. More generally, the increasingly prominent schism between US reservations toward open trade with China on the one hand and its claimed leadership in the so called "global rules-based order" weakens wider confidence in the multilateral trading system (Chatham House 2015). Indeed, if protectionist trade policies are imitated worldwide the multilateral trading system could collapse. Even more concerning, given the great gains achieved in recent decades from the integration of the global economy, are the associated potential restrictions on foreign investment, migration and international collaboration on R&D.

2.2 The Inequality Motive

Substantial increases in inequality in the advanced economies in recent decades have meant that working class households have witnessed, but not shared in, the bounty of economic integration between the advanced economies and the transitional ones, including China. While the rise of inequality in the transitional economies follows well anticipated paths (Kuznets 1971), inequality has also increased in the advanced economies, departing from the prediction of the inverted U-shaped Kuznets Curve. One consequence of this has been growing political pressure to protect those industries still employing relatively low skill workers, both in advanced and transitional

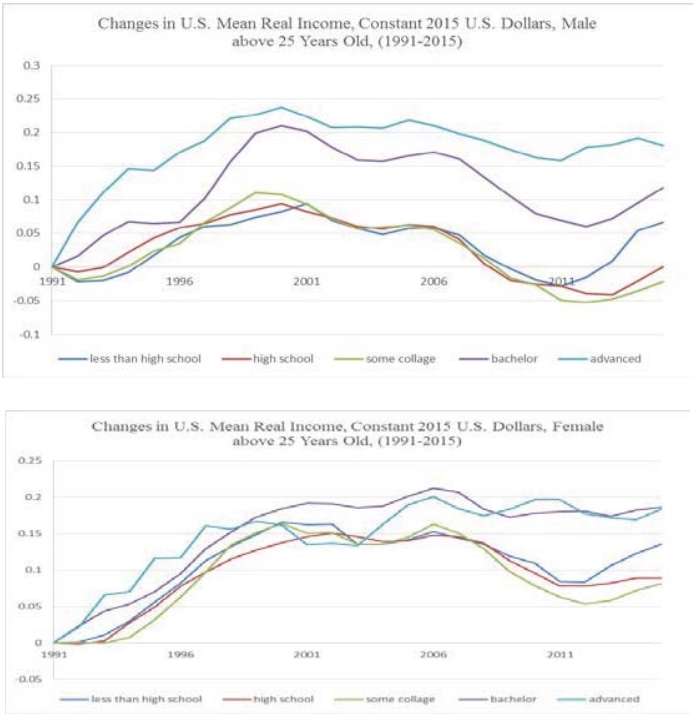
economies. Figure 3 shows the rising trends in income inequality in the advanced economies, as measured by Gini coefficients, and Figure 4 shows the corresponding rise in the household income consequences of rising skilled wage premia since the 1980s. More generally, the global richest 1% captured 27% of the total income growth since 1980, two times more than the bottom 50% of adults, who together captured 12% (Alvaredo et al., 2017).

Figure 3. Gini coefficients before and after taxes and transfers

Source: SWIID database.

Note: The orange line is Gini index of inequality in equivalized household market (pre-tax and pre-transfer) income. The blue line is Gini index of inequality in "equivalized" household disposable (post-tax and post-transfer) income.

Figure 4. Trends in real worker income in the United States



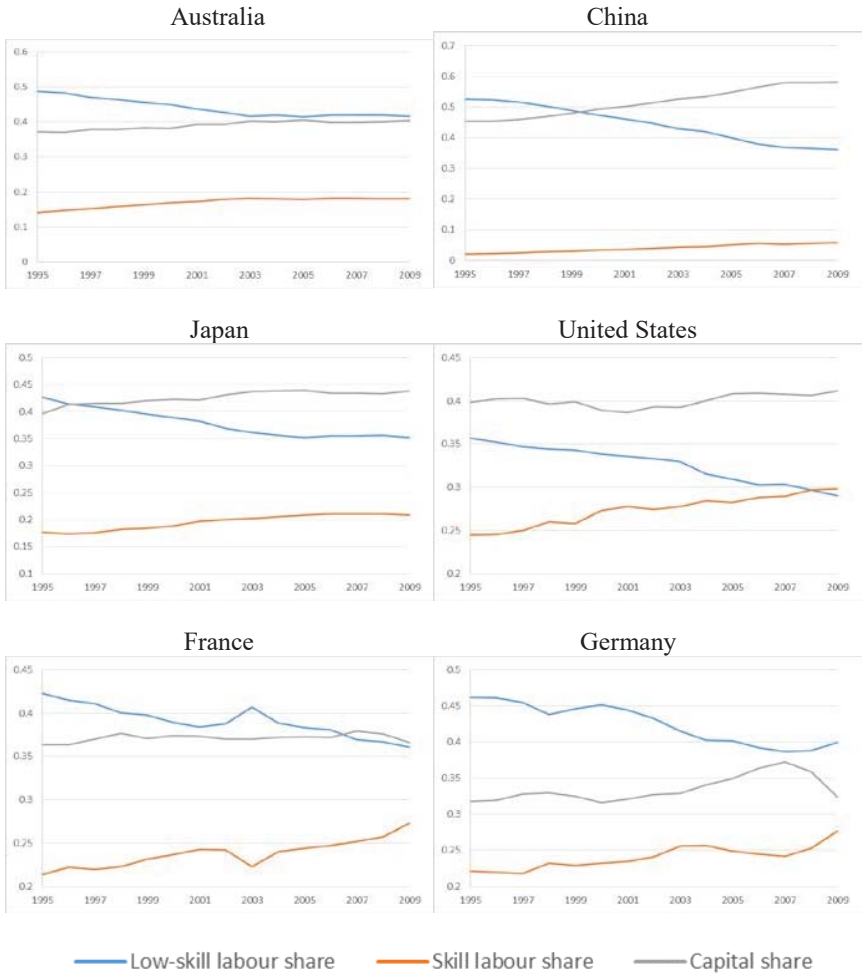
Source: Mean incomes in constant 2015 US dollars by educational attainment based on Table P-18— Educational Attainment, People 25 Years Old and Over by Mean Income and Sex, 1991 to 2015, the US Bureau of the Census. Note: Cumulative percentage changes are shown relative to 1991 means. These are adjusted for price inflation, money earnings for working males and females (aged 25 and above) by educational cohort in terms of the highest level of education attained. Changes along the y-axis are log changes (which approximate percentage changes), smoothed to three-year moving averages to eliminate occasional annual volatility. Less than high school and some high school workers correspond to low-skill workers; high school grad and some college correspond to medium-skill workers; college grad and more than college correspond to high-skill workers.

These trends in income distribution have occurred in response to increased global competition amongst workers through economic integration as well as structural and technical change. Specific explanatory stories include 1) comparative growth in transitional economies, including China, and a resulting surge in labour intensive imports by the advanced economies,[2] 2) the rise of intellectual property products as components of increasingly important intangible capital (Koh et al. 2016), 3) the interaction between IT development and the diminution of competition within IT-intensive oligopolies (Moazed and Johnson 2016, Ezrachi and Stucke 2016), and 4) the wider displacement of workers by increasingly intelligent machines (Acemoglu and Restrepo, 2017).

[2] There is a long literature on the roles of Asian finance and trade in labour market performance in advanced economies, with recent contributions including Pierce and Schott (2012), Autor et al. (2013), Arora et al. (2015), Acemoglu et al. (2016) and Tyers (2015b, 2016).

Taken together, these effects have seen the share of low-skill wages in total income fall steeply since 1980, while the share of income accruing to skilled workers and capital owners has risen, as illustrated in Figure 5.

