Trade Wars and Trade Disputes: the Role of Equity and Political Support

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15 March 2019

Abstract

The theoretical and quantitative analysis of trade wars is grounded in a relatively narrow treatment of optimal tariff theory and non-cooperative Nash equilibria. The lynchpin of this analytical framework is the assumption that trade policymakers are rational and have a simple well-established objective function to optimize. We argue that the preferred specification of this objective function ignores inequality at its peril. Working with a numerical model, we show that including equity (a primary focus of the earlier literature) as a determinant of social welfare can substantially change the non-cooperative Nash outcome. In addition, when policy-makers do not meet the core assumption of rationality on trade policy, the economic outcomes of trade wars may also be very different from what estimates grounded in optimal tariff theory would suggest.

JEL codes: F13, F14, D3, D72

Keywords: Trade wars, general equilibrium trade models, income distribution, political support

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1. Introduction

In a dramatic break with the post-War elite consensus, the Trump administration entered office with the expressed intention of transforming the liberal international economic order which had previously been based on, among other things, a commitment to liberal trading relations. Thus, starting in 2018 we have observed the onset of trade conflicts involving the United States, spanning many goods and many trading partners. With the US imposing tariffs on steel and aluminium imports from most of its trading partners, raising tariffs on about $260 billion in Chinese imports, and with retaliation by most of its trading partners, these tensions have the potential to grow from a set of limited trade disputes (essentially "trade skirmishes") into a full blown trade war.

This shift from a more multilateral to a more confrontational trade policy on the part of the US has in turn led to a sizeable literature on the economic repercussions of these measures. This literature ranges from conventional CGE-analyses (Devarajan et al., 2018, Francois and Baughman, 2018, Li et al., 2018, Walmsley and Minor, 2018) and related new quantitative trade (NQT) models (Ossa, 2014, Felbermayr et al., 2017, Amiti et al., 2019, Fajgelbaum et al., 2019), to analyses with macro-econometric models (Dizioli and Roye, IMF, 2018, Bolt et al., 2019). In addition, some studies have focused on the impact of more drastic scenarios in which the trade tensions turn into a full blown global trade war (Bouët and Laborde, 2018, Bekkers, 2019, Bekkers and Teh, 2019, Robinson and Thierfelder, 2019). Finally, a numerical literature is developing which analyses the current trade tensions from the perspective of rational trade wars based on Nash equilibria (Balistreri and Hillberry, 2017).[2]

This renewed interest in trade conflict does not mean the issue is itself new. The issue of retaliation has actually been part of the trade policy literature from the start. From Mill (1844, pp. 28-29) forward, analysis of terms-of-trade gains from trade taxes are usually accompanied by a warning that such taxes are likely

[2] Well pre-dating this recent literature, there is a sizable body of work, both scholarly and practical, from the 17th and 18th Centuries onwards, on the relationship between power and plenty in which trade relations between countries plays a significant role. The classic study remains Heckscher (1935) as extended by Viner (1955).[2] The core of modern and contemporary analytics on interactive trade theory are the optimal tariff analytics. Recognizably modern versions of the optimal tariff argument can be found in Bickerdike (1906) and, especially, Edgeworth (Edgeworth, 1908a, b, 1925). Issues related to the optimal tariff have attracted the interest of leading trade economists from the time of Edgeworth to our own. The classic reference here is (Johnson, 1951, 1959).

to attract retaliation which, in turn, will reduce the gains, possibly resulting in overall losses (Gorman, 1958). The history of actual trade wars suggests that this is far from a merely theoretical concern (Conybeare, 1987). Much of the early work on trade wars considers a "tit-for-tat" process potentially ending in autarky, certainly reducing global welfare and probably reducing the welfare of each participant individually.[3] This literature begins with Scitovsky (1942) and reaches its most sophisticated form in Johnson (1953-4). Johnson considers a trade war as a process in which each country imposes an optimal tariff assuming that the other is passive and the countries alternate in tit-for-tat fashion until they reach a point where neither country can gain from a change in its tariff when its turn to retaliate comes. His analysis then follows Cournot's (1960) discussion of a tit-for-tat process leading to a stable duopoly equilibrium. Since the integration of game theoretic tools in international trade (as in many disciplines) in the 1980s, the Nash equilibrium tariff has emerged as the preferred representation of trade wars in the contemporary literature.

The analysis of optimal tariffs and Nash optimal tariffs is obviously an exercise in counter-factual analysis. The historical cases tend to be from periods for which data are not generally available, and, except for the US-China case, contemporary trade conflicts are what we can call "trade skirmishes." For these reasons, the complexities involved in quantitatively estimating optimal and Nash tariffs, which require large-scale general equilibrium trade models, hindered the empirical analyses of trade wars until the 1980s.[4] The good news here is that the tools of counterfactual analysis with application to general equilibrium are by now very well-developed.[5] In addition to the analysis of domestic economic policies, these methods have been used extensively to study the effects of multilateral trade agreements (Francois *et al.*, 1996b, Harrison *et al.*, 2012) and preferential trade agreements (Egger *et al.*, 2015). Thus, it is not surprising that even before

[3] It should be noted that "tit-for-tat" here, unlike in the Kreps *et al.* (1982) case we discuss below, involves each country acting rationally (in that it chooses its *optimal* tariff, though without taking into account the reaction of the other country). Thus, while the end point should be a Nash equilibrium, and like the analysis of Cournot, this analysis is not game theoretic in the modern sense. We will shortly get to full game theoretic rationality.

[4] As will be discussed in more detail below, a remaining constraint on numerical analyses is the high dimensionality when estimating optimal tariffs for specific (even broadly defined) sectors. With N countries, S sectors and T possible tariff levels, then ST^N simulations are required. The number of simulations, therefore, can easily become unfeasible (running into the millions) if this set is not constrained. Thus, all analyses employ either uniform country-specific tariff levels or modify only the tariff of one sector at a time.

[5] For overviews of the methods and results, see: Shoven and Whalley (1992); Ginsburgh and Keyzer (1997); Francois and Reinert (1997); and Dixon and Jorgenson (2013).

the recent shift in policy environment, these methods were also used to calculate rough orders of magnitude from trade disputes (e.g. Hamilton and Whalley, 1983, Whalley, 1985, Baldwin and Clarke, 1987, Markusen and Wigle, 1989, Harrison and Rutström, 1991, Bouët and Laborde, 2010). Overall, the literature suggests a wide range of possible values for trade war outcomes, conditional on the model characteristics and parameter values employed.

In this paper, we focus on numerical analysis of a US vs. rest of the world (RoW) trade war. Our emphasis is on some of the assumptions made in the contemporary literature regarding policy objectives. We examine the implications of broadening our set of policy objective functions, including moving away from a single representative agent (i.e. including inequality effects), as well as core rationality assumptions underpinning the contemporary literature. We work an Eaton-Kortum based, structurally estimated general equilibrium model (SEGE model) that incorporates estimated effects on US household inequality. In the process, we also introduce a comprehensive computational method for identification of the Nash equilibrium set of tariffs that identifies the optimal reaction functions of each country. This allows for a better analysis of the range of policy responses depending on retaliation. In contrast to the recent literature, our approach allows us to examine an issue at the core of the modern (i.e. pre-1990) theory of optimal tariffs, but more or less missing from the more recent literature: the fundamental concern in the former with household heterogeneity and how income distribution can fundamentally change welfare considerations. Incorporating these and other political economy considerations into modern optimal tariff analysis is the main contribution of this paper.

This papers is organized as follows. Section 2 discusses the importance of including income distribution considerations in the objective function to be optimised by the policy maker in an optimal tariff setting. In Section 3 we lay down the quantitative trade model and the numerical strategy that we use in our trade war and trade dispute simulations. The results of these simulations are presented and discussed in Section 4 and we then conclude in Section 5.

