Cooperation vs. Exit: a Quantitative Exploration of Euroscepticism in Trade

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Abstract

Some European politicians --and voters-- have recently expressed strong concern regarding the trade-off between the benefits of EU cooperation and the costs of being constrained in their national policy choices. We provide a numerical exploration of these issues by imbedding various versions of a large-scale calibrated general equilibrium model of trade and production into different sets of Nash games in tariffs. We show, among other things: (a) that the result from the theoretical literature that ”big countries win trade wars” is clearly over-simplistic and highly misleading from a policy perspective; (b) that the link between trade elasticities, the size of the economy, and the welfare gains from tariffs is actually quite loose; (c) that the GATT/WTO most-favored-nation rule proves a poor cohesion mechanism for the EU; (d) that most –though not all-- member states would experience potentially significant losses in case of a “trade war” in Europe, and in particular the large countries.

JEL Classification: F13, F15, F17, F51

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1. Introduction

“America first!”; *“Vote Brexit to take back control!*”; "*Brexit and now France!*"… At the time they were used, these words were only slogans. Since then, American voters have followed Donald Trump, and the US have unhesitatingly started building walls reminiscent of Hoover’s 1930 Tariff Act, better known as Smoot-Hawley tariff. Since then, British electors have transformed Eurosceptic feelings into a EU rejection decision following Boris Johnson and others. Since then, however, French electors have set aside temptations to follow populist leaders into an isolationist adventure: for how long? Will other European voters make the same choice in the forthcoming years? Though the nationalistic feelings and anti-EU resentments have obviously causes that extend beyond the field of economics, one can safely conjecture that the underlying frustrations have their roots in the evaluation of the trade-off between the perceived benefits of EU cooperation and the perceived costs of being constrained by the cooperative rules in the pursuit of self-interest.

Restricting our attention to trade protection by use of tariffs, our contribution in this paper is to provide a quantitative appraisal of the gains and costs to individual countries of being part of the European Union. For this, we make use of a rather sophisticated calibrated multisector general equilibrium (GE) model that identifies as endogenous economies each of the 27 member states of the Union in 2007, the year we choose for calibration purposes. Trade barriers within the Union were close to zero in 2007: we interpret this equilibrium as the cooperative solution to a trade game with 27 actors. We know from theory that such equilibrium is typically unstable due to individual players facing incentives to deviate. We provide estimates of the welfare that would be gained by individual member states if they were each to deviate *alone* from the cooperative equilibrium and opt for a trade protection policy based on setting optimally bilateral sector-specific *ad valorem* tariffs. These numbers presumably provide upper-bounds to what anti-EU politicians like Boris Johnson and Marine LePen have in mind when they exhort voters to “take back control", at least w.r.t. trade in goods. The welfare gains, however, are achieved through improvement of the deviating country’s terms-of-trade necessarily at the expense of its trading partners whose terms-of-trade worsen, so that the latter can be expected to retaliate. Retaliation will either be collective and coordinated, with the Union setting common tariffs on imports from the exiting partner, or individual with each nation deciding to free itself from the collective discipline in the pursuit of its own interest. In both cases a “trade war” is likely to follow that could leave most (all?) players worse off relative to free trade. We imbed our calibrated GE model into different sets of Nash games in tariffs, and compute estimates of the potential impact on welfare for European national households. In order to assess robustness, we do this for various model specifications and parameter values.

The terms-of-trade argument for tariffs can be traced back at least to Edgeworth (1894) and Bickerdike (1907) who first establish a relationship between welfare improving tariffs and the price-elasticity properties of the foreign country's offer curve. Despite this long history, the idea that individual countries can set tariffs in response to their market power in international markets generally raises skepticism, presumably due to a lack of empirical evidence. In a recent influential paper, however, Broda, Limão and Weinstein (2008) provide such evidence: they show that non-members of the World Trade Organization (WTO) do systematically set higher tariffs on goods in which they have market power; they also report evidence that US trade restrictions not covered by the WTO are significantly higher in goods where the US has market power. Bagwell and Staiger (2011) provide further evidence that terms-of-trade considerations indeed play a role in governments' tariff choices.

The tariff war that followed the adoption in June 1930 of the Smoot-Hawley Tariff Act (The Economist, 2008) painfully contributed to establish the perception that these gains are illusionary in nature, because of retaliation that will leave all players worse-off as compared to free trade (Scitowsky, 1942). Harry Johnson (1953), however, established that in a two-good pure exchange economy, this is not necessarily the case: some countries may actually gain from setting tariffs optimally despite retaliation. The conclusion that tariff wars need not always end-up in Prisoner's Dilemma situations was extended by Gorman (1958) to more general preference structures. Using a similar set-up, Kennan and Riezman (1988) explored the role of size, suggesting that the intuition "…big countries win trade wars" is correct. Syropoulos (2002) significantly improves upon this literature by incorporating a fairly general production structure into an otherwise standard two-good Hecksher-Öhlin model, and shows that this generalization does not affect the previous conclusion on the role of size.[1] More recently, Opp (2010) reaches similar conclusions albeit using a Ricardian-with-continuum-of-goods set-up. All these results are however established within two-country framework, which raises the question of their generality. Indeed, in his concluding remarks, Syropoulos (2002)

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[1] By means of numerical simulations performed on various versions of the two country two good Hecksher-Öhlin model with more general specifications of preferences and technologies, Hamilton and Whalley (1980) show that these results are quite robust within the class of models they explore.

acknowledges the stringency of this two-trading partner restriction: “It is also very important to re-examine tariff wars in multi-country settings. In the presence of several trading partners, terms-of-trade externalities between subsets of countries may be positive. This creates the possibility that […] small countries benefit from global tariff wars, as compared to global free trade!”. Our numerical exploration provides evidence that this intuition is correct: in this respect, conclusions derived from simple 2x2x2 models of trade prove over-simplistic.

Despite the extensive related theoretical literature, our paper has surprisingly few predecessors, none of which related to the EU. The focus of Perroni and Whalley (2000) is the new regionalism that entered global trade arrangements in the 90s (Canada-US, NAFTA, EU accession agreements with Eastern European countries) involving very asymmetric partner sizes and strikingly asymmetric concessions made by the smaller acceding countries. The model structure is essentially the one used by Hamilton and Whalley (1983) extended to seven regions calibrated on real world data; they keep the two-goods formulation (importables, exportables) and trade policy is allowed to operate only at the most aggregate level, with a single tariff applying against all imports from any given country. More recently, Ossa (2014) makes a significant step forward by departing from the conventional neoclassical trade model, incorporating Dixit-Stiglitz-Krugman-type intra-industry trade into a world model with 7 endogenous regions and 33 industries. For all its merits, the extension is not costless, however: adopted from Eaton and Kortum (2002), technologies are single-factor Ricardian in labor (there is no independent role for capital) requiring no intermediate material inputs, a theoretically convenient feature, but one that is far from being innocuous when it comes to real-world policy assessments, as we shall show.[2]

The remainder of the paper is organized as follows. Section 2 describes our numerical set-up. Results are reported and commented in Section 3. Section 4 concludes and offers suggestions for future research.

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[2] It should be noted that, in contrast to us, Ossa (2014) uses a gravity-based approach. See Costinot and Rodriguez-Clare (2014) for a presentation of this literature. We view the two approaches as complementary rather than substitutes, each approach having its own merits and limitations.

2. The Numerical Set-up

2.1 The general equilibrium model

The model we use has much in common with RHOMOLO, the spatial calibrated GE model extensively used by the European Commission and described in details in Mercenier et al. (2016). The two models differ, however. In this section, we first highlight the differences. Then, to avoid lengthy replication, we provide a non-technical description of our model, and refer the interested reader to that document for a detailed formal presentation.

A first important difference between the European Commission's and our model is that, in contrast with the EC, we are not constrained by every-day policy considerations, and can select a different more appropriate base year for calibration purposes: we choose year 2007 because it is prior to a decade of severe recession, any year of which would therefore fail to properly qualify as an equilibrium in which supply and demands are balanced by flexible enough prices. Secondly, we are not interested in specific regional issues. We can therefore substantially reduce the dimension of the numerical system by working with national rather than with regional units and take advantage of this size downscaling to adopt a finer sectoral disaggregation. (RHOMOLO also includes a very ad hoc R&D bloc, which we do not retain.) Finally, the EC's model does not acknowledge the possibility of intra-EU policy induced trade restrictions, so it has no tariffs.

The model used in this paper includes the 27 member states of the European Union in 2007 (hereafter *E27*).[3] All countries have identical structures; the model is closed by a 'rest-of-the-world' (hereafter *RoW*) that is kept exogenous except for the volume of its bilateral trade which is price responsive, so that its trade balance with respect to each individual EU member state is endogenous though fixed for the EU as a whole. The *RoW* prices serve as numeraire.