Figure 5. Factor shares in selected economies, 1995-2009



Note: The capital share is calculated as the share of payment for capital in value added; labour share is the share of payment to medium- and low-skilled persons in value added; skill share is the share of payment to highskilled persons in value-added. Labour skill types are classified on the basis of educational attainment levels as defined in the International Standard Classification of Education (ISCED): low-skilled (ISCED categories 1 and 2), medium-skilled (ISCED 3 and 4) and high-skilled (ISCED 5 and 6). Capital compensation is derived as a residual and defined as gross value added minus labour income. Hence it is the gross compensation for capital, including profits and depreciation allowances. Because of its derivation as a residual, it reflects the remuneration for capital in the broadest sense. This does not include only traditional reproducible assets such as machinery and buildings, but it also includes non-reproducible assets. Examples are mineral resources and land, intangible assets (such as R&D knowledge stocks, software, databases, brand names and organizational capital) and financial capital.

Source: authors' own calculation based on data from the World Input Output Database (WIOD) (Timmer et al. 2015).

The first explanation for rising inequality, globalization and its associated trade adjustments, is closely linked to the trade conflict under study. The biggest gainers from globalization live in China while those losing most live in Sub-Saharan Africa or South Asia (Wade 2018). In North America and Western Europe there are marginal net gains.[3] At issue, however, has been the domestic distribution of these gains. In the advanced regions at least, the gross gains appear to have accrued to the skilled and to capital owners and, except in some European economies such as France and Germany, governments have failed to ensure that the embodied "potential" Pareto improvements from globalization have been realized (Piketty and Zucman 2014). "Free market economics" and open borders are widely seen as serving only the very wealthy and intellectual elites, thus fostering support amongst the working classes for reactionary movements that reject the economic arguments against protection and isolationism.

2.3 Changing Trade Patterns

The current phase of globalization started from around 1990, when offshoring and global value chains (GVCs) began to proliferate. So called "barge economics"[4] widened the political separation between workers on the one hand and professionals and capital owners on the other.[5] A consequence of this has been the that manufactured goods are assembled in one country from components made in others for shipping mainly to the advanced regions for final consumption. The pattern of trade in value added therefore no longer matches the corresponding pattern of trade in final products (Athukorala 2011, Benedetto, 2012; Derviş et al., 2013 and Johnson, 2014). The consequences, then, of trade conflicts that lead to tariffs on imports are less obvious than prior to the development of these value chains. Their analysis requires careful distinction between intermediate inputs and final goods in production and in the matrix of trade flows.

At the same time catch-up by the transitional economies is seeing a convergence between the patterns of their exports and those of the advanced economies. The mix of China's exports

[3] See Tyers (2015) for numerical evidence of net gains from global integration.
[4] As stated by Jack Welch, former CEO of General Electric, "Businesses would like to put their factories on barges which could be moved easily to anywhere in world, to minimize costs and maximize profits" (Palley, 2018a, 2018).
[5] Goodhart distinguishes "anywhere people" (professionals and the wealthy) and "somewhere people" (workers tied to place or country (Goodhart, 2017), that is, between the "elites without borders" and "people living in nation states who wish to protect economic security, culture and language".

across manufacturing classes has converged rapidly on that of exports from the US, Europe and Japan, so that now these regions and China export both light (labour intensive) and heavy manufacturing. The share of light manufactures in China's exports has fallen in recent decades as it approaches that in the exports of the advanced economies. The major emerging difference is the rise in the share of services in US exports, to about a third today, while China's exports of services remain below a tenth. Since traded services tend to be intensive in skill, the convergence of China's trade pattern lags in this respect due to temporary differences in skill endowment, combined with strategic interventions that protect Chinese services.[6] While this suggests some residual scope for Heckscher-Ohlin-Samuelson forces to drive trade between the US and China, the broad pattern of manufacturing trade is approaching the intra-industry structure that exists between the advanced regions. In our modelling, therefore, we separate intermediates from final goods but do not account for the residual effects of the remaining differences in factor intensities and endowments.

3. US – China Conflict: Prior Assessments

Trade conflicts and their impacts are established topics in the economics literature, that component of which is well reviewed by Bouët and Laborde (2017). Here we focus on literature that has addressed the recent trade conflict between the US and China. This literature, too, is substantial and growing, though it is complemented by our approach, which takes account of monetary policy environments that differ amongst the affected regions, so that protection in one or more regions has differing region-specific effects on consumer and producer price *levels*.

The more standard mechanisms by which protection impacts on economic performance include, first, the substitution between domestic and imported goods caused by change in the relative price of goods coming from different sources (Rosyadi and Widodo, 2018). Second, trade diversion occurs when unilateral protection restricts imports from one region but price incentives remain the same in others (Bouët and Laborde, 2017, Dong and Walley, 2012). Third, terms-of-trade externalities also arise when unilateral protection modifies the domestic terms of trade to

[6] High levels of protection of services, including banking and utilities, have been found elsewhere to reduce overall productivity growth. The liberalization of these sectors in the 1990s in many advanced economies spurred subsequent growth (Nicoletti and Scarpeta 2003, Griffiths and Harrison 2004, OECD 2007).

favor domestic industries. As a consequence, domestic consumers shift expenditure towards home goods so that domestic industries expand, triggering entry and scale expansion at the expense of imports. This demand switch also appreciates the real exchange rate and there is an associated reduction in the share of domestic expenditure that carries international transport costs. These effects tend to offset the inflationary force that stems from the higher domestic prices of imports (Johnson 1953; Bagwell and Staiger, 1999; Ossa, 2011).

These mechanisms are at play in the studies listed in Table 1, which summarizes their findings from experiments in which the US and China increase protection bilaterally. The shocks considered by the studies vary, as to the magnitudes of their effects, but patterns emerge that are of general interest. First, the larger scale of the US economy is occasionally dominant in that its protection increase yields an "optimum tariff" effect that is not always overcome by the negative effects of Chinese retaliation and associated contractions in the rest of the world. Second, China is virtually always the largest *proportional* loser from the conflict, suggesting that it has the most to gain from negotiating new trade agreements. Third, trade diversion effects sometimes dominate global losses, leading to occasional net gains in Europe and Japan, as well as to smaller traders with China such as Australia.

Table 1. Effects of US-China trade conflict under bilateral protection increases

Studies	**Measure of effects**	**US**	**China**	**EU**	**Japan**	**Australia**	**World**
Bouët and Laborde (2017)	Equivalent variation in income	-0.3%	-1.0%		0.1%		
Rosyadi and Widodo (2018)	Real GDP	-1.22%	-5.4%	0.85%	1.52%	1.18%	
Dong and Whalley (2012)	Equivalent variation in income	60 $bn	-19 $bn	-1 $bn	-5 $bn		4 $bn
Bollen and Rojas-Romagosa (2018)	Real GDP	-0.3 %	-1.2%	0.4%	0.4%		-0.1%
Li et al. (2018)	Real GDP	0.3%	-1.0%	-0.001%	0.003%		-0.04%

Source: Authors' review of existing literature analyzing the US-China trade conflict.

By contrast with these studies, our analysis accounts explicitly for differences across regions in targets of monetary policy and for the revenue effects of tariff impositions, which have implications for fiscal deficits or tax rates. Protection raises the home consumer prices of foreign goods relative to the home producer prices of home goods. With the home prices of foreign goods rising there is upward pressure on domestic inflation and so the protagonist's inflation targeting central bank tightens monetary policy to support the anchored domestic expectations. This reduces the home producer price level. Monetary policy in this case therefore reinforces the demand switch to the home product. What differs, however, is that on average, home industries do not see any import parity price rise, but rather must adjust to lower output prices. In the short run, when there is insufficient time to adjust capacity, this causes a loss of employment, and of real GDP and welfare. In the longer run, when the unemployment rate is held fixed but capacity adjusts, unilateral gains are possible for the US but their extent and distributional consequences depend on assumptions about tax rates and fiscal balance. Global losses from this mechanism are pervasive.