2. Inequality considerations in trade policy evaluation

a. Income distribution (still) matters for social welfare analysis

One striking difference between modern (e.g. Scitovsky, 1942, Little, 1949, Baldwin, 1952, Johnson, 1959, et al.) and contemporary (e.g. Bond, 1990, Young, 1991, Bagwell and Staiger, 2002, Broda et al., 2008) optimal tariff theory is the fundamental concern in the former with agent heterogeneity and income distribution. The proximate source of that concern was the then very active research on "the new welfare economics", and the status of the social welfare function in particular (Chipman and Moore, 1978). The potential for taste heterogeneity to undermine the straightforward application of optimal tariff theory has been a theme at least since Johnson's (1959) classic analysis.[6] However, as long as household preferences are identical and Gorman polar form (e.g. homothetic or quasi-linear), redistribution caused by changes in tariff policy has no effect on aggregate demand. In what follows, we abstract from heterogeneous household preferences and work with homothetic preferences across households --although with diminishing marginal utility in composite consumption. However, we do include household heterogeneity regarding factor ownership, such that factor and income distribution matters for social welfare (Francois and Rojas-Romagosa, 2011). In this way, we can still examine numerically the importance of distributional issues.

Even apart from the challenges raised by agent heterogeneity in preferences, problems with the normative part of optimal tariff theory induced by income distribution remain. After all, the "optimal" in "optimal tariff theory" refers to normative analysis. Specifically, without an objective function there can be no optimum. Even with Gorman polar form preferences, heterogeneity in household factor-ownership (the case we examine here) will mean that any change in tariff policy will produce income distribution effects that undermine any hope of applying the logic of Pareto optimality to evaluation of those policies. Except in the case of very restrictive assumptions about both household preferences and the form of the social welfare function, optimality requires redistribution to support the

[6] Johnson uses a standard Heckscher-Ohlin-Samuelson model with taste heterogeneity among single-factor-owning households. Stolper-Samuelson effects thus not only redistribute income among households but change aggregate demand. Johnson shows that even though these household preferences are individually well-behaved, the effect on the offer curve is striking (see figure 3, from Johnson). As Kemp and Shimomura (2002) show, this is just a specific instance of the Sonnenschein-Debreu-Mantel theorem (see Mas-Colell *et al.*, 1995, section 17.e).

optimum. This general need for redistribution to support the social welfare function creates serious problems for political-economic analyses involving state objective functions that give positive weight to social welfare (e.g. Grossman and Helpman, 1995, Bagwell and Staiger, 2002), but who at the same time ignore the redistribution question.

b. Sen-type social welfare

Under the social welfare approach to income distribution measurement, inequality is associated with the dispersion of income around the mean. This raises two measurement problems. The first is that we cannot generally rely on first moment-based indicators (i.e. average real income). The second is that even though the concepts of Lorenz-dominance and general Lorenz-dominance (Shorrocks, 1983) are accepted as ways to impartially rank two different distributions, in many cases the Lorenz-curves intersect at least once, so that we obtain an incomplete ranking of distributions. To solve both these problems, inequality indexes are usually used to rank distributions in indeterminate cases and to provide a summary variable that can be used in empirical models. While the most commonly used is the Gini coefficient, most inequality measures are implicitly based on an implicit social welfare function (Dalton, 1920; Kolm, 1969; Atkinson, 1970). As such, there is no perfect index, and any index has built in social preferences.

We follow Francois and Rojas-Romagosa (2011) here, adopting a Sen-type social welfare function based on the Gini coefficient (Sen, 1974, 1976).[7] In formal terms, households have identical homothetic preferences in defining a composite consumption good *C*, and social welfare SW_r can be split into the mean level of real consumption, and its distribution across households.

$$SW_r = \mu_r(1 - I_r) \qquad (1)$$

where μ_r is an indicator of mean income and I_r is an inequality indicator in country (or region) r. For our numerical simulations we take μ to be a measure of per capita welfare (equivalent variation) and I is the Gini coefficient. In this way we can

[7] Starting from households with constant relative risk aversion (CRRA) preferences, and a homothetic composite consumption good *C*, we arrive through aggregation of household welfare at the Atkinson inequality index as an alternative basis for equation (1). The Gini coefficient means we explicitly define social welfare as rank sensitive (cf. Francois and Rojas-Romagosa, 2011).

compare our non-inequality adjusted welfare results with Sen-type social welfare measures.

c. *Estimating inequality changes for the USA*

The standard approach to evaluating the quantitative impact of trade policy on inequality and poverty is to use a top-down approach (cf. Bourguignon and Bussolo, 2013). At the top level, the macroeconomic changes associated with trade policy are estimated using a quantitative trade model and these macroeconomic changes (mainly the changes in factors and goods prices) are translated into microeconomic effects on households or other disaggregated income groups.

To link the macroeconomic effects simulated by our quantitative general equilibrium model (discussed in the next section) into inequality effects, one needs to have information on the ownership matrix (the shares of total factors owned by each income group), the consumption basket and the income values for each disaggregated income group. The (micro level) disaggregated total income data provide the information required to estimate an inequality indicator, such as the widely used Gini coefficient. The ownership matrix, on the other hand, provides the basic information required to translate changes in factor prices (derived from trade policy shocks) into household income changes. Finally, the household consumption basket is used to map the price changes in final goods to estimates of the changes in household expenditure, which is required to adjust real income. Combining of these three measures provides the main elements needed to perform a top-down analysis. With further assumptions, this allows to estimate the impact of tariff changes on inequality through changes in the Gini coefficient. Ideally, these three measures are taken from household census and/or surveys that provide detailed data on income sources (by factor type and other non-factor income), total income values and consumption baskets.

As we abstract from heterogenous agents here, and as our goal is not one of precise estimation of poverty effects (a key focus in the top-down literature), we develop a more parsimonious approach here. In particular, given identical homothetic technology across households for a composite consumption good, equation (1), combined with information on the income values and income sources of income groups aggregated into in household quintiles, means we are able to proceed from estimation of changes in the Gini coefficient to changes in social welfare based on equation (1). Beyond the standard data burden in computational trade models, this more parsimonious approach only requires information on the ownership matrix.[8]

To estimate the ownership matrix for the US we combine different data sources. First, to estimate the labour income shares in the ownership matrix, we use the share of total households (aggregated by quintiles) in different occupations. This information for 2014 is taken from the US Census Bureau (2015). We aggregate occupations by the five labour groups present in the GTAP database: L1 (officials, managers and professionals), L2 (technicians), L3 (clerks), L4 (service and shop workers) and L5 (agricultural and unskilled workers). We assume that each household has one full time equivalent or representative worker, and thus the share of workers in each occupation by quintile provides the labour income share by occupation of that quintile. This provides the labour ownership shares of the total ownership matrix.

Second, to complete the information needed on the ownership matrix, we then need to estimate the capital shares by income quintile group. This is done in three steps. First, we combine the labour income shares (obtained above) with the total labour income by occupation from the GTAP10 database (base year 2014). This gives us the total income values by labour type (occupation) for each quintile group. Second, we use the total quintile net and gross income values (which include factor and non-factor income sources) from the Congressional Budget Office (2014). In the third and last step, we estimate the total capital income as the allocation needed to reconcile the difference between labour income and total gross income by quintile group. These data yield the capital ownership share by quintile group.[9] Finally, the difference between gross and net quintile income is net government transfers (gross transfers received minus income taxes paid). The labour and capital income shares, plus the net transfers by quintile income group, provides the data for the ownership matrix of the US.

Combining the information on the US ownership matrix and the total income by quintile group we can then conduct our parsimonious top-down analysis. For each simulation of the quantitative trade model we obtain the changes in real

[8] Although a more precise estimation of the inequality effects is clearly preferable if we were providing policy advice, we do not expect our main qualitative results to change.