In each country $j \in E27$, all national households are aggregated into a single representative agent. This agent is endowed with two types of labor, skilled and unskilled, that she allocates within the country, to different sectors of activity in response to wage differentials. Sectoral reallocation choices by national agents result from maximizing labor income subject to a

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[3] Namely, Austria (AUT), Belgium (BEL), Bulgaria (BGR), Cyprus (CYP), the Czech Republic (CZE), Germany (DEU), Denmark (DNK), Spain (ESP), Estonia (EST), Finland (FIN), France (FRA), Great Britain (GBR), Greece (GRC), Hungary (HUN), Ireland (IRL), Italy (ITA), Latvia (LVA), Lithuania (LTU), Luxembourg (LUX), Malta (MLT), the Netherlands (NLD), Poland (POL), Portugal (PRT), Romania (ROU) Slovakia (SVK) and Slovenia (SVN) and Sweden (SWE).

cross-sectoral constant-elasticity-of-transformation (CET) frontier with concavity governed by a transformation elasticity which we denote σ_j^l (where superscript l stands for labour type). National households also hold assets, in the form of physical capital as well as domestic and foreign bonds. Savings rates are assumed fixed to their base year level. Private consumptions --as all other components of the demands for goods, both final and intermediate-- are allocated to different industries using optimal demand systems derived from multi-level CES with nonzero substitution elasticities.

On the production side, we distinguish between ten broad sectors of activities: "Primary"; "Food, Beverages and Tobacco"; "Textiles and Textile Products"; "Chemicals and Plastics"; "Basic and Fabricated Metals"; "Electrical and Optical Equipment"; "Transport Equipment"; "Construction"; "Other Manufacturing"; and "Services". In one version of the model, these industries are all assumed populated by price-taking competitive firms endowed with constant returns to scale (CRS) production functions; in an alternative version, existence of increasing returns to scale (IRS) is acknowledged in a large subset of sectors with competition assumed monopolistic with free entry/exit.[4] Variable inputs --intermediate goods as well as production factors: capital, skilled and unskilled labor-- are combined through nested-CES structures with nonzero substitution elasticities.

The public sector, with its complete set of direct and indirect taxes, is present in the model for base year replication purposes, but assumptions are made to keep its behavior as neutral as possible. In particular, the stock of public bonds is held in constant supply and all tax rates are fixed, except income tax rates that are endogenously adjusted to ensure a fixed level of public consumption.

Importantly, the model captures two features characteristic of modern capital. On the one hand, low transaction costs and efficient banking make financial capital extremely mobile so that owners of physical capital throughout the EU should earn essentially the same return on their assets. On the other, the rental cost of capital for firms is far from being equalized across

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[4] This subset includes all sectors except "Primary", "Other Manufacturing" and "Services". The decision regarding which industry is likely or not to be characterized by IRS technologies and monopolistic competition is difficult, and admittedly bears some arbitrariness. Our choice is based, among other things, on industry concentration statistics (more specifically, on Herfindahl indices), on how roughly homogeneous an industry is (“Services” for instance, include such different sub-sectors as retail trade, restauration and banking, which makes the symmetry assumption difficult to justify), and on how realistic it is to assume that individual firms’ products are differentiated from their competitors (it is, for instance, hard to justify that agriculture goods that constitute a large part of “Primary” are differentiated enough to confer some monopoly power to individual farmers).

sectors and countries due to imperfectly mobile equipment. These features are captured by pooling all the physical capital of EU households into a single stock, rewarding all European capital owners the rental price for this pooled factor. The EU-aggregate physical capital stock is then optimally allocated to EU member states and to sectors within each country by maximizing total rental revenues, subject to a two-level nested CET constraint. The values of the transformation elasticities govern the concavity of these allocation frontiers, and therefore provide a convenient characterization of how mobile physical capital is, both internationally (the upper-level CET, with parameter denoted σ^K) and intersectorally in each country (the lower level CETs, with transformation elasticities $\sigma_j^k, j \in E27$). Calibration of the CETs on base year data ensures that price induced reallocations nevertheless remain anchored to their initial geographical distribution.[5] Pooling European capital into a single stock also obviously requires pooling investment consistently, which imposes some rather technical and innocuous constraints on the modeling of the composition of the investment good (see Mercenier et al., 2016).

Importantly for our purpose, each country's aggregate demand for an industry's good is converted into price-responsive bilateral trade flows using a single-level CES optimal allocation structure. Formally, for each industry *s*, country *j*'s demands for country *i*'s good is determined using the following demand system:

$$\left\{\begin{aligned} \left[p_{j,s}^A\right]^{1-\sigma_{j,s}^A} &= \sum_i N_{i,s}\alpha_{i,j,s}\left[(1+\tau_{i,j,s})p_{i,s}\right]^{1-\sigma_{j,s}^A} \\ Exp_{i,j,s} &= N_{i,s}\alpha_{i,j,s}\left[\frac{p_{j,s}^A}{(1+\tau_{i,j,s})p_{i,s}}\right]^{\sigma_{j,s}^A} A_{j,s} \end{aligned}\right. \qquad i,j \in \{E27, RoW\} \qquad (1)$$

where $A_{j,s}$ is country *j*'s aggregate (intermediate and final) demand for goods from industry *s* with price $p_{j,s}^A$, $Exp_{i,j,s}$ the volume of that good imported from country *i* at f.o.b. price $p_{i,s}$ augmented by an *ad valorem* tariff $\tau_{i,j,s}$; $\sigma_{j,s}^A$ and $\alpha_{i,j,s}$ are respectively substitution elasticities and (simple transforms of) share parameters determined from base year calibration. $N_{i,s}$ is the number of producers (assumed symmetric within national boundaries) in country *i* sector *s* endogenously determined by costless entry/exit and zero profits in monopolistically

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[5] This insurance mechanism of capital owners against idiosyncratic risks can obviously be interpreted as a reduced form representation of the role of financial markets and banking sector activities.

competitive sectors; $N_{i,s}$ is fixed to unity otherwise (therefore with product differentiation at the national rather than at the firm level, the Armington specification). Note that the trade flow equation also applies for $i = j$, defining therefore for each endogenous country the domestic demand functions for domestically produced goods.[6]

The model is closed by imposing that supplies and demands balance on all markets. On labor markets, however, in some scenarios, we make labor supply (or the unemployment rate, depending on the chosen interpretation) endogenous by use of a wage curve.[7]

With budget constraints satisfied for all European agents, it is necessarily satisfied for the RoW by Walras' law: in order to ensure maximum computational accuracy (important in particular because of some large differences in country scale), we nevertheless impose this constraint as an additional equation into the system. The welfare index we report is the equivalent variation.

2.2 Design of the trade games

2.2.1 The initial cooperative equilibrium

Tariff rates are null within the EU in 2007: we can interpret the flows reported in that year's social accounting matrices (hereafter: SAMs) as the equilibrium outcome of a cooperative trade game between member states, and calibrate the GE model with $\tau^0_{i,j,s} = 0 \;\; \forall i, j, s$ so as to reproduce this initial equilibrium data set.[8] [9] Model calibration also requires choosing values for a set of parameters, most of which are substitution or transformation elasticities: the reference-case values adopted are essentially borrowed from Mercenier et al. (2016); we shall however change --and therefore report later-- many of these values in order to appreciate robustness of conclusions.

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[6] If $i = RoW$, $p_{i,s} = p^A_{i,s} = 1$, $A_{i,s}$ is fixed and $\alpha_{i,i,s} = 0$ for all *s*.

[7] The wage curve conveniently provides a single reduced form representation of two different mechanisms of labor market adjustment. One interpretation builds on flexible wages with endogenous labor-supply resulting from implicit households' labor-leisure choices; another interpretation favors market imperfections such as imperfectly flexible real wages as inducing unemployment fluctuations. For exposition ease, we shall refer to exogenous vs. endogenous labor supply.

[8] We make use of SAMs based on Alvarez-Martinez and Lopez-Cobo (2016) kindly made available to us by these authors.

[9] Note that Bulgaria and Romania have formally joined the Union in 2007, so that base year trade flows may possibly not yet fully incorporate, for those countries, the adjustments due to the elimination of trade barriers w.r.t. other EU partners. This noise is however likely to be minor given that most trade barriers had been gradually reduced prior to that date.

2.2.2 The incentive to deviate: individual optimal tariff policy

A cooperative equilibrium is generally unstable as individual players face an incentive to deviate: in a tariff game, this incentive depends on the gains to a country from recovering alone the freedom to set its own-best protection policy (including, w.r.t. the *RoW*). We provide an estimate of these incentives for EU member countries. More specifically, we quantify for each EU member *j* the welfare gains it could reap if it were to individually exit the European cooperative agreement and set its bilateral sector-specific tariff structure $\tau_{i,j,s}$ optimally, conditional on unchanged protection by trade partners (*i.e.* $\tau_{j,i,s} = \tau^{0}_{j,i,s}\ \forall i \neq j, s$), with the tariff proceeds being rebated lump-sum to local households *j*. Observe that, stated as such, the policy violates GATT rules, in particular the most-favored-nation (MFN) principle. We shall also address this issue. In order to reduce the computational burden, we however exclude from this counterfactual policy exploration the smallest countries which are unlikely to have significant effects on trading partners.[10] Also, because tariffs are instruments that can only be used on goods, we exclude from the optimal tariff computations sectors "Construction" and "Services".