A particular complement offered by this approach is to observe the effects of protection on financial markets. Even unilateral protection in the US alone requires a tightening of monetary policies and a contraction in global investment and saving, causing short and long bond yields to rise. This would facilitate continued "normalization" in the US and the return in Europe and Japan to conventional monetary policy, though as will be explained, trade conflicts represent a "bad exit" from the recent global malaise of low rates, low inflation and low growth.

4. Modelling

To provide an ex-ante assessment of the potential impact of the current trade conflict, we construct a multi-region general-equilibrium model to simulate prospective scenarios incorporating US-China trade conflict. This section explains the components of the model related to the macroeconomic behavior and the effects of trade policy. The complete model is documented in an appendix.

Six regions are identified: the US, the EU, Japan, China, Australia and the Rest of the World.[7] The EU is modeled as the full 28 and it is assumed that this collective has a single central bank. In each region there are three households, each with factor-specific income (from low skill labour, skilled labour and physical capital) and each with different reduced form consumption behavior that depends on the regional real interest rate and the levels of current and expected future real disposable income. The three households also have separate income transfers from governments.

4.1 Key elements of the supply side

Each region supplies a single product that is differentiated from the products of the other regions and this product is both consumed directly and used as an intermediate input at home and abroad. Regional production depends on the three primary factors: low-skill labour, skilled labour and physical capital, and the use of tradable intermediate goods. Amongst the three primary factors, low-skill labour is a partially unemployed variable factor while skilled labour and physical capital are fully employed. Although each region supplies a unique differentiated product, production is assumed to draw on a combination of intermediate inputs comprising the home product and imports of products supplied abroad. This allows the capture of differences between the international effects of a policy change in one large country that are due to the dependence of smaller countries on the supply of intermediate inputs on the one hand or final products on the other.

The production technology has output depending on "relative" factor and input use, enabling the separation of shocks to TFP from factor bias shocks that affect factor expenditure shares.[8] In region *i* gross output volume, y_i, is a Cobb-Douglas composite of real value added, v_i, and of intermediates, q_i.

$$(1) \qquad \frac{y_i}{y_i^0} = \left(\frac{A_i^Y}{A_i^{Y0}}\right)\left(\frac{v_i}{v_i^0}\right)^{\beta_i^V}\left(\frac{q_i}{q_i^0}\right)^{\left(1-\beta_i^V\right)}, \forall i, i \in \left(regions\right),$$

[7] The model is a developmental blend of the two developed for Tyers (2015a b, 2016), Tyers and Zhou (2017) and Zhou and Tyers (2017).

[8] Output and factor inputs are expressed relative to initial levels so that shocks to productivity or factor shares do not imply changes in initial output volumes. This facilitates the decomposition of technology shocks as between productivity and factor or input bias, though such shocks are not employed here.

where A^Y is total (factor and input) productivity. Value added, in turn, has Cobb-Douglas dependence on domestic primary factors, raw labor, L, skill, S^K and physical capital, K.

$$(2) \qquad \frac{v_i}{v_i^0} = \left(\frac{A_i^V}{A_i^{V0}}\right)\left(\frac{L_i}{L_i^0}\right)^{\beta_i^L}\left(\frac{S_i^K}{S_i^{K0}}\right)^{\beta_i^S}\left(\frac{K_i}{K_i^0}\right)^{\beta_i^K}, \sum_f \beta_i^f = 1,\ \forall i, f \in (\textit{factors}).$$

To allow for inter-regional substitution in intermediate demand across regional sources, domestically employed intermediate inputs, q, are a CES composite of products acquired from all regions:

$$(3) \qquad q_i = \left(\sum_j \alpha_{ij}^Q q_{ij}^{-\theta_i^Q}\right)^{-\frac{1}{\theta_i^Q}},\ \forall i\ ,$$

where q_{ij} is the quantity of region j's product that is absorbed by production in region i.

The composite prices of value added and intermediate inputs from (1) are related via:

$$(4) \qquad \frac{P_i^V}{P_i^P} = \beta_i^V \frac{y_i}{v_i},\quad \frac{P_i^Q}{P_i^P} = \left(1-\beta_i^V\right)\frac{y_i}{q_i},\ \forall i\ .$$

Here P_i^P is the producer price level – the factory gate price of region i's product, P_i^V is the price of value added and P_i^Q is the price of a composite of home and imported intermediate inputs. The real production wages of unskilled and skilled workers and the capital rental rate depend conventionally on the corresponding marginal products.

The gross volume of output, y, is distinguished from real GDP, which is that portion of output that meets final demand, thus excluding intermediate use, and which equates to real value added, v in (1). The complete set of demands facing country i's industries, which must sum to equate with (1), takes the form:

$$(5) \qquad y_i = \frac{I_i + G_i}{P_i^P} + \sum_j c_{ji} + \sum_j q_{ji}\ ,$$

which is a real version of the standard expenditure identity (on the homogeneous domestic output of region i) with intermediate demand included. I and G are nominal gross investment and nominal government spending on goods and services (net of transfers), c_{ji} is the volume of final consumption of region i's product in region j, and q_{ji} is the volume of region i's product that is

absorbed as intermediate inputs by production in region *j*. Net trade is embodied in the second and third terms and real GDP omits the final term. Equating this with (1) determines producer price levels, P^P, in each region. Producer cost minimization at these prices then determines all the unit factor rewards.

4.2 Income and consumption

Disposable income, for each household, takes the form:

$$(6) \qquad \begin{aligned} Y_{hi}^D = {} & s_{hi}^L \left[\left(1-t_i^L\right) W_i L_i + \alpha_i W_i^o \left(F_i - L_i\right) \right] + s_{hi}^S \left(1-t_i^S\right) W_i^S S_i^K \\ & + s_{hi}^K \left(1-t_i^K\right) K_i \left(P_i^P \, MP_i^K - P_i^K \, \delta_i\right) + T_{hi}^R \,, \quad \forall h \end{aligned} ,$$

where s_{hi}^f is the ownership share of household *h* in region *i* of factor *f*. $[\, s_{hi}^f \,]$ is a unit diagonal matrix in this analysis since households are defined by their source of factor income.[9] K_i is the regional capital stock, F_i is the labour force, W_i is the nominal low-skill wage rate, W_i^S is the corresponding skilled wage and t_i^f is the direct tax rate on income to factor *f*. P_i^K is the price of capital goods in region *i* and δ_i is the corresponding depreciation rate. $T_h^R = t_h^R N_h Y$ is a direct transfer to the household from government revenue, with t_h^R the transfer rate to household *h* per unit of group population, N_h, and per unit of nominal GDP.[10]

For each household, *h*, in region *i*, consumption expenditure, C_{hi}, is a nominal sum but real consumption behavior is motivated by current and expected future real, per capita, disposable incomes and the real interest rate. Real consumption, (lower case) c_{hi}, depends negatively on the after-tax real return on savings (the home bond yield, *r*) and positively on both current and expected future real disposable income per capita for that household:

$$(7) \qquad c_{hi} = \frac{C_{hi}}{P_i^C} = N_i^h A_{hi}^C \left(\frac{r_i}{\tau_i^h}\right)^{-\varepsilon_{hi}^{CR}} \left(\frac{Y_{hi}^D}{N_i^h P_i^C}\right)^{\varepsilon_{hi}^{CY}} \left(\frac{Y_{hi}^{De}}{N_i^h P_i^C \left[1+\pi_{hi}^{Ce}\right]}\right)^{\varepsilon_{hi}^{CY}} ,$$

where the tax rate on interest income, τ^h, is household specific, set as the tax rate on the

[9] Mixed sources of factor income are included in earlier single country studies by Tyers and Zhou (2017) and Zhou and Tyers (2018). At the global level empirical evidence is not sufficient to construct factor income matrices for all represented regions.