[9] For low income quintiles the calculations yielded negative capital income, so we had to make some slight adjustments to the labour shares to rebalance the matrix.

factor prices, which using the ownership matrix are translated into changes in the total income of each quintile group. Furthermore, employing the initial total income data we can then estimate the changes in the underlying income distribution (by quintile) and the variations on the US Gini coefficient. The US Gini coefficient is then estimated using the net income values by quintile.[10] While there are clearly potential shortcomings one can raise about this approach, depending on the question at hand, compared to the more data intensive top down exercises discussed above, the present approach does provide detailed information on the inequality impact of income changes for six production factors (five labour types and capital) on five different income groups. This yields more information than the traditional use of a single representative household with one or two labour types.[11] It also allows us to perform an inequality analysis that is not feasible when using a single household.[12]

[10] Alternatively, we could estimate the Atkinson inequality index, which can also be mapped to a Sen-type social welfare function (see Francois and Rojas-Romagosa, 2011). At the same time, for an actual policy advice setting, we would want to work with far more detailed household ownership data.
[11] For instance, the so-called new quantitative trade models (NQTM) employ a single factor (labour) and a single household (see for example, Ossa, 2014). Computational general equilibrium models, on the other hand, also use a representative household but have more factors. Even though they usually aggregate labour types into two categories (low and high skill).
[12] In what follows, we focus on the US. For the RoW, we assume when analysing Sen-type social welfare objective functions a fixed Gini coefficient of 0.5 for RoW. Lakner and Milanovic (2016) find that the global Gini coefficient in 2008 was 0.71. However, using any fixed Gini value for RoW will not affect our results since we do not estimate how that Gini is changing with the trade war tariff increases.

3. Our Basic Numerical Model

In this section we first describe the theoretical structure and calibration of our quantitative model. We then explain how we run our numerical simulations to obtain single-country optimal tariffs and the different non-cooperative Nash equilibria when using alternative policy objective functions.

a. Theoretical structure of the model

We employ a general equilibrium model in the spirit of the new quantitative trade (NQT) literature (Costinot and Rodriguez-Clare, 2013; Caron, Fally and Markusen, 2014; Caliendo and Parro, 2015) with all parameters of the model not determined by functional forms being structurally estimated. Therefore, we call the model a structurally estimated general equilibrium (SEGE) model. A representative agent maximises Cobb-Douglas utility over public and private consumption in different sectors.[13] Within each sector the representative agent chooses between goods from different countries. Trade is modelled according to the model of comparative advantage by Eaton and Kortum (2002) with productivity in each country drawn from a Frechet distribution. Production takes place with intermediates and factor inputs, consisting of capital and five labour types.[14] In line with much of the literature the choice between intermediates and value added is governed by a Leontief production function, whereas the choice between intermediates from different sectors is Cobb-Douglas. The choice between production factors is also Cobb-Douglas. Labour and capital are perfectly mobile across sectors. The total supply of production factors is fixed. Following the theoretical literature, and to allow us to focus explicitly on trade policy in isolation from macroeconomic questions (such as modelling changes in net foreign savings positions), our underlying data are adjusted to set the trade balance at zero in the benchmark and also in our policy experiments.[15]

With this setup our model is very similar to Caliendo and Parro (2015) with

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[13] We distinguish between public and private consumption to account for the fact that import shares in the data are different for the two types of goods. In the model the representative agent also spends a fixed share of her income on savings. Given that the trade balance ratio is fixed, savings will be equal to investment. In determining optimal tariffs, we focus on welfare from total consumption.

[14] Capital also includes the land and natural resource factors.

[15] In our view, there are important questions about strategic interactions between macroeconomic policy and trade policy. These are however well beyond the scope of the present paper.

three minor differences. First, in line with observed data in input-output tables the expenditure shares on domestic and imported goods vary by agent. In concrete, they vary across public consumption, private consumption, investment, and intermediate demand. Second, again following observed data in input-output tables the model features a host of domestic taxes such as income taxes and endowment taxes. Third, our model contains five labour types and capital instead of two labour types.

b. Calibration and parameter estimation: structural gravity

Following the approach in both the CGE-literature and the NQT-literature, we calibrate the baseline of our model to actual data from 2014 using the GTAP database version 10.[16] Given our parsimonious SEGE-model, the only behavioural parameters we need to estimate are the trade elasticities. We estimate these elasticities structurally, based on a gravity equation following from the theoretical model and estimated with the same data as used in the simulations, the GTAP database version 10.[17] As is well-known from the literature, the Eaton-Kortum model implies the following gravity equation:

$$v_{ijk} = \left(\frac{(1+t_{ijk})\tau_{ijk}c_{ik}}{P_{jk}}\right)^{-\theta_k} = exp\{-\theta_k \ln(1+t_{ijk}) + \beta' x_{ijk} + \mu_{ik} + \lambda_{jk} + \varepsilon_{ijk}\} \qquad (1)$$

With v_{ijk} the value of trade from i to j in sector k, t_{ijk} the ad valorem tariff rate, τ_{ijk} iceberg trade costs, c_{ik} the costs of input bundles in exporting country i, P_{jk} the price elasticity in importer i, θ_k the sector-specific dispersion parameter of the Frechet distribution, x_{ijk} a vector of bilateral observables to proxy for iceberg trade costs, μ_{ik} and λ_{jk} exporter and importer fixed effects, and ε_{ijk} an error term.

One of the variables proxying for iceberg trade costs is the presence of preferential trade agreements (PTAs). We use a two-stage estimation methodology to account for the endogeneity of PTAs. In the first stage we follow the same

[16] As discussed in Bekkers (2019) baseline calibration in these two strands of literature is different from baseline calibration in the structural gravity literature in which baseline trade shares are equal to the predicted shares from the estimated gravity equations.
[17] The GTAP version 10 database is currently only available for consortium members of the Global Trade Analysis Project. For documentation on the previous version of the dataset see Aguiar et al. (2016). In the gravity estimation we work with a highly disaggregated 138 country database, whereas in the simulations we then collapse the model to 2 regions, the US and Rest of World (RoW).

procedure as in Egger et al. (2015) and Egger and Francois (2019). In particular, we estimate probit regressions to obtain the control-function on generalized Mills' ratios (cf. Egger et al., 2011). The probit regressions are ordered by PTA depth based on the DESTA database (Dür et al., 2014). Thus, we estimate a separate probit equation for three levels of depth of PTAs (shallow, medium and deep) for trade in goods data and one separate probit equation for trade in services flows.[18]

The second-stage is estimated using logit regressions with the value of trade in share terms (normalized by total expenditures in the importing country). We use the logit estimator with structural zeros from Papke and Wooldridge (1996).[19] We have estimated the gravity equation separately for each sector, thus obtaining sector-specific estimates of the trade elasticity. As bilateral regressors we include the Mills' ratios obtained from the first stage, and a number of control variables: the ones also used in the first stage, in addition to a rules-of-origin index and PTA depth.

Table 1 summarizes the results of our second-stage gravity regressions and presents the sector-specific trade elasticities. In the Eaton-Kortum model the trade elasticity is inversely related to the dispersion of the productivity distribution and thus to the strength of comparative advantage. In sectors with large trade elasticities – e.g. electronics, motor vehicles, machinery, non-ferrous metals and energy– the strength of comparative advantage is relatively weak and reductions in trade costs thus have a stronger impact on trade than in sectors with relatively low trade elasticities: primary agriculture and most services sectors.