2.2.3 Retaliation: a coordinated EU response to exit

Free-riding the EU discipline may be beneficial in absence of adverse reactions, but only short-sighted politicians would favor such a move without acknowledging the potential cost of retaliation. How effective is such a threat? That is: how costly to the deviating country is a retaliation policy likely to be? To evaluate this, we compute for each potential exiting country *j*, the equilibrium to a Nash game between this country *j* and the coalition formed by its former EU partners. More formally, the deviating player *j* sets its tariff optimally with respect to each of its trade partners, taking as given the level of the tariffs it faces on its exports; the EU then imposes a common tariff on its imports from the former partner, chosen so as to maximize EU-aggregate welfare conditional on the tariff structure adopted by *j*.[11] (Because it

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[10] Specifically, we do not compute optimal tariffs for countries that account for less than 0.5 % of base-year intra-EU total trade in goods, namely: Bulgaria (BGR), Cyprus (CYP), Estonia (EST), Lithuania (LTU), Luxembourg (LUX), Latvia (LVA) and Malta (MLT).

[11] Formally, we maximize the un-weighted sum of individual EU-member levels of utility. This Benthamite social welfare function reflects the decision rule that each member state has one vote independently of its size.

is exogenous, the *RoW* is assumed to mechanically reciprocate by imposing on its imports from country *j* the same rates it faces on its exports to that same country *j*.) An equilibrium solution to this game implies that no incentive is left for any of the two players to change its level of protection when taking the other's tariff structure as given. See Appendix 1 for a formal description and for numerical details of the solution procedure.

2.2.4 The end of free trade in Europe: a trade war

Though coordinated retaliation may be the only defensive instrument available to the EU against the centrifugal forces that threaten its survival, it is clearly not the only threat that weigh on potential “exiters”. Indeed, given that free-riding may be beneficial to many (if not to all) individual member states, the risk is that others would also choose to recover control on their own external trade policy and decide to exit the Union, bringing the European free-trade agreement to an end. Increasingly aggressive protectionist moves are likely to follow with each former EU partners ending-up playing a Nash game in (sector-specific) tariffs against all others. We compute the Nash equilibrium of such a European “trade war”, and report welfare implications for each of the twenty active player-country under alternative assumptions on parameter values and/or model specifications.[12]

3. Results

3.1 First step optimal tariff outcome: how important is the incentive to deviate?

We first consider the case of CRS technologies with perfect competition prevailing in all industries. Because they contribute to influence both monopsony and monopoly power of countries on foreign markets, trade elasticities are expected to play an important role in this analysis. We first use, for the substitution elasticities $\sigma^A_{j,s}$, values roughly equal to the gravity estimates reported by Felbermeier et al. (2014); their regressions are performed on aggregate activity data, so they provide a single average value that we therefore impose to all sectors: $\sigma^A_{j,s} = 6.0 \ \forall s$. These values can be thought to be on the high side, at least for most sectors.[13]

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[12] As previously mentioned, we do not compute optimal tariffs for countries that initially account for less than 0.5% of intra-EU trade. For these countries, we assume tit for tat retaliation with identical reciprocal rates.

[13] The European Commission's RHOMOLO model uses this same value. It might be worth at this stage reminding readers unfamiliar with CES-generated trade flows that the preference parameters $\sigma^A_{j,s}$ are not import demand elasticities; the latter also depend, among other things, on import shares so they will differ across

To limit the number of mechanisms at work, we first rule out the possibility for production factors to relocate across sectors and countries by setting $\sigma^K = \sigma_j^k = \sigma_j^l = 0 \;\; \forall l, \forall j$.

Figure 1a reports the welfare gains each country could achieve by free-riding on the common trade discipline of the EU, setting alone its tariffs optimally. Also reported are the induced aggregate terms-of-trade gains, as well as the level of the average optimal tariff (scale on the RHS of the graph for the latter).[14] The table reveals that, though all member states have indeed an incentive to deviate from the free trade arrangement, there is no simple relation between the GDP size of the national economy and the terms-of-trade gains: those countries that gain least are some of the largest (France and Great Britain), and those that gain most are small economies (Hungary, Slovakia and Slovenia). Two important reasons contribute to explain the contrast between the gains experienced by Germany and those of France and Great Britain: firstly, both France and Great Britain have larger shares of their GDP in non-goods industries ("Services" and "Construction") which are therefore immune to tariffs (for Germany, this share is close to 75% at base year, approximately 10% higher for the two other countries); secondly, in the goods sectors, Germany tends to be more open to foreign trade, with its (weighted by base year flows) sector averaged domestic share of aggregate demand (approximately 74%) lower by five percent than it is in the two other large countries. Concerning Hungary, Slovakia and Slovenia, it is of course hard to abstract from the fact that these economies have a high share of their trade with Germany: indeed, we know that bilateral trade shares do have an influence on export and import price elasticities. How tight is that link between trade elasticities and optimal tariff protection?

We explore this issue by performing the same numerical experiments under a different set of values for the $\sigma_{j,s}^A$: we now use values reported by Ossa (2014), obtained from using different data sets and econometric strategy. Though the industry classification used for these estimations does not exactly match ours, we can infer the following approximate values for $\sigma_{j,s}^A$:

	Primary	Food, Bever & Tobacco	Textiles	Chem. & Plastics	Basic & Fabri. Metals	Elect. & Optic. Equip.	Transp. Equip.	Other Manuf.
$\sigma_{j,s}^A$	4.0	2.75	2.80	2.35	3.0	2.5	2.8	3.0

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countries and industries even if all $\sigma_{j,s}^A$ have the same values. The values of the substitution elasticities are nevertheless likely to play an important role.

[14] All reported terms-of-trade and tariff averages use bilateral trade volumes as weights.

For the sectors "Construction" and "Services", which trade no goods, we keep the previous value of $\sigma_{j,s}^{A} = 6.0$.[15] As all trade elasticities are either significantly lower or unchanged, simple intuition suggests that optimal tariffs and terms of trade gains should systematically be higher. The results reported in figure 1b reveal that this intuition is over-simplistic: though it is indeed confirmed for most countries --it is, in particular, true for Germany, Slovakia and Slovenia who see their optimal tariffs and welfare gains more than double-- it is not the case for all member states: both Denmark and Poland find it optimal to reduce (rather than increase) their average tariffs. Not surprisingly of course, these are also the two member states of the EU that experience the lowest gains from tariffs.

That the link between trade elasticities and welfare gains from tariffs is rather loose is of course no surprise for trade theorists who know that the ability an economy has to transform import tariffs into terms-of-trade gains depends on a complex set of essentially domestic interactions between supply and demand considerations, in which the role of the economy's input-output structure may in particular be significant. To highlight this, let us consider the --agreeably questionable in terms of realism but nevertheless instructive-- possibility that tariff rates on intermediate and final demands be differentiated.[16] More specifically, we contrast the gains from three different policies: the first assumes that the deviating country sets optimally bilateral tariffs on final demands only; the second considers the option of tariffs being levied optimally on intermediate demands only; finally, in the third scenario, bilateral optimal tariff rates are differentiated between the two components of aggregate demand. We do this for both high and low trade elasticities, and report (respectively in figures 2a and 2b) the welfare gains of the first two policies in the form of a stacked histogram, and compare these cumulated welfare gains to those produced by the third policy choice. We first note the contrast between the gains generated by the two first policies: not only are the two numbers hugely different in terms of levels for each country, but also of relative magnitudes across countries (the cross-country correlation between the two welfare series is 0.27 for the high trade elasticity case, and 0.17 for the low $\sigma_{j,s}^{A}$ scenario). We also observe that, though for most countries, the sum of the gains from the first two policies approximately equals the welfare level generated by the third, it is not the case for all. This clearly reveals strong non linearities in the aggregate offer curves of some countries. It is quite striking that those countries that reveal the highest

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[15] In the remainder of the paper, we shall refer to this as the "low trade elasticity" case, and to the previous one as the "high trade elasticity" scenario.

[16] The demand system (1) is therefore split between final and intermediate demands.

non linearities in their offer curves are precisely those that were identified earlier as having the strongest incentive to deviate from the EU free-trade agreement: Hungary, Slovakia and Slovenia. Clearly, this has little to do with the size of the economy, nor with the values of the trade elasticities.