[10] The expression (6) is more complex if the households have multiple sources of factor income and labour force participation rates of low skill workers are unequal across households or if participation rates of skilled workers are unequal across households.

household's dominant source of direct factor income. The expected inflation rate of the consumer price level is π^{Ce}. The elasticities in this expression vary by household, ensuring different consumption responses.

4.3 Consumption driven trade and pricing

To capture the home household's substitution between home and foreign products, real aggregate consumption in region *i* is a CES composite of region *i*'s consumption of products from all regions:

$$(8) \qquad c_i = \left(\sum_j \alpha_{ij}^C c_{ij}^{-\theta_i^C} \right)^{-\frac{1}{\theta_i^C}}$$

The home household then chooses its mix of consumed products to minimize consumption expenditure in a way that accounts for home consumption and trade taxes, foreign export taxes, differing foreign product prices and exchange rates:

$$(9) \qquad C_i = P_i^C c_i = P_i^P \tau_i^C c_{ii} + \sum_{j \neq i} \tau_i^C \tau_i^M \tau_j^X c_{ij} P_j^P \frac{E_j}{E_i} \ ,$$

where τ_i^C is the power of region *i*'s consumption tax, τ_i^M is the power of its average import tariff on consumption goods, τ_j^X is the power of the average export tax in the region of origin, *j*, and E_i and E_j are the nominal exchange rates of regions *i* and *j* relative to the US $, measured as US$ per unit of home currency.[11] Optimum consumption is consistent with an elasticity of substitution between home and foreign products of $\sigma_i^C = 1/\left(1+\theta_i^C\right)$. Given these consumption volumes, the composite price of all consumption, or the consumer price level, emerges as:

$$(10) \qquad P_i^C = \tau_i^C \left[\left(\alpha_{ii}^C\right)^{\sigma_i^C} \left(P_i^P\right)^{1-\sigma_i^C} + \tau_i^M \sum_{j \neq i} \left(\alpha_{ij}^C\right)^{\sigma_i^C} \left\{ \frac{P_j^P E_j}{E_i} \right\}^{1-\sigma_i^C} \right]^{\frac{1}{1-\sigma_i^C}} .$$

4.4 Intermediate input demand driven trade and pricing

[11] The US$ is the numeraire in the model, so $E_{US}=1$.

To capture region *i*'s home firms' substitution between intermediate inputs sourced from home and abroad, real aggregate input use, q_i, is a CES composite of intermediate demands for products from all regions (3). Home firms then choose their mix of intermediate products to minimise expenditure on such intermediates, V_i^Q , in a way that accounts for home indirect tax rates, foreign export taxes and differing foreign product prices and exchange rates:

$$(11)\ V_i^Q = P_i^Q q_i = P_i^P y_i - P_i^V v_i = P_i^P q_{ii} + \sum_{j \neq i} \tau_i^M \tau_j^X q_{ij} P_j^P \frac{E_j}{E_i},$$

Where the composite price of intermediate inputs is P^Q. Consumption taxes are not levied on intermediate input use. Optimum intermediate use is consistent with an elasticity of substitution between home and foreign products of $\sigma_i^Q = 1/\left(1+\theta_i^Q\right)$. The corresponding derived demands are then:

$$(12)\qquad q_{ii} = \left(\alpha_{ii}^Q\right)^{\sigma_i^Q} \frac{V_i^Q}{P_i^Q}\left[\frac{P_i^P}{P_i^Q}\right]^{-\sigma_i^Q}, \quad q_{ij} = \left(\alpha_{ij}^Q\right)^{\sigma_i^Q} \frac{V_i^Q}{P_i^Q}\left[\frac{\tau_i^M P_j^P \left(E_j/E_i\right)}{P_i^Q}\right]^{-\sigma_i^Q}, i \neq j \ .$$

Given these volumes, the composite price of all intermediates in region *i*, $\hat{P}_i^Q$, emerges from the combination of (3) and (11) as:

$$(13)\qquad P_i^Q = \frac{1}{A_i^Q}\left[\left(\alpha_{ii}^Q\right)^{\sigma_i^Q}\left(P_i^P\right)^{1-\sigma_i^Q} + \tau_i^M \sum_{j \neq i}\left(\alpha_{ij}^Q\right)^{\sigma_i^Q}\left\{\frac{P_j^P E_j}{E_i}\right\}^{1-\sigma_i^Q}\right]^{\frac{1}{1-\sigma_i^Q}} .$$

4.5 International finance and money markets

The multi-region general equilibrium structure used centres on the global financial capital market. It is assumed that the financial products of each region are differentiated and that portfolio managers assign new net saving across regions so as to maximise expected portfolio returns given this differentiation. Although there is a tendency for financial flows to move the global economy toward uncovered interest parity, in the length of run considered asset differentiation leaves this process incomplete. At the same time, expected rates of return depart from regional bond yields, the latter reflecting short run equilibria in regional financial markets, as between savers, indebted governments and investors.

In each region the demand for domestic money as a financial asset is driven by a "cash in advance" constraint applying across the whole of GDP and by growth in financial wealth for given liquid portfolio shares.[12] Home money is held in a portfolio with regionally differentiated long maturity bonds, which are claims over physical capital and government debt across the regions. Since portfolios are dominated by long maturity assets, the opportunity cost of holding money is the long bond yield, which is modelled as emerging from equilibrium in a thus weakly segmented global market for loanable funds. Central banks derive monetary expansions in regionally specific proportions from conventional monetary policy and from UMP, with reliance on the market segmentation theory of the yield curve (Johnson et al. 2010) to ensure that conventional monetary policy has no *direct* impact on the market for long term bonds. Short rates are therefore not modelled explicitly, rather the monetary base in each region is determined as endogenous to the target of monetary policy and an exogenous parameter determines the share of any change in the monetary base that takes the form of long asset balance sheet expansion. UMP expansions raise home long maturity asset prices and lower long yields, causing imperfect spill-overs across regions due to global arbitrage that is only partially constrained by asset differentiation.

Real money balances (lower case m) are measured in terms of purchasing power over home products at the GDP price, P^Y. Money market equilibrium takes the form:

$$(14) \qquad m_i^D = a_i^{MD}\left(y_i\right)^{\varepsilon_i^{MY}}\left(w_i^F\right)^{\varepsilon_i^{MW}}\left(\frac{r_i\left(1+\pi_i^e\right)}{\tau_i^K}\right)^{-\varepsilon_i^{MR}} = \frac{M_i^S}{P_i^Y} = \frac{\mu_i M_i^B}{P_i^Y}.$$

For region i, y_i is real, regional gross output, as distinct from real GDP since intermediates are transacted as well as goods and services entering final demand. Real financial wealth is w_i^F, τ_i^K is the power of the capital income tax rate in region i and π_i^e is the expected inflation rate of the consumer price level, P^C, defined as a CES aggregate of home and imported consumer prices. Real financial wealth or assets, w^F, is represented as the present value of an infinite stream of real dividends that are equal to after-tax returns on the capital stock, at the expected real rate of return on installed capital, r^{ce}, discounted at the current real financing rate, r. A price adjustment

[12] The inclusion of financial wealth in the money demand equation follows Ragot (2014) and Mena and Tirelli (2017), who incorporate Baumol (1952) – Tobin (1956) behaviour.

is also made for relative inflation or deflation of capital goods prices, which raise or lower the purchasing power of financial wealth over home products.

$$(15) \qquad w_i^F = \frac{r_i^{ce}\left(1-t_i^K\right)\left(P_i^K / P_i^Y\right)K}{r_i} \ .$$

Thus, money demand is driven by transactions (y), portfolio expansion (w^F) and portfolio rebalancing as it affects the liquid component (driven by the opportunity cost, r).