---Insert Table 1 About Here---

[18] For a detailed description of this first stage see the Appendix in Egger et al. (2015).
[19] See also Baum (2008).

c. Numerical experiment design and grid search

The estimation of optimal tariffs and non-cooperative Nash equilibria, for a full set of tariff combinations, requires large numerical computations for even small dimensional models. With *S* sector-specific tariffs, *T* possible tariff levels and N countries, we would need ST^N simulations, which can results in an unfeasible number of simulations if we have more than 2 countries or *S>1* sector-specific tariffs.[20] This dimensionality issue has been one of the main limitations in the literature to tackle optimal tariff estimations. In our analysis here, we constrain dimensionality in our numerical examples by assuming single tariffs imposed across goods by each of 2 regions against the other (the US against the RoW, and the RoW against the US).[21]

There are several methods (grid searches) that can be used to find the Nash equilibrium. The most common method is to use a convergence grid search that starts with current (factual) tariffs, computes the optimal tariff for the first country, then imposes this tariff on the second country to compute the optimal tariff for the second country, and so forth, until a convergence criterion is satisfied --i.e. no country can increase its objective function value with another tariff change. This method does not require information on the full tariff space, and thus greatly saves computational requirements and time. As such, it is the common method employed in the literature (Perroni and Whalley, 2000, Ossa 2011, Ossa 2014, Bouët and Laborde, 2018).

The equilibrium identification method outlined above has the limitation that the Nash tariffs found can be conditional on the starting point and thus, one cannot rule out the existence of multiple equilibria.[22] For instance, the inclusion of more complex modelling features (e.g. imperfect competition, economies of scales, capital accumulation) and/or the optimization of more complex objective functions

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[20] For instance, three countries, 20 sectors and 20 tariff levels requires 64 million simulations, unless very strong assumptions are made to isolate individual sectors.

[21] For example, we have also been working work a 74-region version of the same model, and could go to 138 regions with the model. For the purposes of this paper, however, where we want to compare different Nash equilibria when using alternative objective functions to be optimised, we have opted for a simplified two-region representative model that lets us clearly illustrates differences in policy objective functions. In a complementary paper (Bekkers et al, 2019), we do systematically analyse how different model and methodological characteristics of the quantitative analysis --e.g. dimensions, underlying theoretical model, production and demand technologies, and parameter values-- affects the precise values of the Nash equilibria.

[22] Ossa (2014) claims that using different starting tariff values does not affect his results, but it is not stated how far away these starting points are from the initial tariff levels.

(as we do in this paper) creates the possibility of generating not well-behaved reaction curves and thus increases the probabilities of having multiple equilibria.

In this paper, we introduce a more comprehensive tariff-space grid search. Our numerical experiments involve three steps. In the first step, using our SEGE model, we simulate the economic impact of different tariff combinations to obtain a discrete three-dimensional space: own tariffs, partner tariffs and own welfare changes (or more precisely, changes in the objective function that is optimised).[23] To further constrain our search grid and the required computational burden, we initially run 17 tariff levels (ranging from 0 to 80 percent in intervals of 5 percentage points). This implies running one model simulation for each tariff level pair, for a total of 289 general equilibrium simulations. This creates a discrete tariff-welfare three dimensional space for the US trade policy (US welfare, US tariffs and RoW tariffs), while we simultaneously obtain the tariff-welfare space for the RoW. In addition, each simulation of the quantitative general equilibrium model also provides other economic effects, besides welfare, that are used to evaluate other objective functions. In particular, the changes in real factor prices are used to estimate changes in inequality measured by the Gini coefficient and the changes in capital rents that are used in the political support function with capital lobbying. An advantage of this approach is that we can run our grid search once, and examine alternative specifications of the policy objective function, without needing to re-run the grid search for each objective function specification.

In the second step, we use fractional polynomial regressions to estimate a continuous welfare-tariff space for alternative policy objective functions.[24] This procedure creates a full tariff-welfare mapping for tariffs below 80 percent.[25] Using the information on the welfare changes --and other economic variables required for more complex objective functions-- from this numerical procedure, we can then plot the reaction curves for each region. These reaction curves --or best-tariff policy strategies-- represent the own-tariff level that can achieve the highest

[23] In the explanation of our numerical procedure we will refer to welfare as the objective function being optimised. However, we employ several objective functions in our analysis, but the numerical procedure is equivalent for all cases.

[24] In other words, we fill in the gaps between our discrete 5-percentage point tariffs gaps using tariff values with three decimal points. This procedure allows us to plot continuous reaction curves for each region.

[25] In our simulations, the Nash tariffs are well within this tariff space, However, as discussed below, the use of more extreme assumptions regarding the objective function to be optimised may require the expansion of this tariff space.

welfare levels for that country, conditional on the tariff level of its trading partner and the assumed policy objective function. In our third and final step, we obtain the non-cooperative Nash equilibria based on the best-tariff curves that we previously estimated. As such, the intersection of both reaction curves provides the non-cooperate Nash equilibrium, where no region can increase its welfare (or the value of another objective function) by changing its Nash tariff level. Note, that this comprehensive procedure, either as described in the text or in the footnote below, is more exhaustive than the convergence procedure commonly used in the literature. The procedure commonly used in the literature finds the optimal tariff response for country A for a single (initial or optimal response) tariff in country B, while the comprehensive procedure identifies the effects for all discrete tariff levels. Our approach allows us to map the reaction curves of both countries.[26] The current numerical literature does not identify reaction curves in a broadly large tariff space. This allows us to find the Nash equilibria from any starting or assumed initial tariff level.

Once we obtain the reaction curves, we can solve a one-off non-cooperative game, where each player (i.e. country in the trade war) chooses his Nash tariff based on the reaction curves, which are obtained by fully informed policy makers. Using this tariff-space information from our grid search, we estimate the values of the objective function relative to the initial free trade baseline. The implicit assumption is that both countries are fully informed rational players that know the welfare implications for itself and the other player. Or alternatively, the implications for other objective functions, which include inequality concerns or lobbying for protection. Thus, both countries can solve the entire game (e.g. the system of reaction functions) simultaneously and then play (set the tariffs) at the Nash equilibrium.

[26] Another method to perform the grid search is to use a sequential estimation of the changes in the objective function for a country A, by keeping fixed the tariff level of the partner country B. Hence, we then compare the new objective function value of country A for a full set of tariffs, with respect to the initial value of the objective function when country B has imposed a tariff. In other words, by estimating the welfare changes in country A associated with all (or a large set) of possible own tariffs, conditional on a particular tariff level of country B, we can obtain the optimal tariff response of country A. Proceeding in this sequential grid search we then obtain the optimal reaction curves for each country. This sequential procedure provides the same information as the comprehensive grid search we use on this paper (indeed it should, as it an alternative implementation of the same strategy), since it gives the full welfare-tariff space information.

4. Simulation Results

a. Rational outcomes with alternative political objectives

Having mapped out our specification of social welfare inclusive of inequality, our basic numerical model, and our grid search, we now turn to actual trade war simulations. We assume alternative underlying policy objective functions. Given our numerical approach as outlined in Section 3, we are able to examine these alternative assumptions about underlying objectives in reaction curve space. Figure 1 shows the optimal tariff reaction curves for both regions. The intersection of these curves defines the non-cooperative Nash equilibria.

Each panel in Figure 1 represents the reaction curves when the USA is optimizing its tariff levels to maximise a particular objective function. We work with three objective functions: (i) average economic welfare (with a single representative consumer); (ii) Sen-type social welfare (including both average welfare and equity considerations); and finally (iii) a political support function that weighs social welfare and capital income --with social welfare being either type (i) or type (ii). We work with a range of weights in this last case based on Francois and Nelson (2014). Under case (i) and (ii), we focus on shifts in the US reaction curves, thus for the RoW region implicitly assuming either type (i) preferences or redistribution such that inequality remains unchanged if type (ii) preferences in RoW would hold.