Up to now, we have explored within-EU optimal tariff outcomes assuming perfect competition and national-level product differentiation. We have shown how ingredients other than trade elasticities contribute majorly to the properties of aggregate offer curves, and hence on the size of each country's incentives to individually deviate from free trade. How specific to this set-up are our findings? More specifically, how are these results likely to be affected if, as realism suggests for most industries, firms operate IRS technologies and produce differentiated goods? We know from Feenstra et al. (2001) that, due to endogenous entry/exit, a country's net exports are more sensitive to own than to partner's income fluctuations in the monopolistic-competition model, whereas the opposite is true with national (Armington) product differentiation. Clearly therefore, as protection increases and trade volumes shrink, and with them, the equilibrium number of surviving producers, the predictions of the two models can be expected to differ significantly. Figures 3a and 3b report, for the case with monopolistic competition, what was previously reported in figures 2 under the Armington model structure.[17] Comparing these results reveals that the Armington structure tends to predict welfare gains that are both systematically and significantly more favourable to tariff protection. Though this can hardly be a surprise --lower product variety impacts negatively on welfare, directly through the cost-of-living index and indirectly by increasing the price of material inputs of firms-- the difference in magnitude is presumably more unexpected. Despite the differences in levels, however, country rankings are essentially unaffected with all cross-country correlations close to 0.9 between the series underlying figures 2 and 3. Furthermore, the previously identified strongly non-linear nature of some national aggregate offer curves is clearly preserved, confirming the robustness of the conclusion that those economies that face the strongest incentives to free-ride the EU trade agreement are *none* of the big countries but Hungary, Slovakia and Slovenia.

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[17] A word of caution is worth here: as is well known, it is a characteristic feature of monopolistic competition with CES demands and endogenous product differentiation (the Dixit-Stiglitz specification), that the parameters $\sigma^A_{j,s}$ characterize both substitution in demands and equilibrium price-cost margins. This has implications for the calibrated technologies: indeed, imposing zero profits conditional on base-year industry concentration data (Herfindahl indices), it is not possible to calibrate the firms' fixed costs independently of the chosen value of $\sigma^A_{j,s}$, so that changing one implies also adjusting the other, with the level of calibrated fixed costs being inversely related to the values of the $\sigma^A_{j,s}$.

All our explorations so far have assumed countries have the ability to set differentiated tariffs on bilateral partners. Such a policy design may seem in violation to GATT/WTO rules, among which the most prominent one is the most-favoured nation (MFN). This is unclear however: MFN indeed forces countries to impose the same tariff against all trading partners but this constraint is enforced at the tariff-line level and therefore does not have to hold within the broad industry categories considered here.[18] We nevertheless now consider such a constrained policy, implemented at the industry level. Figures 4a to 4d report, for the two sets of trade elasticity values and for the two model specifications (Armington and monopolistic competition), the welfare gains resulting from MFN-constrained optimal tariffs, compared to the unconstrained tariffs outcome.[19] Clearly, at this level of industry aggregation at least, the MFN rule performs more than poorly as a deterrence mechanism against individual deviations from free trade within Europe. (The correlation between the two welfare series is equal or above 0.97.) We can therefore safely abstract from these constraints in the rest of the paper.

Production factor relocation is an important adjustment mechanism to shocks, yet we have forced factors to remain immobile. We have also up-to-now neglected the potential importance of labor market feedbacks: because import tariffs directly affect the cost of living index, they are likely to retroact through labor markets either by inducing labor supply changes due to leisure-work substitution, or by changing the unemployment rate because of imperfectly flexible real wages. We now make a step towards more realism by relaxing these restrictions. Factor mobility is controlled by the values to the CET parameters σ^K, σ_j^k and σ_j^l: we acknowledge *intra*national sectoral mobility by setting $\sigma_j^k = \sigma_j^l = 0.7$, and *inter*national mobility of physical capital by setting $\sigma^K = 0.3$. On labour markets, we set the wage curve elasticity to the value of -10%, borrowed from the EU model RHOMOLO (see Mercenier et al., 2016). Figures 5a and 5b reveal that, in a world of CRS and perfect competition with national product differentiation, factor mobility has little effect on the outcome of a country's protectionist venture. In contrast, because they affect the size of the labor force --rather than its allocation across industries-- labor market assumptions have more important quantitative effects: the induced contraction of employment (either due to a fall in labor supply by households, or to a fall in labor demand by firms, depending on the interpretation of the mechanisms underlying the reduced-form wage curve) can almost

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[18] Ossa (2014) also makes this point.

[19] For this comparison, we impose once again identical tariffs on final and intermediate demands, as in Figures (1) and (2).

completely offset the gains from a more protectionist policy (e.g., Spain). For most countries, however, the erosion factor due to labor market feedbacks is roughly one half and does not, therefore, change the two main conclusions: that most member states face a positive incentive to individually deviate from the initial free-trade cooperative equilibrium; and that those with highest such incentive are not the large players.

Moving to a world of IRS technologies and monopolistic competition (figures 5c to 5d) does not affect these basic conclusions if trade elasticities are high enough, though effects on individual economies are more differentiated. Inspection of the detailed (unreported) results suggests that intersectoral mobility contributes most to these results, with Hungary being a rather exceptional case (with flexible wages, the inflow of physical capital is almost null for Ireland, for instance, whereas the outflow is close to 1.2% for Hungary). In the low trade elasticity case (in which calibrated fixed costs are also higher), results become much more contrasted. This is because both endogenous labor supply and cross-border movements of physical capital induce agglomeration effects of the type highlighted by Krugman (1991) and Krugman and Venables (1995), that launched the *new economic geography* literature.[20] This is clearly the case --and indeed quite spectacularly so-- for CZE and SVK where the two mechanisms tend to reinforce each other: with national employment levels fixed, CZE and SVK are both able to attract foreign capital --with locally available stocks increasing by approximately 2.3% in both countries-- which raises local real wages; if the labor supply curve is upward sloping, this real wage increase raises employment levels which contributes to push further up the national welfare. In the latter case, the supply of capital increases locally by 3.97 and 3.57% respectively in CZE and SVK, with employment levels rising between 4.4% and 20% (depending on the labor skill category). Not all countries benefit from such a favorable “snow-ball” effect, however. Indeed, in SVN the agglomeration mechanism operates with negative sign: the country experiences an outflow of capital even in the case of flexible wages; this outflow is amplified once labor supply is made endogenous with unemployment rising, pushing further down the welfare gains from protection to almost zero. For most countries, however, the results convey essentially the same conclusion as before: the gains to be expected from a move out of the free-trade agreement are indeed positive though potentially extremely modest, in particular if one acknowledges the existence of imperfectly competitive firms operating IRS technologies.

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[20] Our model is actually a highly sophisticated version of the so-called ‘footloose capital with vertical linkages’ model of the new economic geography literature (see e.g. Baldwin et al, 2003).

3.2 Coordinated retaliation: a dissuasive outcome?

Retaliation is meant to threaten the benefits from free-riding, and therefore to deter exit from the Union. How effective is such a threat? We evaluate this by comparing the "first step optimal tariff" outcome of the previous section with the results of a "tariff war" between each individual member state and a coordinated rest of the EU. To conserve on space, we only report the CRS case with immobile factors and fixed employment level: figure 6 displays the comparison between the case with and without retaliation for the low elasticity case.[21] We see that coordinated retaliation as an instrument against the centrifugal forces of free-riding is only modestly effective: though for most countries, gains from exiting the Union indeed turn into negative numbers, not all countries are bound to lose if they were to trigger a trade war against the rest of the EU. Though such an outcome can hardly be a surprise since Harry Johnson's (1953) seminal paper, the fact that the countries that would win such a trade war against the rest of the EU are among the smallest may be more unexpected in view of results from the theoretical literature.

3.3 Facing the risk of a tariff war: is it worth?

From the previous subsection, we have learned that some countries would be better off taking back control of their trade protection policies even if they were to face EU retaliation. In such circumstances, and in view of the hypothetical nature of such a coordinated threat, can we rule out as unlikely that some members would choose to reclaim control on their own external trade protection, hence leaving no choice to the others but to follow. At what cost?

We provide an answer to this question in figures 7a-7b where we report the welfare changes (w.r.t. initial free trade) induced by a Nash tariff game within the EU involving its twenty largest trading partners. To conserve on space, we only report the fixed employment level case.

The numbers reported in figure 7a once again confirm that Harry Johnson's conclusion "a country *may* gain by imposing an optimum tariff even if other countries retaliate by following the same policy" (1953, p.153) is far more general than his model assumptions suggest. In contrast, the prediction that "big countries win trade wars" again clearly proves invalid once

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[21] Results for the two elasticity scenarios convey the same basic message; they differ in absolute magnitudes but not in relative terms. To conserve on space, we therefore report results for the low trade elasticity case only.

national-level product differentiation is taken into account. Indeed, all the largest European trade partners are unambiguously hurt by the trade war in all the reported scenarios, whereas a few small economies may end-up better-off under specific assumptions (regarding in particular international factor mobility), with Slovakia being the only one to robustly "win the trade war". Such robustness suggests that, "in presence of several trading partners, terms of trade externalities between subsets of countries may be positive" (Syropoulos, 2002, p.722). Syropoulos adds: "This creates the possibility that "small" countries that could ride on the policy actions of larger partners with similar trade patterns may destroy the monotonic relationship between tariffs and relative size. More starkly, it may imply that small countries benefit from global tariff wars, as compared to global free trade!" Though the model on which he builds this conjecture assumes industries with undifferentiated national goods, nothing prevents a priori such mechanism to operate in our Armington set-up.