On the supply side of the money market, the proportion of expansions that occur via the purchase of long maturity assets (UMP) is parameterised. Conventional expansions directly affect the money supply while UMP expansions affect both it and the long end of the yield curve. UMP expansions raise home long maturity asset prices and lower long yields, causing imperfect spill-overs due to global arbitrage that is only partially constrained by asset differentiation.[13]

Regional financial market clearance requires that the home financial market in each region clears separately and this implies clearance at the global level. For region i, the nominal value of domestic investment, I_i^D, represents the sum total of all domestic long bond issues. This is then equated with demand for those bonds from home and foreign (net private and government) savings, along with demands for home long bonds that arise from the "quantitative easing" components of monetary expansions by both home and foreign central banks.

4.6 Global financial balance

Financial balance then requires that total investment spending in region i, in i's local currency, is equated with the total supply of financing directed from all represented regions:

$$(16) \qquad I_i^D = \sum_j \left(\left[i_{ji}^S S_j^D + \theta_{ji}^{QE} s_j^{QE} \Delta M_j^B \right] \frac{E_j}{E_i} \right), \quad \forall i \ ,$$

where i_{ji}^S is the endogenous share of region j's domestic total (private and government) saving, S_j^D, that is directed to assets in region i. E_i is the nominal exchange rate of region i relative to

[13] By contrast, conventional monetary policy involves trade in short term instruments which has no direct, immediate impact on the market for long term bonds, which are major components of the global portfolio. Short rates are therefore not modelled explicitly, rather the monetary base in each region is determined as endogenous to the target of monetary policy and an exogenous parameter determines the share of any change in the monetary base that takes the form of long asset balance sheet expansion.

the US$. The "quantitative easing" share of the current period's expansion of the monetary base by region *j*'s central bank, s_j^{QE}, and the share of this expansion that takes the form of acquisitions of region *i*'s long bonds, θ_{ji}^{QE}, both determine central bank demand. These flows are originally in foreign currency and are therefore converted at the appropriate cross rates. The regional real bond yields (interest rates, r_j) emerge from this equality. Their convergence across regions is larger the larger are the elasticities of asset substitution, σ_j^I.[14]

The balance of payments condition requires that the sum of net inflows of payments on the current account and net inflows on the capital and financial accounts, measured in a single (home) currency is zero:

$$(17) \qquad X_i - M_i + \sum_{j \neq i} \left(\left[i_{ji}^S S_j^D + \theta_{ji}^{QE} s_j^{QE} \Delta M_j^B \right] \frac{E_j}{E_i} \right) - \sum_{j \neq i} \left(i_{ij}^S S_i^D + \theta_{ij}^{QE} s_i^{QE} \Delta M_i^B \right) = 0, \quad \forall i \neq "US"$$

The first terms are nominal values of exports and imports (formulated in an appendix) while the second two terms are financial inflows and outflows. The first parenthesised term represents acquisitions of region *i*'s home-issued long bonds by foreign savers and by foreign central banks, the latter associated, as above, with the "quantitative easing" component of the current period's expansions of the monetary bases across regions. These net saving and central bank flows are originally in foreign currency and so are converted at the appropriate cross rates. The second parenthesised term represents acquisitions of foreign-issued long bonds by region *i*'s home savers and its own central bank. A balance of payments in the US is implied by balance in all the other regions. These equations determine the nominal exchange rates. Since these are defined relative to the US$, that for the US is always unity $\left(E_{US} = 1 \right)$, though nominal and real effective exchange rates are also calculated.

4.7 Calibration

The model database is built on national accounts, international trade and financial data for the global economy in 2016. The relative sizes of the four major economic regions, the US, the EU, Japan and China indicate that China's economy (even measured without PPP adjustment) is not

[14] This elasticity is central to the characterization in the model of the global financial market in which economies have varying degrees of integration (Tyers and Zhou 2019). The representation of global financial markets is described in full in the accompanying appendix.

the smallest of them and it matches the largest in investment, exports[15] and saving. The structures of the regional economies differ in important ways. The US has a high consumption share of GDP, China a low one. Necessarily, then, the US has a low saving share while China has a high one. Some regions, such as the EU and China) are more dependent on indirect taxes than others, which makes a difference to the proportion of GDP made up of factor cost and hence the size of the household budget and the gap between producer and GDP prices. Since these taxes fall most heavily on consumption, changes in saving behaviour have strong implications for fiscal deficits and, indirectly, for interest premia, which are endogenous to the scale of fiscal deficits relative to GDP levels. Investment is larger in some regions than in others, being extraordinarily high in China. And then, of course there are the fiscal deficits that are largest in the EU and Japan, and the current account surpluses or capital-financial account deficits in Japan and China, at least partly funding the substantial deficit in the US.

5. Simulated Effects of Protection

To provide an ex-ante assessment of the potential macro impacts of the current trade conflict, here we begin with a brief description of the impacts of protection through the prism of the model just described. In particular, we wish to highlight the dependence in this model of protection effects on the targets of monetary policy and on fiscal policy as it drives fiscal balance. Then we detail the simulated effects of US unilateral protection, both domestically and in China and other trading partners. A corresponding analysis of the effects of a Chinese response follows.

5.1 Macro Protection Stories

In the short run employment is flexible and protection leads to unemployment and the associated contractions in both real GDP and welfare, defined as the purchasing power of disposable income at home consumer prices. A long run is also defined such that the capital stock (or capacity) can adjust around the world so as to restore the initial values of the expected rate of return on installed capital net of depreciation and tax. So in this length of run employment is fixed but capital use is variable. Initial differences across regions in the expected rate of return

[15] EU exports, for this comparison, are net of intra-EU trade.

on installed capital are assumed to be associated with risk considerations not endogenous in the model. Following a policy shock the model solves for an equilibrium in which these differences are restored by capital stock adjustments that are consistent in direction with changes in real investment.

Central to the analysis of the trade dispute are changes in the price levels represented in the model. The consumer price, P^C , is the weighted average of the home producer price and the domestic currency price of foreign goods, which is boosted by the power of the tariff, $\tau_M = (1+t_M)$, where t_M is the average ad valorem tariff rate on imports. Of course, P^C is further boosted by the power of the consumption tax, $\tau_C = (1+t_C)$, where again, t_C is the ad valorem rate. While it is more complex in the model due to its constant elasticity of substitution (CES) price index and the separation of intermediates from final goods, we can usefully simplify Equation (10) to:

$$(18) \qquad P^C = \tau_C \left[\alpha_H P^P + (1-\alpha_H)\left(\frac{\tau^M P^*}{E} \right) \right],$$

where α_H is the home product share of consumption, P^* is the landed price of foreign goods and E is here the nominal effective exchange rate expressed as the purchasing power of the home currency over others.

An increase in the home tariff on imports raises the second term in the square parentheses. This is the expected rise in the home prices of foreign goods, relative to the home producer price of home goods, P^P, that induces the desired substitution in consumption toward home goods. Because the protagonist's central bank targets consumer price inflation and we are making one-off shocks, we equate inflation targeting to price *level* targeting. So the (short) policy rate is adjusted so as to change the money supply[16] to keep P^C constant in local currency per unit of volume. With the second term rising, a monetary tightening is required to sustain the equality in (18) and this causes the nominal producer price level, P^P, to fall.

[16] The money supply is the key monetary policy variable in the model. The short policy rate is not included explicitly. The effects of UMP on the markets for long assets and long yields in Europe and Japan are accounted for, however, as indicated in the previous section.

Of course, this primary effect is opposed in the model (and in reality) by a nominal exchange rate appreciation ($E\uparrow$) and a rise in the share of the home product that is consumed ($\alpha_H \uparrow$), but these do not reverse the direction of price effects. This is counterintuitive because we expect that the protection is implemented to create a price incentive to raise home production, arising from a switch in domestic demand as home consumers substitute away from imports toward home products. Indeed, this switch does occur, but the producer price *level* would only rise if the protagonist's monetary policy were to break the P_C inflation anchor and implement a surprise expansion.[17] Falling nominal producer prices prove contractionary in most cases, in the short run because of fixed nominal wages and rising unemployment and in the long run because of diminished expected rates of return.