--- Include Figure 1 About Here ---

Figure 1 highlights the importance of the underlying political objective function when estimating the tariffs that result from a trade war or an otherwise from non-cooperative tariff setting. A common feature of the different Nash equilibria depicted is that the reaction curves are in positive tariff space for the case when the partner has zero tariffs. This illustrates the typical terms-of-trade gains that a country obtains when it unilaterally increases tariffs and there is no retaliation by the partner. As the partner retaliates, tariffs increase and the new equilibrium (when starting from a free trade point) displays larger tariffs than in the unilateral (first mover) case. This reflects an iterative result from the tit-for-tat tariff literature. Another result illustrated by Figure 1 is that the reaction curve of the RoW is relatively insensitive to changes in US tariffs. On the other hand, the US reaction curve is more sensitive to changes in RoW tariffs. This reflects the differences in regional economic sizes, with the aggregate RoW is about four times larger than the US, and thus less affected by USA tariff changes than in the reverse situation. We note that Dixit (1987) also considers another Nash equilibrium, in which initial tariffs are so high that there is no trade and this autarky equilibrium cannot be broken, or alternatively where autarky may be an appropriate response. We examine this in the next section, in the context of extreme retaliation.

The upper-left panel in Figure 1 represents a policy objective function which is standard in the current literature. The policy maker cares only about mean real income (or average welfare), and it is implicitly assumed that there is redistribution of income to maintain the initial inequality levels constant, or that inequality is not relevant to social welfare. In this case, we observe that the non-cooperative Nash tariff for the USA is around 16 percent and 14 percent for the RoW. The precise Nash tariffs are shown in Table 2.

--- Include Table 2 About Here---

When we move away from implicit redistribution and assume that the US political objective function is type (ii), so the policy maker cares about how inequality is affected by trade policy, we find that the Nash tariff for the USA is significantly reduced (by around half) to a tariff level of 10 percent in the figure. This result is driven by an increase in inequality (measured by the Gini coefficient) the further the US moves from the free trade baseline. Figure 2 shows the estimated Gini coefficient after each simulation in our grid search for a given US tariff. It shows that inequality is always increasing and that higher tariff levels result in higher inequality with lower inequality but more variation at lower tariff levels. Under these conditions, a policy maker who cares about inequality should have lower tariffs than otherwise. The US inequality results are based on the underlying changes in factor prices. In Figure 4 in the Appendix, we present the percentage changes in real factor prices. There we observe that in general all factor prices are reduced with the tariff increases, but low-skill workers (L4 and L5) are hit harder than medium (L3) and high-skill workers (L1 and L2). Moreover, capital rents are decreasing the least, but the negative shock is reduced when tariff changes become larger. With some US-RoW tariff combinations, capital rents are even increasing. Thus, the increase in US inequality with increased trade protection is driven mainly by the negative effects on low skill workers (L5, in particular) and the relatively positive (less negative) effects on capital rents.[27] [28]

--- Include Figure 2 About Here ---

In the case of a type (iii) objective function, where the policy maker optimises a political support function, policy weight is attached to capital income while the policy maker also cares about either average welfare or inequality-scaled social welfare. Here we use three different political weights for capital income: 0.25, 0.33 and 0.50, so that the maximization exercise is to optimize the political Ω. Following Francois and Nelson (2014): $\Omega = a \cdot SW + (1 - a)r$, where r is real capital income and a are the political weights for capital income. In the left column in Figure 1 we observe an upward shift in the US reaction curve, thus increasing the Nash tariff for the US, for a given RoW reaction curve. In other words, the US Nash tariff is increasing as the political weight on capital rents is rising. With the highest political weights on capital income, the Nash tariffs are more than double compared to objective function (i). (again, see Table 2). These results are driven by a relative (if not absolute) increase in capital rents as the tariff rises (see upper left panel in Figure 1). Since tariff protection benefits capital income in relative terms, the resulting tariff change is larger the larger the political weights that capital income has.[29]

In Figure 1 we have held the RoW reaction curve fixed. This allows us to focus on the shift in the numerically estimated US reaction curve under types (i),

[27] Notwithstanding intuition grounded in low dimensionality homogenous good models --in particular the HOS model and the Stolper-Samuelson theorem-- with heterogenous goods and intermediate linkages, and indeed in much of the related large-scale modelling literature incorporating such features, increased trade costs can and usually reduces all real factor incomes even as relative factor incomes diverge. See Francois and Nelson (1998) for further discussion and numeric examples. While we do not consider this here, one can also imaging a case where policy makers have intuition (rules of thumb) on tariff-income mappings guided by simple blackboard-based endowment models of trade that do not reflect actual mappings. In such a case, well intentioned notional outcomes might distort our reaction curves

[28] As explained above, we do not model heterogenous household expenditures, let alone heterogenous preferences. Even with identical but non-homothetic preferences, we could expect that inequality effects should be higher than what we have estimated here, as lower-income household spend relatively more income on actual consumption than richer households, resulting in even lower Nash tariffs.

[29] The reason seems to be that the manufacturing and agricultural sectors, in which tariffs can be imposed, are relatively more capital intensive.

(ii), and (iii) political objective functions. For this reason, Nash tariffs do not change much, not because the US curve does not shift, but because the RoW has a relatively flat reaction curve as noted above. In Figure 3 (in the appendix), we step away from the analysis of the shifting US reaction curve, and provide a mapping of estimates where we vary both the US and RoW political objective functions across types (i)-(iii). Here we find that RoW capital rents are negatively related to tariff increases, such that the optimal tariff schedule with the type (iii) objective function shifts to the left. The examples in Figure 3 further illustrate how sensitive the estimated Nash equilibrium is to the particular objective function being optimised by the policy maker. For instance, if both regions maximise a political support objective where capital rents have a 0.5 weight, Nash tariffs will be 13 percent for US and zero for RoW. However, if only US cares about capital lobbying, then the Nash tariffs will be 17 and 34 percent, respectively.[30]

Table 3 presents the macroeconomic results from our model under each of the Nash equilibria in Figure 1. In all cases both regions lose in the model with a trade war. Given the relative differences in the size of the US compared to the RoW (around four times smaller), the negative impact of the trade war is larger for the US. When the policy maker only cares about average welfare, welfare falls by around 0.7 percent and exports decrease by around two-thirds.[31] These loses are increased when capital rents receive extra weight. In the type (iii) case where a =0.5, we have a one percent welfare loss, with exports decreasing by three-quarters. The Gini coefficient is also increasing in all cases, with the extra weight on capital income increasing inequality even more.

---Include Table 3 About Here---

In the type (ii) case the overall welfare loses for the US and the effects on exports are dampened. As expected, the Gini coefficient is less affected when the policy maker includes equity considerations in the optimization process. Again, extra weighting of capital income increases the loss, but at a lower magnitude

[30] Compare Table 2 and Table 5. In the case when RoW optimises Sen-type social welfare the results do not vary much because, lacking data, we are assuming that RoW inequality is fixed

[31] We should stress that our model here is essentially static with competitive markets. While we focus on inequality and the specification of the objective function, we have abstracted from other model features common in the literature. For example, models with imperfectly competitive markets and/or comparative steady-state effects imply much larger welfare and real income effects.

than when the policy maker does not care about inequality. In this sense, the competing objectives of keeping inequality from rising and benefiting capital rents offset each other somewhat, and both the tariffs and the macroeconomic results are less than in the previous case. One pattern we see in the results across the various examples, is that in cases in which policy makers care about distribution of income and not just its level, the inefficiencies of the non-cooperative prisoner's dilemma are reduced.

b. The limits of rationality and stupid trade disputes

Essentially by definition, the recent game theoretic approach to trade wars assumes we start with rational political agents. What we mean here is that when we assume a "rational trade war," the objective function of the government with respect to trade derives from economic objectives that map to the material self-interest of individuals that make up the national political-economy represented by that government. When we depart from this assumed rationality, we enter the realm of what we call stupid trade disputes (STDs). With respect to the rationality baseline, we can think of two different versions of STDs. The weak version treats any deviation from such objective functions as "weakly stupid". Thus if a government whose objective function takes into account non-economic objectives, as in Johnson (1965), in its prosecution of a trade war is involved in a weak STD. As Johnson's analysis suggests, there is nothing irrational about such a policy, it just isn't consistent with the theory of rational trade wars. Similarly, if the US were committed to a system transformation of the liberal international economic system because it believes a power-based system better reflects its broader political interests, it would be acting rationally on non-economic grounds. This case will be again weakly stupid relative to the theory of rational trade wars.