Though there is of course no reason why these positive terms of trade externalities could not also exist in an environment where individual producers differentiate their products, the IRS properties of the technologies together with the different nature of the competitive game are both likely to make these terms of trade externalities of a second order of magnitude. This is indeed what the numbers reported in figure 7b indicate: whichever scenario is considered, a large-scale trade war between former EU member states is bound to produce a devastating outcome for all (with the only exception of CZE where strong agglomeration forces may overturn this verdict in one special parameter configuration). Averaging country results over the four reported sets of parameter values, the welfare loss involved by such a European trade disintegration scenario is highest for Germany and the Netherlands (more than 3%), with Hungary and Sweden following closely (2.9% approximately). Observe that, despite the relative immunity to tariffs due to the scale of its service sector, Great-Britain would end-up loosing 1.2% of its welfare.

Though our calculations reported in figures 7a-7b differ significantly in orders of magnitude --suggesting therefore that the Armington structure offers a poor alternative to the Dixit-Stiglitz-Krugman model-- the following policy conclusion clearly emerges from our numerical explorations of both models: even though an impatient reading of the costs and benefits of "losing own control" in favor of "cooperative trade rules" --as assessed in subsection 3.1-- may bend in favor of the former, this is likely to be a very myopic perception. Pushing the European free trade agreement to an end --with the trade war inevitably to follow-

- would clearly be much more costly, therefore making largely illusionary the benefits of “taking back control” of one’s own tariff protection policy.

4. Conclusion

The idea that a country can improve its terms-of-trade and welfare by imposing positive import tariffs has formally been proven more than a century ago. That these gains are earned at the expense of others, who are therefore likely to retaliate, has also been acknowledged for almost as long. Does retaliation make these gains largely illusionary? Theory tells us this need not be the case: a trade war could be beneficial to some players, and the answer can only be circumstantial, and indeed empirical.

In view of this, it cannot be entirely surprising that European politicians, in a legitimate pursuit of national interests, do differ in their evaluations of the trade-off between the benefits of EU cooperation and the costs of being constrained in their policy choices. Amazingly, little empirical effort seems to have been made to reassess these costs and benefits in a systematic way. This paper has contributed to fill this vacuum by focusing on tariff protection in the goods-industry.

To achieve this goal, we have made use of a large-scale multi-industry calibrated general equilibrium model of trade and production that identifies as endogenous economies each of the 27 member states of the Union in 2007. The GE model has been imbedded into different sets of Nash games in tariffs to provide estimates of the potential welfare costs and benefits to national households within Europe. In order to assess robustness, we have made use of various model specifications and parameter values.

Our numerical exploration contributes to the theoretical literature by showing first, that Harry Johnson’s result that “a country may gain by imposing an optimum tariff even if other countries retaliate by following the same policy” (1953, p.153) is far more robust than his model assumptions suggest, and secondly that, intuitive as it may seem, the perception emerging from the theoretical literature that ”big countries win trade wars” that followed his seminal contribution is clearly over-simplistic and highly misleading from a policy perspective.

Our numerical results have also quite starkly highlighted something that trade theorists are well aware of, but empirical policy researchers maybe less so: given that an economy's ability to transform import tariffs into terms-of-trade gains depends on the properties of its aggregate offer curve, an extremely complex general equilibrium object in which input-output interactions in particular play a crucial role, the link between trade elasticities, the size of the economy, and the welfare gains from tariffs is actually quite loose.[22]

From a policy perspective, the main conclusions that emerge from our numerical exploration may be summarized as follows. (a) Large countries are not those that would gain most from individually deviating from the current EU trade discipline (most large member states would actually gain almost nothing). (b) The GATT/WTO most-favored-nation rule proves a poor cohesion mechanism among EU partners. (c) EU-coordinated retaliation against individual member deviation does not constitute a sufficient threat to ensure stability to the initial cooperative equilibrium. (d) Most member states would experience potentially significant losses in case of a "trade war" in Europe, and in particular the large members.

Though our results suggest that these conclusions are quite robust, our exploration has been restricted to retaliation mechanisms in the form of standard normal form Nash games. A problem inherent to this concept is that the game is played simultaneously in mutual secrecy, with players assumed myopic. To overcome this limitation, Oladi (2005) suggests reformulating tariff retaliations based on an alternative open negotiation process, referred to as "contingent threat situation" (Greenberg, 1990), in which players are assumed to be forward-looking. Admittedly, the latter assumption may not appear immediately attractive to some observers of today's political debates in Europe, this alternative formulation of a trade war seems nevertheless worth exploring in the future.

5. Acknowledgments

I am indebted to Maria Alvarez-Martinez and Montse Lopez-Cobo for making their data set available to me. I also wish to thank, without implicating, Federico Perali and Ebru Voyvoda, for comments and encouragements. This work was initiated while I was visiting the Economics Dept. at M.E.T.U. (Ankara) with financial support from TÜBITAK (2221-

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[22] It is quite striking that in Ossa's (2014) somewhat simple structure --where, among other things, the role of intermediate demands is not taken into account-- a link between trade elasticities and welfare gains from tariffs appears much stronger.

Fellowship for Visiting Scientists Program): I thank these institutions for their hospitality and/or financial support.

Appendix 1: Computational strategy

Optimal tariffs are computed by setting the problem in a nonlinear programming (NLP) format with country specific (or alternatively un-weighted sum of countries') real aggregate household consumption(s) as objective function, and the GE model as system of (approximately 26.000) nonlinear constraints. All computations are performed using CONOPT3 within the GAMS numerical environment (GAMS).

The computation of a Nash equilibrium involves a (large) number of iterations --say, indexed ι-- each requiring the following set of operations:

(*a*) parameterize the sector-specific set of tariff matrices $\left[\overline{\tau}^{\iota}_{isj}\right]$ and compute the supported GE allocation;

(*b*) compute sequentially, for each player *j*, the sector specific optimal tariff vectors $\hat{\tau}^{\iota}_{isj} \geq 0 \; \forall i,$ conditional on the GE system with tariffs by other players i, j' fixed at $\overline{\tau}^{\iota}_{isj'} \; \forall i, \; \forall s, \; \forall j' \neq j$;

(*c*) adjust all tariffs towards the optimal rates: $1+\overline{\tau}^{\iota+1}_{isj} = \left(1+\overline{\tau}^{\iota}_{isj}\right)\left[\frac{\left(1+\hat{\tau}^{\iota}_{isj}\right)}{\left(1+\overline{\tau}^{\iota}_{isj}\right)}\right]^{\vartheta}$ ($\vartheta > 0$ a damping parameter), and repeat from (*a*) using $\left[\overline{\tau}^{\iota+1}_{isj}\right]$.

Convergence is achieved when the distance $\left|\hat{\tau}^{\iota}_{isj} - \overline{\tau}^{\iota}_{isj}\right|$ is small enough $\forall i, s, j$ and welfare evaluations do not change for a large number of iterations. Observe that we impose $\hat{\tau}^{\iota}_{isj} \geq 0$ even though we know (see e.g. Feenstra, 1986, Costinot et al., 2015) that it could be welfare improving for a country to subsidize rather than to tax its imports in some sectors: we rule this out as being a politically infeasible policy option.[23] Obviously, nothing ensures uniqueness of solution in such a Nash game; the size and complexity of the numerical procedure exclude more than a superficial exploration of this issue.[24]

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[23] We also impose that $\overline{\tau}^{\iota}_{isj} \leq 1.50$ to limit the risk of corner solutions with some bilateral trade flows becoming close to machine null. That constraint is however very exceptionally binding.

[24] Huang, Whalley and Zhang (2013) explore this issue numerically within a simple pure exchange two country model, and show that multiple equilibria may exist. Their results however suggest that this occurs only with unreasonably low trade substitution elasticities. Can these conclusions be extended to more complex games remains of course an open question.

References

Alvarez-Martinez, M. T. and M. Lopez-Cobo (2016). “Social Accounting Matrices for the EU-27 in 2010. Building a new database for RHOMOLO”, Tech. rep. JRC101673, Institute for Prospective Technological Studies, DG-JRC, European Commission.

Baldwin,R., R. Forslid, Ph. Martin, G. Ottaviano, and F. Robert-Nicoud (2003). *Economic Geography and Public Policy*, Princeton: Princeton University Press.

Bagwell, K. and R. Staiger (2011). “What Do Trade Negotiators Negotiate About? Empirical Evidence from the World Trade Organization,” *American Economic Review* 101 (4), 1238-1273.