The effect on free trading home economies of protection by other regions is also evident from (18). In their cases, even though there is no change in their tariff rates, the second term in parentheses still rises, because their currency depreciates. If their central banks target inflation then their producer price levels are forced to contract as in the protecting economy. In the case of China, where inflation expectations are set at zero while the nominal exchange rate is the principal target of monetary policy, the second term in parentheses falls only slightly. This is because the increase in protection abroad raises global supply and reduces international trading prices, causing a decline in P^*, as represented in (18). But China's *real* exchange rate must depreciate in response to the foreign protection, since that protection switches demand away from Chinese goods toward those that are protected. Its fixed nominal exchange rate then requires a deflation of all its price levels, including its consumer price, P^C, and for the above reason to a lesser extent, its nominal producer price, P^P. For China, then, both sides of (18) decline in response to US unilateral protection.

The Short Run

Here nominal wages are rigid, as is the level of capital use and government spending on goods and services, while tax revenue is endogenous at fixed rates, so that the initial regional fiscal balances are not sustained. Following the implementation of the tariff, firms face no change in

[17] In the case of US unilateral protection against China alone, in the short run P^C inflation of a per cent or so would be sufficient to prevent real GDP decline. If the protection were directed to all sources of imports then five per cent would be needed, supported by a very substantial monetary expansion the like of which would require a return by the Fed to UMP.

unit labour costs but a cut to revenue and so react in spirit with the traditional Phillips curve, reducing employment. Output therefore falls, as does welfare more generally. In free trading partner economies producer prices also deflate, with consequences that are similar as to direction.

The Long Run

The long run is different in three ways. First, nominal wages are flexible and unemployment rates remain constant. Second, expected rates of return on investment net of depreciation and capital income tax are sustained while regional capital stocks adjust and, third, all regions retain their initial nominal fiscal imbalances, allowing adjustment in tax rates on capital income.[18]

5.2 Unilateral protection by the US

Since the US appears to have been the progenitor in recent trade disputes we devote some attention to the consequences of its unilateral protection in the absence of retaliation. The simulations and the policy changes represented in them are detailed in Table 2. The tariff rate imposed is a crude simplification, given that the actual tariffs are applied over a limited number of products with presumed enforcement imperfections. The long run cases all require conserved fiscal balance and the adjustments in expenditure and tax rates required for this are noted.

Table 2: US Unilateral Protection against China: Simulated Fiscal Effects[a]

% changes	Short run	Long run		
		Govt exp adjusts	Consn tax adjusts	Capital tax adjusts
Shock to power of import tariff vs China	5.00	5.00	5.00	5.00
Endogenous fiscal effects				
Government expenditure on goods	0	1.13	0	0
Power of capital income tax rate	0	0	-0.32	-0.77
Change in fiscal position, %GDP	0.11	0	0	0

a Four simulations are represented, one with employment adjustment and fixed capital use (short run) and a further three with capacity adjustment, constant unemployment rates and constant fiscal balance with adjustment of expenditure or rates of tax on capital income (long run).

[18] Here we assume the long run trend is toward reduced capital income tax rates in the advanced economies, so it is these that are here adjusted to sustain fiscal balance. In a separate paper we analyze the effects of both alternative monetary targets and alternative tax mix switches in the long run (Tyers and Zhou 2019). As it turns out, the global distribution of net gains and net losses depends importantly on these policy choices.

US Effects

The US domestic effects of the unilateral tariffs are summarized in Table 3. Producer price levels fall in most cases for the reasons discussed above. There are falls in either employment or capital stocks and hence in real GDP and the US$ appreciates in nominal and real terms. Investment falls relative to saving and there is a shift in the current account that reduces the US deficit. Monetary policy tightens to sustain the consumer price inflation target. As the volume of domestic saving falls excess demand for investment funding rises and long bond yields rise.[19] Associated with this and the reduced capital stock, the real value of financial assets falls. The effects on aggregate welfare, defined as the real purchasing power of disposable income at domestic consumer prices, are mixed however. In the short run the loss of employment ensures a

Table 3: US Unilateral Protection against China: Simulated Domestic Effects[a]

		Long run		
	Short run	Govt exp adjusts	Consn tax adjusts	Capital income tax adjusts
Producer price level, %	-0.13	-0.09	0.24	-0.09
Long bond yield, %	0.23	0.59	0.37	-0.09
Nominal effective exchange rate, %	0.25	0.34	0.21	0.37
Real effective exchange rate, %	0.70	1.07	0.85	1.07
Change in fiscal position, %GDP	0.11	0.00	0.00	0.00
Change in employment, millions	-0.20	0.00	0.00	0.00
Physical capital stock, %	0.0	-0.04	-0.03	0.23
Money supply, %	-0.41	-0.61	-0.19	-0.23
Change in current account, % GDP	0.20	0.15	0.09	0.11
Real financial assets, %	-0.60	-0.80	-0.35	0.14
Real consumption low-skill wage, %	0.00	-0.13	0.21	-0.03
Gini coefficient, %	-0.12	-0.06	0.01	0.33
Real GDP, %	-0.05	-0.02	-0.01	0.09
Aggregate welfare, %	-0.15	-0.10	0.20	0.20

a Four simulations are represented, one with employment adjustment and fixed capital use (short run) and a further three with capacity adjustment, constant unemployment rates and constant fiscal balance with adjustment of expenditure or tax rates on capital income (long run).
Source: Simulations of the model described in the text.

[19] This rise is aided by monetary contractions outside the US, where UMP implies reduced demand for long assets by central banks, combined with the partial integration of global capital markets.

contraction in disposable income and this is also true in the long run, when tariff revenue allows a small rise in government expenditure on goods and services or a contraction in the tax rates on consumption or capital income.

In the long run the additional revenue finances either increased expenditure or reduced rates of tax on consumption and capital income. Increased expenditure reduces expected rates of return and so leads to a contraction in capacity in the long run that roughly parallels the short run results. Tax relief of either type, however, sees the tariff increase as net beneficial to the US. To see why this is a consequence of the reduced consumption tax rate, which in the US would require lower indirect tax rates at the state level, it is useful to return to equation (18). Fiscal balance then requires the consumption tax rate, τ_C , to fall. Just as in the short run, the home price of foreign products rises relative to that of home products, P^P, which is the desired effect of the protection. In the long run, however, the fall in τ_C , and with P^C fixed by monetary policy, creates room for a *rise* in P^P. Domestic wholesale prices of both home and foreign goods rise relative to final consumer prices, with the foreign product prices rising by more.

The clearing labour market ensures that the protection-induced rise in home product prices also leads to rises in nominal factor incomes in the protagonist. But with a constrained consumer price level this implies rising purchasing power of disposable income over final goods and hence rising welfare. This does not imply rising real output or real GDP, however. While *nominal* GDP does rise in the protagonist, the GDP price level, P^Y, inflates by a proportion that deviates from the rise in P^P due to the change in overall indirect tax revenue. Thus, real output actually falls in the protagonist. This counterintuitive result arises because the new trade distortions reduce global demand, and the re-establishment of the original expected rates of return across regions requires that capital stocks are lower, even in the protagonist economy. Its home industry's larger share of domestic demand notwithstanding, the protagonist's real appreciation sees a decline in exports.

If the fiscal policy choice is a decline in the power of the capital income tax rate, τ_K , the rise in the second term in (18) due to the tariff then causes a decline in the US producer price level, placing downward pressure on expected rates of return. But this negative effect is more than offset by the tax relief itself, which sees a net increase in the expected rate of return on US

capital and therefore in investment and long run production capacity. This implies rising purchasing power of disposable income over final goods and hence rising welfare.