Weak stupidity does not imply irrationality, but there is no place for it in the current theory of rational trade wars. Indeed, such interests are orthogonal to the definition of interests in terms of the optimal tariff logic. Ex post, we might tell a story about power instead of economic interest, but we will be telling a different story. Furthermore, suppose we assume that the other major trading nations are rational in precisely the way assumed by interactive trade theory, and that this theory in its repeated game version accounts for the deviation from Nash optimal tariffs. Even then that theory provides no guidance as to how those other countries should deal with a power obsessed (e.g. Trump) administration. However, as long as all players in the trade policy game are rational (including weakly stupid), the expertise of policy economists remains valuable, both to understanding what is driving policy and what would constitute a sensible response to anti-systemic, but only weakly stupid, policy.

Strong stupidity is more problematic. Suppose, instead of the weak stupidity that permits rationality with a non-economic objective function, that the Trump administration literally has no consistent objective with respect to trade policy.[32] This is certainly a view held by many with respect to the Trump administration trade policy. While there is no shortage of attempts to rationalize that policy (there are as many of these rationalizations as there are people proposing them), the fount of that policy itself periodically changes justifications for the policy. Basically, we define "strongly stupid" to denote the lack of a coherent objective function, of any kind. This may be the best ex ante plausible account of current US trade policy. From the perspective of interactive trade theory, or virtually any other coherent framework, this is literal irrationality.[33]

What does interactive trade theory tell us about the appropriate response of a deviator from the cooperative solution supported by repetition, or indeed about how we should respond to a player who exhibits strongly stupid behaviour? Trigger strategy-based theories make a simple recommendation (or "prediction" if we take these theories as predictive) with deviation by a player who remains otherwise rational. This involves some form of collective punishment, which might include autarky (a full trade embargo outcome).

To provide insight on possible outcomes with a sustained US detour into strong stupidity, in Table 4 we present numerical results when the USA unilaterally increases tariffs by 25 percent. Conditional on the response by the RoW, we have four scenarios: no retaliation, retaliation by the RoW also increasing tariffs against

[32] The case of the current UK "government" on trade policy is similar. As far as one can tell from news reports, the Conservative government is characterized by multiple objectives, associated with multiple individuals/groups within the party. Some of these may be rational in the required sense, some might be weakly stupid, and others might be strongly stupid. On any given day, reports suggest that one or another of these factions might be dominant. The main point is that there is no coherent objective in response to which the EU can construct its own policy. The Trump case is starker, as it is associated with a single individual, so we will stick with that as our leading example.

[33] Note that the Kreps, Milgrom, Roberts and Wilson (1982) model of cooperation in a finitely repeated prisoners' dilemma is also based on an example of strong stupidity as we are using it here. Thus, it is clearly possible that strongly stupid players, if they are of the "right" sort, can produce collectively better outcomes than play by fully rational players. It should be clear, however, that from the perspective of the system as a whole a Trumpian strongly stupid player is not functional in that way.

the US to 25 percent (a tit-for-tat outcome), an optimal retaliation (based on the reaction curves of the RoW when optimises type (i) welfare), and finally the "trigger-strategy" case in which there is extreme retaliation by RoW with a trade embargo.[34] This last case might be justified if there is belief, for example, that this will eventually force a return to rational policy by the US.

--- Include Table 4 About Here-----

As shown in Table 4, we find that under a type (i) objective function, the optimal retaliation for the Row, when the US increases its tariffs to 25 percent, is to increase tariffs to 15.4 percent. In all the scenarios, the RoW loses in terms of our welfare measure, while the US losses are maximised in the last scenario, with the most punitive response reducing US welfare by 4.56 percent. On the other hand, the USA only gains when there is no retaliation, and the losses are always larger than in the non-cooperative, but non-stupid Nash equilibria (compare Table 4 with Table 3).

[34] To model this last case, we assume that there is no trade and then endogenously determine the tariff levels that achieve this outcome. The resulting tariff level is extremely high with tariffs usually above one thousand percent.

5. Conclusions and discussion

There is a fundamental divorce between modern (prior to 1990) and contemporaneous trade (post 1990) theory regarding basic social welfare questions as they relate to household heterogeneity and income distribution. Contemporaneous numerical (CGE and NQT) analyses (essentially all of the recent literature) on ongoing US trade disputes has implicitly assumed that income is seamlessly redistributed after a trade policy shock such that we have no inequality changes. Thus, while numerically analysing a non-cooperative Nash equilibrium, it is taken as a given that the policy maker concerns himself only with optimizing average real income (or welfare) while setting the tariff. The current popular backlash against globalization, which directly or indirectly includes trade, can be partially explained by a concern about the unequal benefits and the distributional impacts resulting from fundamental changes in the pattern of production and trade. This is not the same as saying that protection will always reduce inequality, or increased trade will drive it up, once we include intermediate goods and limited substitutability in the mix. Indeed this point is made in our discussion of the numerical results offered here. Regardless of the direction of the effects is specific cases, though, the general question is an important one (and may lend insight into observed deviations from estimated optimal tariffs that ignore such questions).

In this context, we consider it important to include income inequality changes when asking ourselves what the appropriate objective function is for the policy maker to optimise during a trade war. Employing a Sen-type social welfare function, with household factor-ownership heterogeneity, we find that the numerical Nash equilibrium is significantly different from an equilibrium where inequality concerns are absent. Moreover, when we also use a political support objective function where capital income receives an additional weight (from lobbying for example), we find further divergence from estimated Nash tariffs based on pure welfare maximization for a representative agent. These results highlight the importance of determining what matters when the question we pose above about specifying an appropriate representation of the policy maker's objectives when estimating Nash tariffs.

There are more flies in the analytical ointment, beyond inequality, when addressing the specification of policy drivers. One is the assumption that the policy maker is rational, in the sense of aiming to maximize an economic objective.[35] When the policy maker has no consistent economic objective with respect to trade policy, which is arguably the case with the Trump administration (and the current British government regarding Brexit), then the message to be derived from optimal tariff analysis is an empty one. Specifically, without a clear objective function we cannot identify an optimum. We refer to such cases as stupid trade disputes (STDs). As an example, we employ the model develop here to examine the best rest of world (a notional collective WTO Membership) response in a case of irrational policy decision by the US in the form a US 25 percent tariff. In our numerical results, the worst economic response by RoW is to embark on a tit-for-tat trade dispute, while by definition, its best response is to apply its optimal tariff. The US can only gain when the RoW does not retaliate at all. In the extreme retaliation case, where both regions cease trading (i.e. the trigger strategy), the US suffers a 4.5 percent drop in in welfare, the RoW loses are lower, but still significant at 1.8 percent.[36]

[35] We could rationalize the optimization of a non-economic objective, such as a trade embargo based on geo-political reasons.

[36] Another problem goes back to the initial concerns of modern trade theory regarding heterogenous household preferences and their effect on aggregate demand. While we do not address this here (and neither does the rest of the literature, to offer a lame defense for what we do not examine here), solving for an optimal tariff with heterogeneous household preferences is essentially impossible.