Bickerdike, C.F. (1907). “Review of A.C. Pigou's protective and preferential import duties,” *Economic Journal* 17, 98–108.

Broda, C., N. Limao and D.E. Weinstein (2008). “Optimal tariffs and market power: the Evidence,” *American Economic Review* 98 (5), 2032–2065.

Costinot, A. and A. Rodriguez-Clare (2014). “Trade Theory with Numbers: Quantifying the Consequences of Globalization.” In: Gopinath G., E. Helpman and K. Rogoff ‘(Eds), *Handbook of International Economics*, vol. 4. Elsevier.

Costinot, A., D. Donaldson, J. Vogel and I.Werning (2015). “Comparative Advantage and Optimal Trade Policy,” *Quarterly Journal of Economics*, 659-702.

Eaton, J. and S. Kortum (2002). "Technology, Geography, and Trade," *Econometrica* 70(5), 1741-1779.

Felbermayr, G. J., B. Heid, M. Larch and E. Yalcin (2014). "Macroeconomic potentials of transatlantic free trade: A high resolution perspective for Europe and the world," CESifo Working Paper Series, 5019.

Feenstra, R.C. (1986). “Trade policy with several goods and market linkages,” *Journal of International Economics* 20 (3), 249–267.

GAMS: https://www.gams.com/

Gorman, W.M. (1958). “Tariffs, retaliation, and the elasticity of demand for imports,” *Review of Economic Studies* 25 (3), 133–162.

Greenberg, J. (1990). *The Theory of Social Situations: An Alternative Game Theoretic Approach*, Cambridge: Cambridge University Press.

Hamilton, B. and J. Whalley (1983). "Optimal Tariff Calculations in Alternative Trade Models and Some Possible Implications for Current World Trading Arrangements," *Journal of International Economics* 15, 323-348.

Hui Huang H., J. Whalley and S. Zhang (2013). “Multiple Nash equilibria in tariff Games,” *Applied Economics Letters* 20, 332–342.

Johnson, H.G. (1953). “Optimum tariffs and retaliation,” *Review of Economic Studies* 21 (2), 142–153.

Kennan, J. and R. Riezman (1988). “Do big countries win tariff wars?” *International Economic Review* 29 (1), 81–85.

Krugman, P. (1991). “Increasing returns and economic geography,” *Journal of Political Economy* 99, 483–499.

Krugman, P. and A.J. Venables (1995). “Globalization and the inequality of nations,” *Quarterly Journal of Economics* 110, 857–880.

Mercenier, J., M. Alvarez-Martinez, A. Brandsma, F. Di Comite, O. Diukanova, D. Kancs, P. Lecca, M. Lopez-Cobo, P. Monfort, D. Persyn, A. Rillaers, M. Thissen, and W. Torfs (2016). “RHOMOLO-v2 model description: A spatial computable general equilibrium model for EU regions and sectors,” JRC Technical Reports JRC100011. Institute for Prospective Technological Studies, DG-JRC, European Commission.

Oladi, R. (2005). “Stable tariffs and retaliations,” Review of International Economics 13(2), 205-215.

Opp, M. (2010). “Tariff wars in the Ricardian Model with a continuum of goods,” *Journal of International Economics* 80, 212–225.

Ossa, R. (2014). “Trade Wars and Trade Talks with Data,” *American Economic Review* 104(12), 4104-46.

Perroni, C. and J. Whalley (2000). "The New Regionalism: Trade Liberalization or Insurance?", *Canadian Journal of Economics* 33(1): 1-24.

Scitovsky, T. (1942). “A reconsideration of the theory of tariffs.” *Review of Economic Studies*, 9(2), 89–110.

Syropoulos, C. (2002). “Optimum tariffs and retaliation revisited: how country size matters,” *Review of Economic Studies* 69 (3), 707–727.

The Economist (2008). “A cautionary tale about how a protectionist measure opposed by all right-thinking people was passed”. (Dec. 18th).

Figure 1a: Individual deviation without retaliation (high trade elast., CRS)

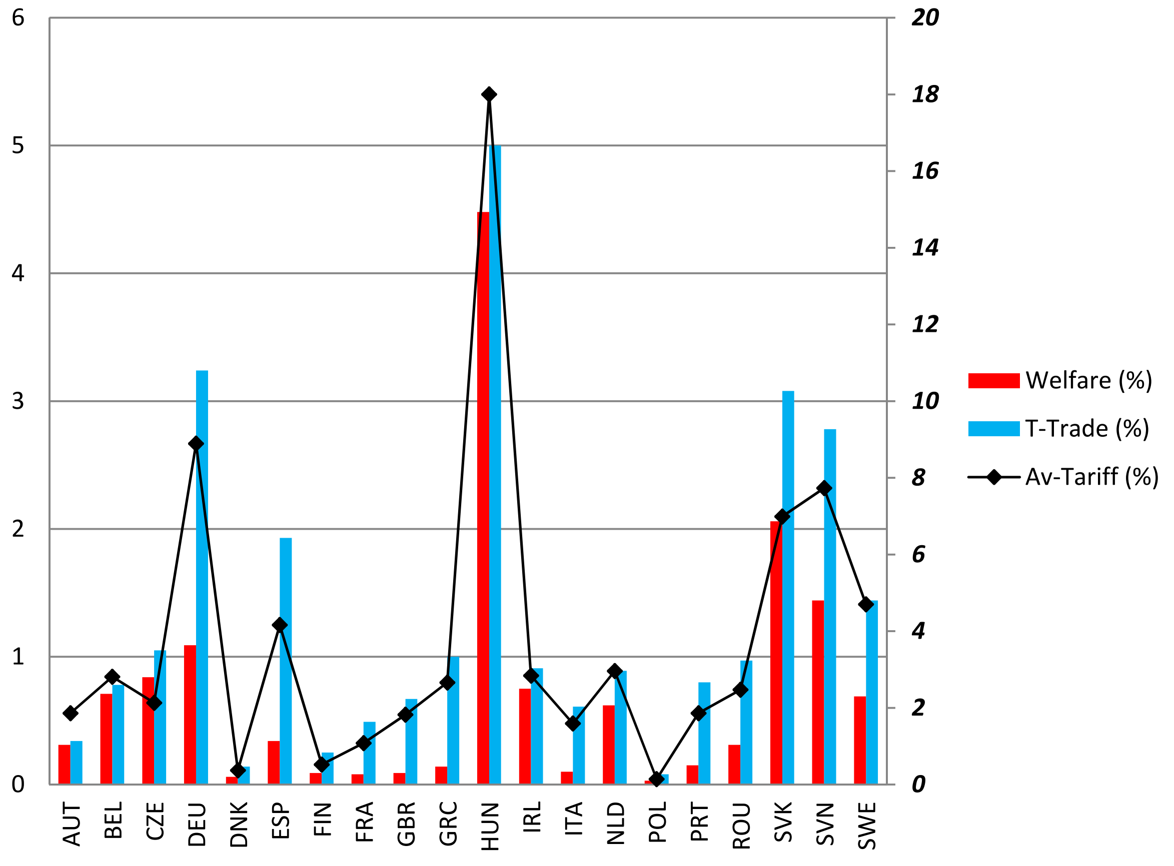


Figure 1b: Individual deviation without retaliation (low trade elast., CRS)