The protagonist's net welfare improvement might be thought of as due to the "optimal tariff" effect of protection in a large country. But its achievement depends on the allocation of the new tariff revenue. It is largest in the case of a reduced capital tax rate, which causes the most considerable "beggar thy neighbor" effects. The protagonist's capital long run capital expansion is at the expense of the rest of the world, with the global capital stock declining by more than in any other case. This is associated with a unilateral net welfare gain and it is the only case in which there is also an expansion of real GDP.

Effects outside the US

In partner regions, as in the short run, the effects the protagonist's protection increase are negative across the board, irrespective of these tax mix adjustments, and worst when tariff revenue accommodates capital income tax relief. The effects on China are detailed in Table 4. These are uniformly negative and by a considerably greater margin than for the other regions modelled. The short run result is dominated for China by its deflation and the associated, substantial worker displacement. Amongst the long run results, the case of tariff revenue yielding capital income tax relief is the worst, requiring the largest monetary contraction to defend the exchange rate and causing the largest decline in the capital stock and in real financial assets. The Chinese proportional loss to its GDP is four times the US proportional gain and the corresponding proportional loss of Chinese welfare is more than four times larger than the proportional US gain.

The within-region distributional effects are summarized in Table 5 for the case in which there is unilateral US protection with tariff revenue yielding capital tax relief. The big US winners are capital-owning households, though, by redirecting global investment into the US and raising its production capacity at the expense of the rest of the world, the combination of tariffs and capital tax relief does also offer net advantage to working households. In other regions the pure protection case harms all households and those of capital owners most.

Table 4: US Unilateral Protection against China: Simulated Effects on China[a]

	Short run	Long run		
		Govt exp adjusts	Consn tax adjusts	Capital income tax adjusts
Producer price level, %	-1.19	-1.51	-1.28	-1.43
Consmer price level, %	-1.03	-1.32	-0.68	-1.27
Long bond yield, %	0.28	0.75	0.44	1.33
Nominal effective exchange rate, %	0.30	0.38	0.24	0.42
Real effective exchange rate, %	-0.77	-0.96	-0.85	-0.84
Change in fiscal position, %GDP	0.11	0.00	0.00	0.00
Change in employment, millions	-16.82	0.00	0.00	0.00
Physical capital stock, %	0.0	-0.25	-0.27	-0.76
Money supply, %	-2.87	-2.51	-1.92	-2.99
Change in current account, % GDP	-0.25	-0.28	-0.19	-0.26
Real financial assets, %	-2.39	-0.96	-0.80	-2.03
Real consumption low-skill wage, %	1.04	-0.44	-0.87	-0.66
Real GDP, %	-0.88	-0.13	-0.14	-0.40
Aggregate welfare[b], %	-0.63	-0.43	-0.86	-0.89

a Four simulations are represented, one with employment adjustment and fixed capital use (short run) and a further three with capacity adjustment, constant unemployment rates and constant fiscal balance with adjustment of expenditure or tax rates (long run).
b Aggregate welfare is the real purchasing power of disposable income at domestic consumer prices.
Source: Simulations of the model described in the text.

Table 5: Distributional Effects of Unilateral US Protection and Tax Reform

	Household		
Simulated net welfare[b] effects by region, %	Low-skilled	Skilled	Capital owning
US	0.05	-0.02	0.57
EU	-0.19	-0.18	-0.35
Japan	-0.20	-0.20	-0.31
China	-0.65	-0.65	-1.17
Australia	-0.37	-0.37	-0.62

a The US unilateral protection case represented here is that in which revenue from protection allows capital income tax relief, with capacity adjustment and constant unemployment rates. There is a constant fiscal balance with adjustment of the tax rate on capital income.
b Welfare is the real purchasing power of group disposable income per capita at domestic consumer prices.
Source: Simulations of the model described in the text.

5.3 US Protection with Chinese Retaliation

Here we combine the US protection considered previously with Chinese retaliation of like magnitude. We then examine the effects of both seeking to avoid leakage by imposing this level of protection on imports from all trading partners. A summary of key results is offered in Table 6. Since both countries now increase protection, both experience nominal effective appreciations, while the currencies of their other trading partners depreciate. In the short run, while nominal government expenditure on goods and services is held constant, the added tariff revenue improves the US fiscal position. In China, however, the effect of the bilateral protection is to contract the economy and this causes a net impairment of revenue and a worsening fiscal position. The US current account balance does move toward surplus, as in the unilateral protection case, while that of China only does so if protection is imposed on all its imports.

Whether the protection increase is bilateral only or US and China against the world, the US is the only long run gainer and the global economy shrinks. China's real GDP contractions are slightly smaller than in the unilateral protection case (Table 3) offering partial justification for the retaliation, but the negative effect on welfare is only slightly offset in the long run when full employment returns. In the case of US and China against the world, however, the Chinese real GDP and welfare contractions are very large, as is the associated global contraction.

The domestic distributional implications of bilateral protection are summarized in Table 7. This shows that, in the case where capital tax relief is facilitated by the tariff revenue, the only gainers from US protection are US capital owners. All other household groups across the globe are losers. When both the US and China protect against all trading partners there is a very slight gain to US low-skill households but the major gainers again are US capital owners. The increased protection in China now benefits its own capital owners, but far more slightly than in the US.

The global effects embodied in all these simulation results are summarized graphically in Figure 6, which shows welfare expressed in US$ per person and the proportional change in real consumption wages. Chinese retaliation is seen to only marginally improve its net welfare position, irrespective of the tax mix switch adopted. But China's retaliation does significantly reduce the corresponding net gains to the US. Note that the welfare losses to China in US$ per

Table 6: US Protection with Chinese Retaliation: Simulated Effects[a]

	5% US-China bilateral tariffs		5% tariffs against all imports to the US and China	
	Short run	Long run with capital income tax adjustment	Short run	Long run with capital income tax adjustment
Nominal effective exchange rate, %				
US	0.16	0.27	1.05	1.05
EU	-0.35	-0.66	-2.45	-2.45
Japan	-0.51	-0.75	-3.06	-3.06
China	0.20	0.31	1.20	1.20
Australia	-0.59	-0.74	-2.59	-2.59
Change in fiscal position, %GDP				
US	0.09	0.00	0.34	0.00
EU	-0.02	0.00	-0.21	0.00
Japan	-0.02	0.00	-0.34	0.00
China	-0.40	0.00	-0.17	0.00
Australia	-0.07	0.00	-0.49	0.00
Change in current account, % GDP				
US	0.14	0.06	0.51	0.23
EU	0.01	0.09	0.01	0.30
Japan	0.04	0.15	0.17	0.66
China	-0.09	-0.16	0.47	0.18
Australia	0.00	0.11	-0.07	0.38
Real GDP, %				
US	-0.06	0.07	-0.17	0.23
EU	-0.01	-0.05	-0.13	-0.32
Japan	-0.01	-0.05	-0.27	-0.52
China	-0.72	-0.24	-1.17	0.25
Australia	-0.05	-0.09	-0.31	-0.57
World	-0.16	-0.06	-0.52	-0.22
Aggregate welfare[c], %				
US	-0.20	0.10	-0.56	0.51
EU	-0.03	-0.17	-0.37	-1.14
Japan	-0.05	-0.19	-0.99	-2.07
China	-0.86	-0.76	-1.89	-0.32
Australia	-0.14	-0.35	-0.94	-2.15

a Four simulations are represented, two with employment adjustment and fixed capital use (short run) and two with capacity adjustment, constant unemployment rates and constant fiscal balance, with adjustable of capital tax rate.
b Aggregate welfare is the real purchasing power of disposable income at domestic consumer prices.
Source: Simulations of the model described in the text.

person fail to represent the proportional effects, which are larger because disposable income in China is still substantially less than in the US and the other regions shown. This difference is reflected in the real consumption wage graphs, which show that Chinese workers suffer greater proportional losses from the trade conflict. Retaliation only improves their circumstances, and then marginally, if the tariff revenue offers consumption tax relief. This suggests that, for China, the renegotiation of trade arrangements with the US is a superior alternative to retaliation.