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Figures and Tables

Table 1 Second-stage logit regressions results for each individual sector

sector	trade elasticity		pseudo-R2
Primary agriculture	-2.345	*	0.9639
Energy	-13.397	**	0.9097
Processed Food	-6.451	***	0.9518
Beverages and tobacco	-3.046	***	0.9291
Textiles	-7.396	***	0.9121
Clothing	-10.01	***	0.9041
Footwear, leather	-6.239	***	0.8771
Petrochemicals	-9.953	***	0.833
Chemicals, rubber, plastics	-11.955	***	0.8977
Iron and steel	-4.468	*	0.8706
Nonferrous metals	-22.687	***	0.7604
Metals	-6.837	***	0.9381
Motor vehicles	-10.189	***	0.8719
Other transport equipment	-7.154	*	0.7683
Wood, paper	-11.434	***	0.951
Electronic equipment	-20.322	***	0.8682
Other machinery	-12.714	***	0.902
Other goods	-10.29	*	0.9565
Construction	-1.892	*	0.9973
Transport	-1.766	***	0.9853
Trade and distribution			0.995
Other commercial services	-1.536	***	0.9879
Personal and recreational services	-5.804	***	0.9904
Other services	-4.689	***	0.9985

Notes: Dependent variable: bilateral trade flows for 2014, including own-trade (domestic absorption). The trade elasticity is the negative of the estimated coefficient for the tariff margin variable, except in services where it is the estimated elasticity for the NTM index as discussed in the text. Logit regressions include country fixed effects and several control variables. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Sources: GTAP version 10 database. Observations are 19,044 in all sector regressions.

Figure 1 Reaction curves and non-cooperative Nash equilibria, RoW always optimises welfare (EV) while the USA optimises different objective functions

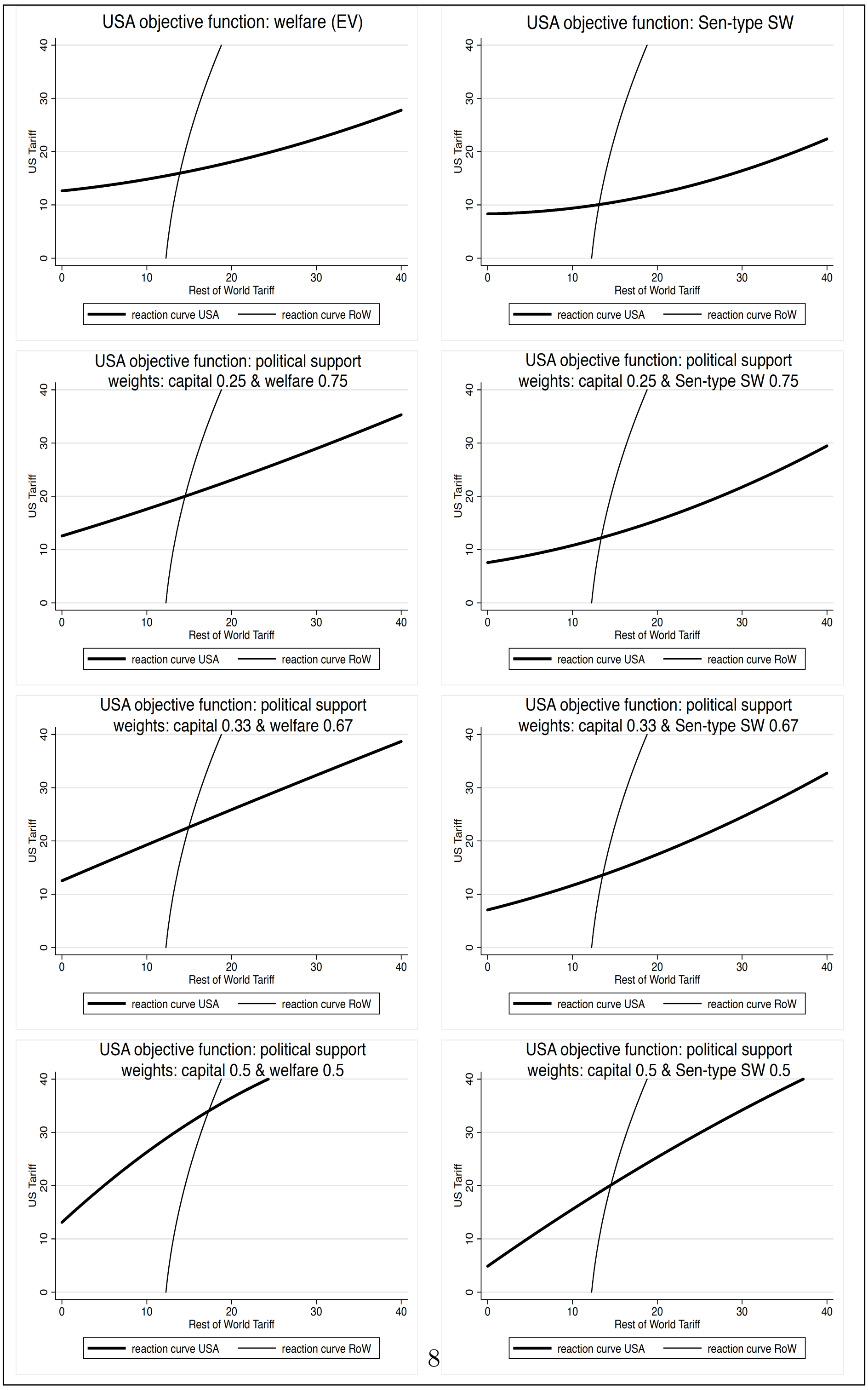
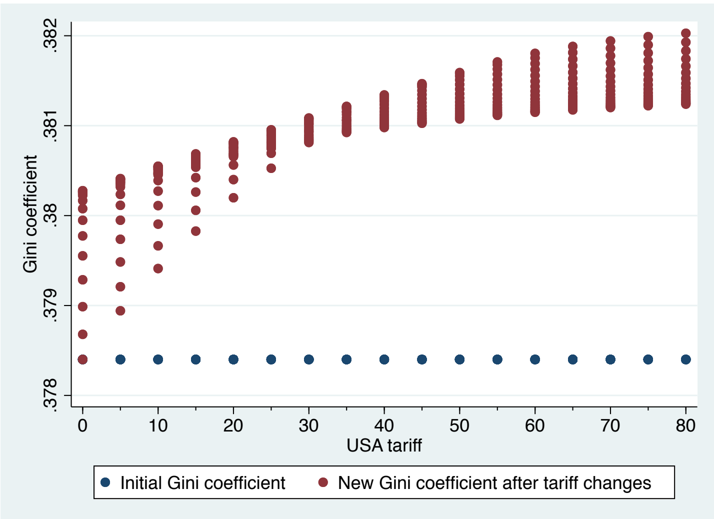


Table 2 Nash non-cooperative tariffs when the USA optimises different objective functions

Objetive function:	**USA**	**RoW**
Welfare (EV)	15.96	13.90
Sen-type social welfare	10.07	13.14
Political support function with welfare		
weights: capital 0.25 & welfare 0.75	20.01	14.52
weights: capital 0.33 & welfare 0.67	22.56	14.95
weights: capital 0.50 & welfare 0.50	34.03	17.31
Political support function with Sen-type (SW)		
weights: capital 0.25 & SW 0.75	12.22	13.40
weights: capital 0.33 & SW 0.67	13.60	13.57
weights: capital 0.50 & SW 0.50	20.10	14.53

Source: Own numerical simulations using GTAP-10 database. Notes: We assume that RoW only optimises welfare (EV). Welfare is the per capita utility (equivalent variation) from consumption. Sen-type social welfare and the political support function are defined in Equations 1 and 2, respectively.

Figure 2 Gini coefficient level by USA tariff at different RoW tariff levels



Source: Own numerical simulations using GTAP10 database and CBO and USCB data.