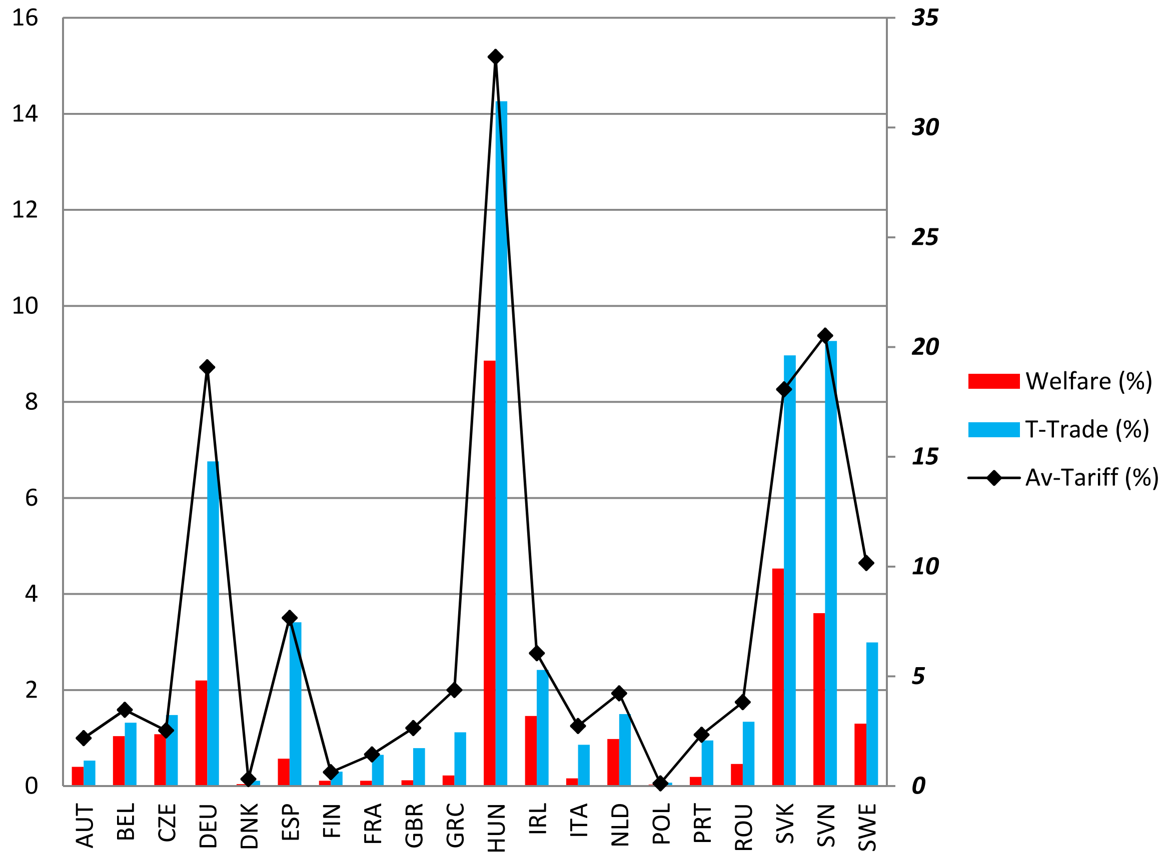


Figure 2a: Individual deviation without retaliation, differentiated tariffs on final & interm. demands
% welfare (high trade elast., CRS)

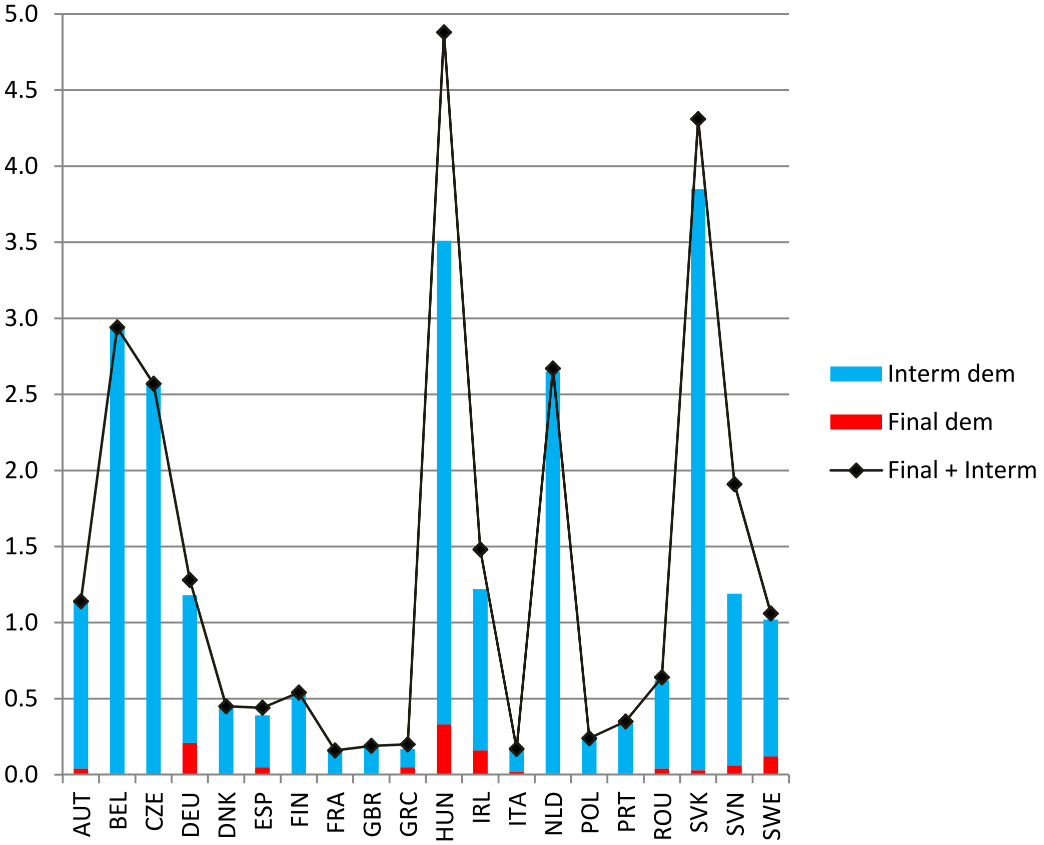


Fig. 2b: Individual deviation without retaliation, differentiated tariffs on final & interm. demands
% welfare (low trade elast., CRS)

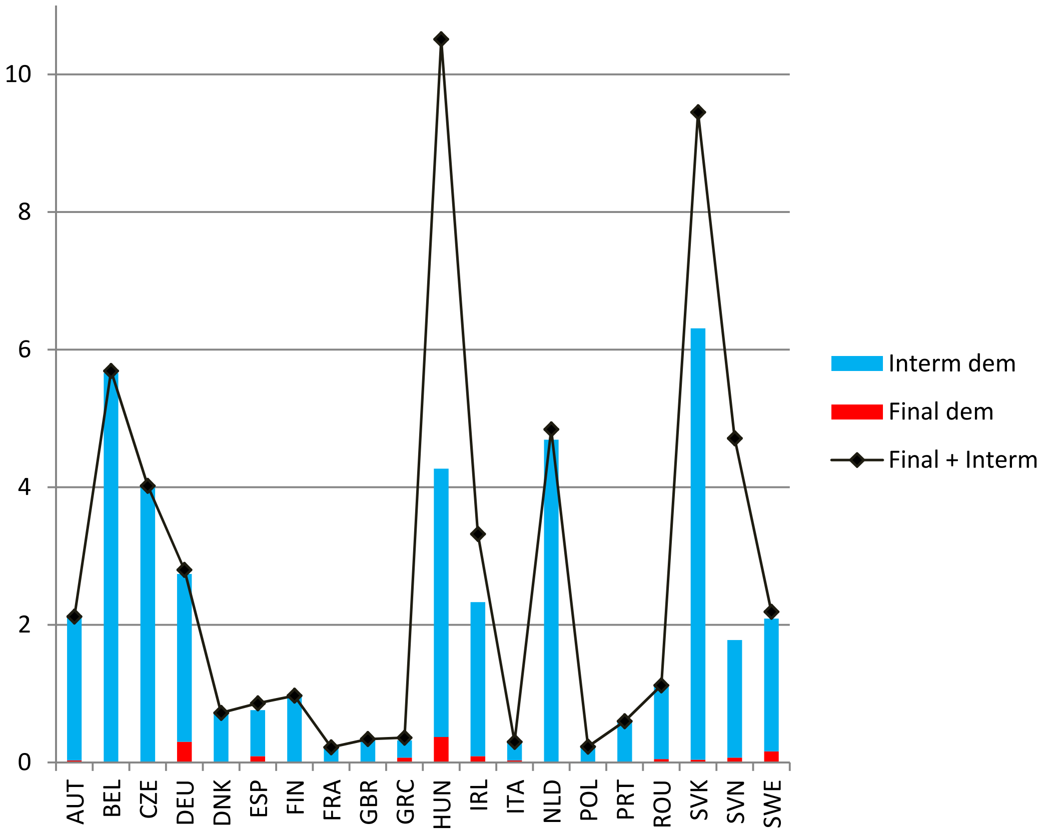


Figure 3a: Individual deviation without retaliation, differentiated tariffs on final & interm. demands % welfare (high trade elast., IRS)