Table 7: Distributional Effects of Bilateral US-China Protection[a]

	Household		
Simulated net welfare[b] effects by region, %	Low-skilled	Skilled	Capital owning
5% bilateral tariffs, US-China			
US	-0.04	-0.11	0.45
EU	-0.13	-0.13	-0.26
Japan	-0.16	-0.15	-0.24
China	-0.72	-0.73	-0.81
Australia	-0.28	-0.28	-0.46
5% tariffs by US and China against all imports			
US	0.03	-0.19	1.69
EU	-0.89	-0.88	-1.66
Japan	-1.65	-1.64	-2.58
China	-0.91	-0.95	0.37
Australia	-1.71	-1.71	-2.82

a In both simulations presented here there is full capacity adjustment, constant unemployment rates and revenue from protection and fixed fiscal balance allow capital income tax relief, with capacity adjustment and constant unemployment rates.
b Aggregate welfare is the real purchasing power of disposable income per capita at domestic consumer prices.
Source: Simulations of the model described in the text.

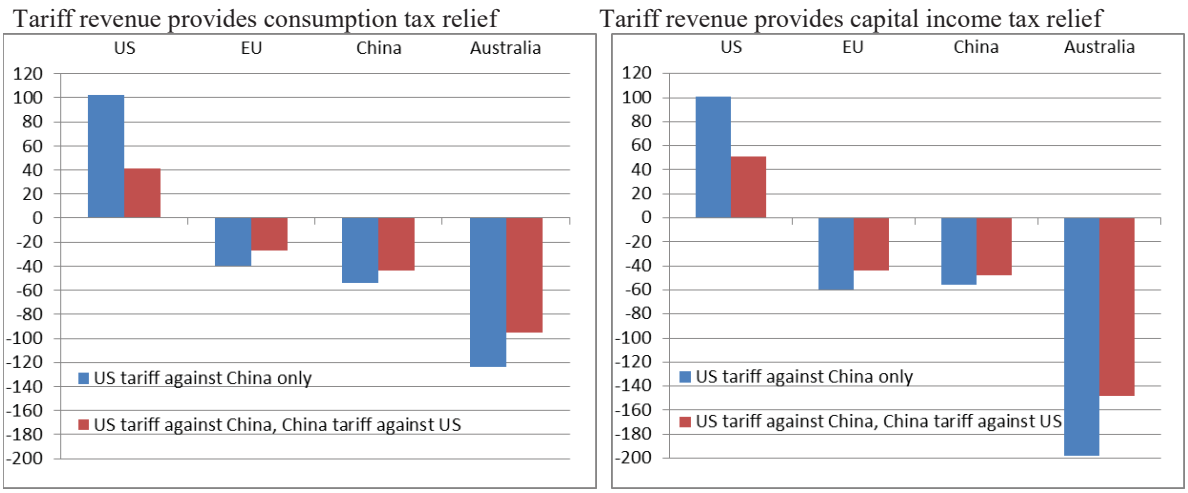
It is also evident from Figure 6 that the US$ per capita losses suffered by China, notwithstanding their proportional significance, are smaller than those incurred by other trading partners when consumption tax relief is offered. In this case those dependent on trade with China, such as Australia, suffer most.[20] When the fiscal adjustment is via capital tax relief the US economy expands by more at the expense of the rest of the world, and of China in particular, making China lose by most. Interestingly, the third country losses are moderated when China retaliates.

[20] Simulations not presented here show that larger increases in protection, either in the US, China or both, cause proportionally larger losses for third country trading partners.

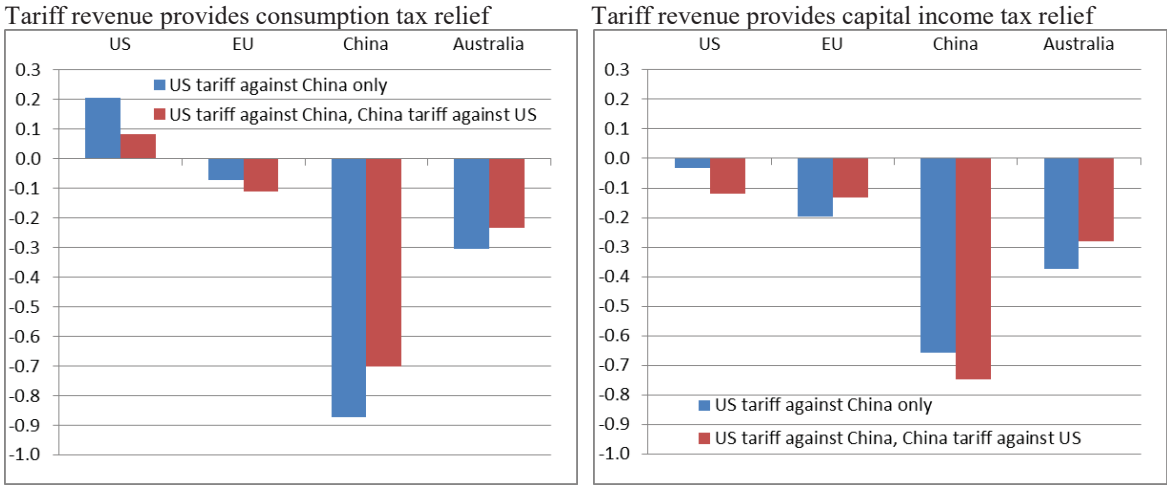
This is mainly because retaliation reduces the scale of China's associated real GDP contraction and therefore the effects on the welfare of its other trading partners.

Figure 6: Effects with Capacity Adjustment and Full Employment, $/person[a]

Welfare, US$ per person



Real consumption low-skill wage, %



a Illustrated results from model simulations, offered numerically in the tables.

4. Conclusion

The trade conflict between the US and China has blossomed recently and traditional international trade models have already been applied to evaluating its effects. In this paper the effects are examined using a calibrated global macro model that accounts for their dependence on monetary policy and associated changes in fiscal positions or tax rates. Economic performance and inequality are both found to depend quite importantly on the particular "tax mix switch" that is chosen in response to the arrival of additional revenue from new trade tariffs. For the progenitor, in this case the US, the long run economic gains to be derived, in aggregate welfare rather than real GDP, are greatest if the tariff revenue facilitates either consumption or capital income tax relief. Since the US has no federal consumption tax, reduced capital income tax is the more likely of these, though this alternative derives US welfare gains at greater expense to China and the rest of the world in the long run. Indeed, such an outcome goes some way toward the effects of the recent tax reform in the US. If the embodied reduction in capital tax is added, the "beggar thy neighbor" character of US tariffs and tax reform emerges strongly.

Not only is US welfare improved on average by its protection but, if the tariff revenue were to allow consumption tax relief then so also would be the real consumption wages of the low-skilled. This notwithstanding, the skilled and capital owners would gain by more. Though we recognize that "it was ever thus", the point to emerge is that US tariffs and tax reform might benefit US workers but it will not reduce US inequality.

The net welfare gain to the US is greatly reduced if China retaliates in kind, though the net cost to China of the protection is reduced little by this. Indeed, as a share of initial income, the losses to China irrespective of the tax mix switch assumed are much larger than the gains to the US. This suggests that renegotiation is superior to retaliation for China. Finally, if the two protagonists were to seek to avoid leakage by imposing protection against all sources, global losses would be still larger and borne primarily by third regions, including Europe and small traders with China, such as Australia.

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