Table 3 Macroeconomic results for Nash non-cooperative trade war when USA optimises different objective functions, relative changes with respect to free trade baseline

Objective function:	welfare (EV)		Political support weights: 0.25 capital 0.75 welfare (EV)		Political support weights: 0.33 capital 0.67 welfare (EV)		Political support weights: 0.5 capital 0.5 welfare (EV)	
	USA	RoW	USA	RoW	USA	RoW	USA	RoW
Uniform tariff	15.96%	13.90%	20.01%	14.52%	22.56%	14.95%	34.03%	17.31%
Welfare (US$ million)	-105,439	-104,278	-111,724	-131,301	-116,927	-146,022	-146,354	-197,048
Welfare (% change)	-0.72%	-0.24%	-0.77%	-0.30%	-0.80%	-0.33%	-1.00%	-0.45%
Exports	-63.59%	-5.54%	-67.09%	-5.97%	-68.95%	-6.21%	-74.92%	-6.99%
Terms-of-trade	-0.95%	0.10%	-0.37%	0.04%	-0.07%	0.01%	0.77%	-0.08%
Gini coefficient	0.54%	--	0.60%	--	0.63%	--	0.74%	--
Objective function:	Sen-type SW		Political support weights: 0.25 capital 0.75 Sen-type SW		Political support weights: 0.33 capital 0.67 Sen-type SW		Political support weights: 0.5 capital 0.5 Sen-type SW	
	USA	RoW	USA	RoW	USA	RoW	USA	RoW
Uniform tariff	10.07%	13.14%	12.22%	13.40%	13.60%	13.57%	20.10%	14.53%
Welfare (US$ million)	-103,884	-55,432	-103,250	-74,685	-103,630	-86,199	-111,913	-131,777
Welfare (% change)	-0.71%	-0.13%	-0.71%	-0.17%	-0.71%	-0.20%	-0.77%	-0.30%
Exports	-56.92%	-4.75%	-59.61%	-5.07%	-61.17%	-5.25%	-67.16%	-5.98%
Terms-of-trade	-2.00%	0.22%	-1.59%	0.17%	-1.34%	0.14%	-0.36%	0.04%
Gini coefficient	0.43%	--	0.48%	--	0.50%	--	0.60%	--

Source: Own numerical simulations using GTAP-10 database. Notes: Rest of the World (RoW) optimises welfare (EV). Welfare is the per capita utility (equivalent variation) from consumption.

Table 4 Macroeconomic results for stupid trade disputes for different retaliation scenarios, percentage changes with respect to free trade baseline

Scenario:	No RoW retaliation		Retaliation RoW tit-for-tat		Optimal retaliation using welfare (EV)		Extreme retaliation (trade embargo)	
	USA	RoW	USA	RoW	USA	RoW	USA	RoW
Uniform tariff	25.0%	0.0%	25.0%	25.0%	25.0%	15.4%	inf	inf
Welfare (US$ million)	29,610	-191,054	-166,175	-164,512	-123,187	-158,972	-676,422	-826,576
Welfare relative change	0.20%	-0.43%	-1.14%	-0.37%	-0.85%	-0.36%	-4.56%	-1.87%
Exports	-55.41%	-5.84%	-74.83%	-6.46%	-70.58%	-6.41%	-100.00%	-6.35%
Terms-of-trade	5.33%	-0.55%	-1.88%	0.17%	0.15%	-0.02%	--	2.06%
Gini coefficient	0.56%	--	0.67%	--	0.66%	--	-0.26%	--

Source: Own numerical simulations using GTAP-10 database. Notes: Optimal retaliation based on optimization of welfare (EV) for RoW.

2. APPENDIX

Table 5 Nash non-cooperative tariffs when both regions optimise different objective functions

Objetive function:	**USA**	**RoW**
Welfare (EV)	15.96	13.90
Sen-type social welfare	10.10	13.26
Political support function with welfare		
weights: capital 0.25 & welfare 0.75	17.11	9.09
weights: capital 0.33 & welfare 0.67	16.84	6.37
weights: capital 0.50 & welfare 0.50	13.11	0.00
Political support function with Sen-type (SW)		
weights: capital 0.25 & SW 0.75	10.55	9.41
weights: capital 0.33 & SW 0.67	10.34	7.39
weights: capital 0.50 & SW 0.50	6.19	1.19

Source: Own numerical simulations using GTAP-10 database. Notes: Welfare is the per capita utility (equivalent variation) from consumption.

Figure 3 Reaction curves and non-cooperative Nash equilibria when each region optimises the same objective function

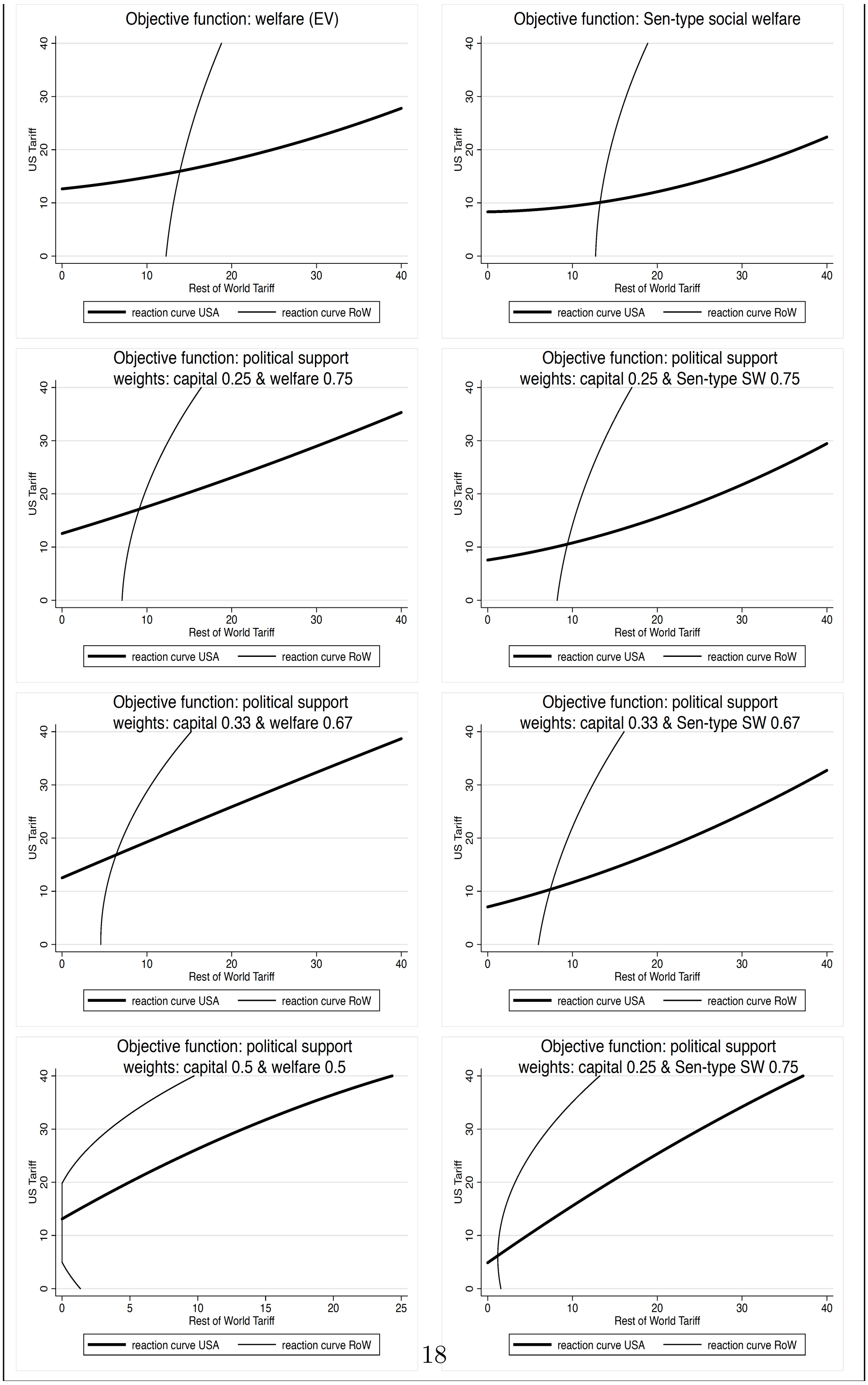


Figure 4 Real factor price changes by USA tariff at different RoW tariff levels, percentage changes with respect to free trade baseline