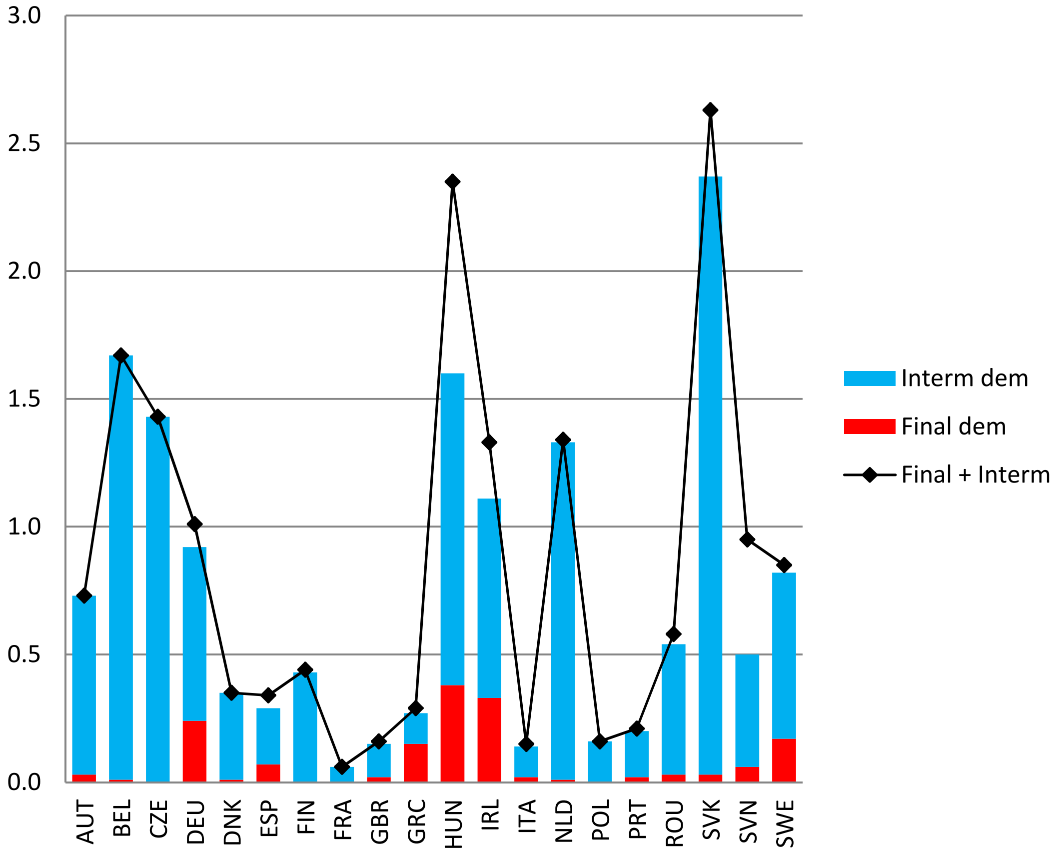


Figure 3b: Individual deviation without retaliation, differentiated tariffs on final & interm. demands % welfare (low trade elast., IRS)

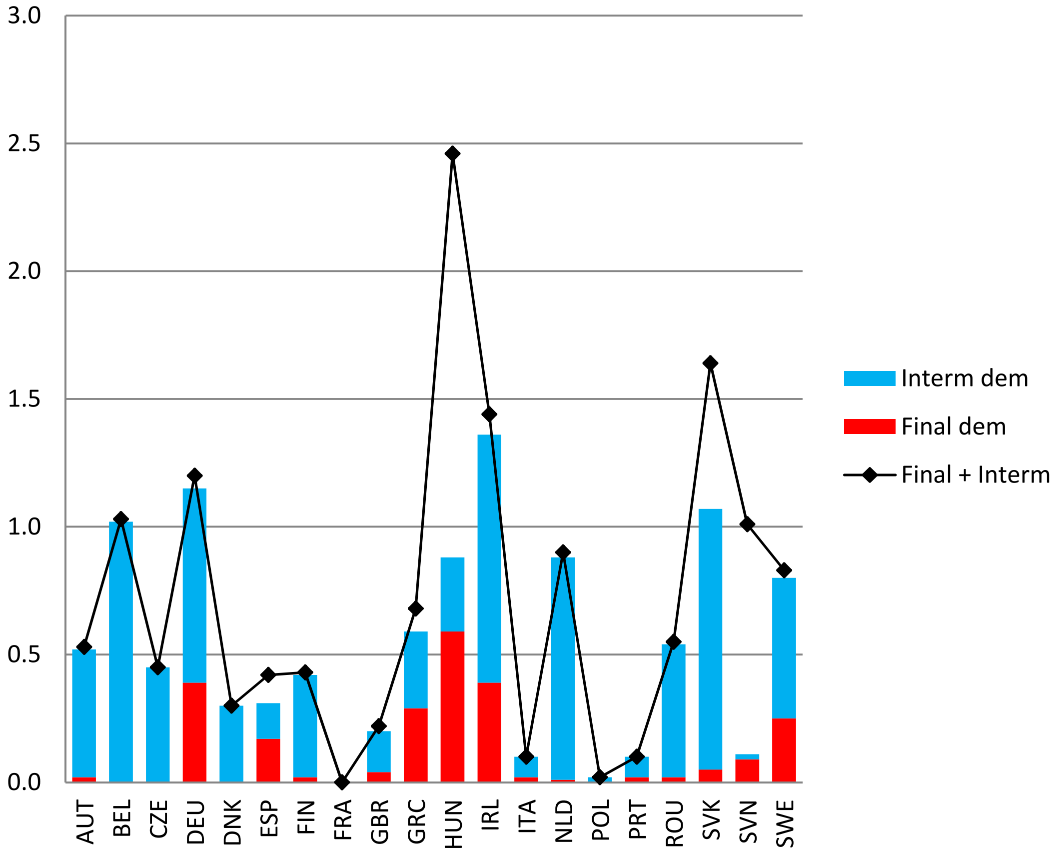


Figure 4a: Individual deviation without retaliation,
tariff rates with & without MFN constraints
% welfare (high trade elast., CRS)

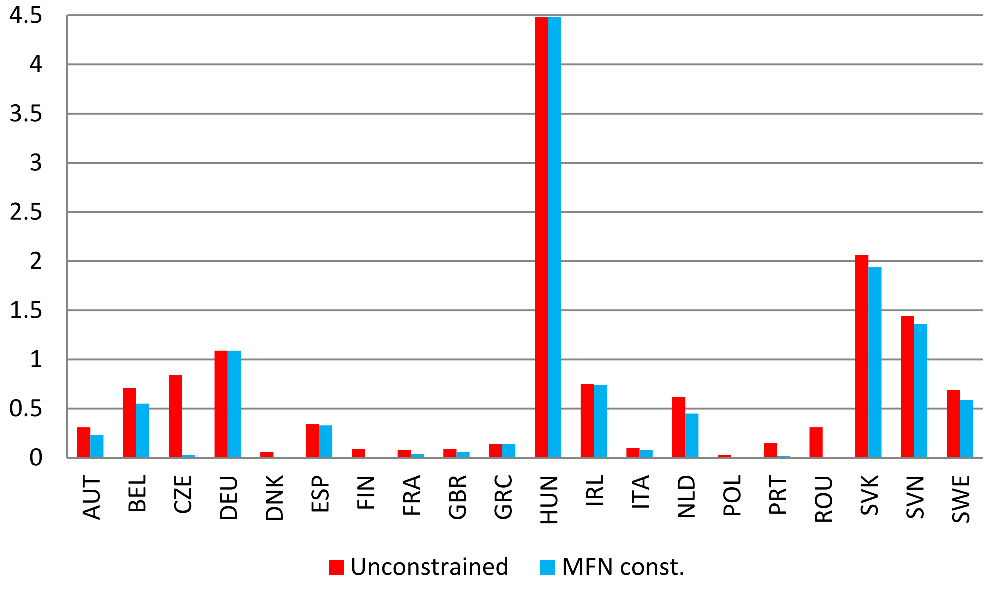


Figure 4b: Individual deviation without retaliation,
tariff rates with & without MFN constraints
% welfare (low trade elast., CRS)

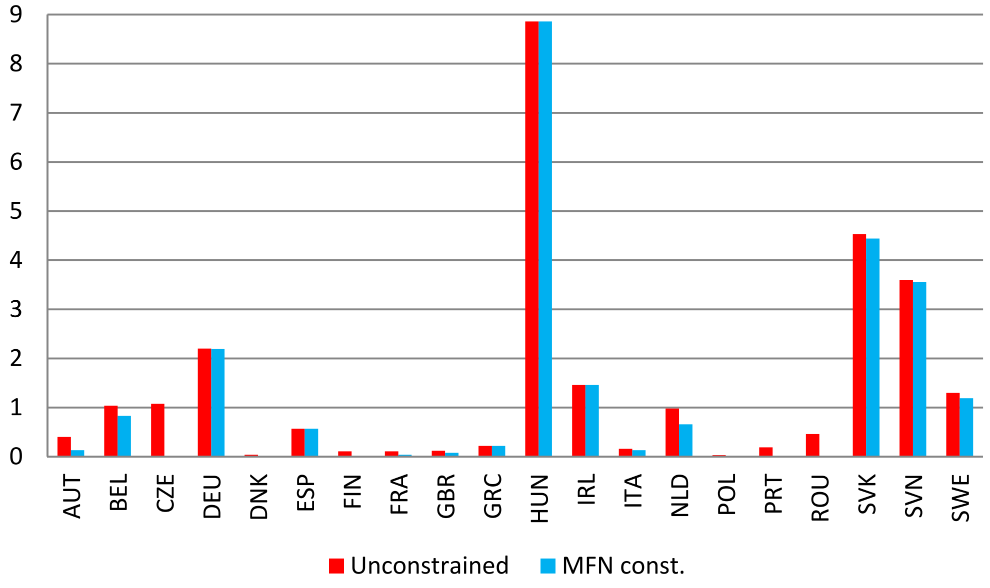


Figure 4c: Individual deviation without retaliation,
tariff rates with & without MFN constraints
% welfare (high trade elast., IRS)

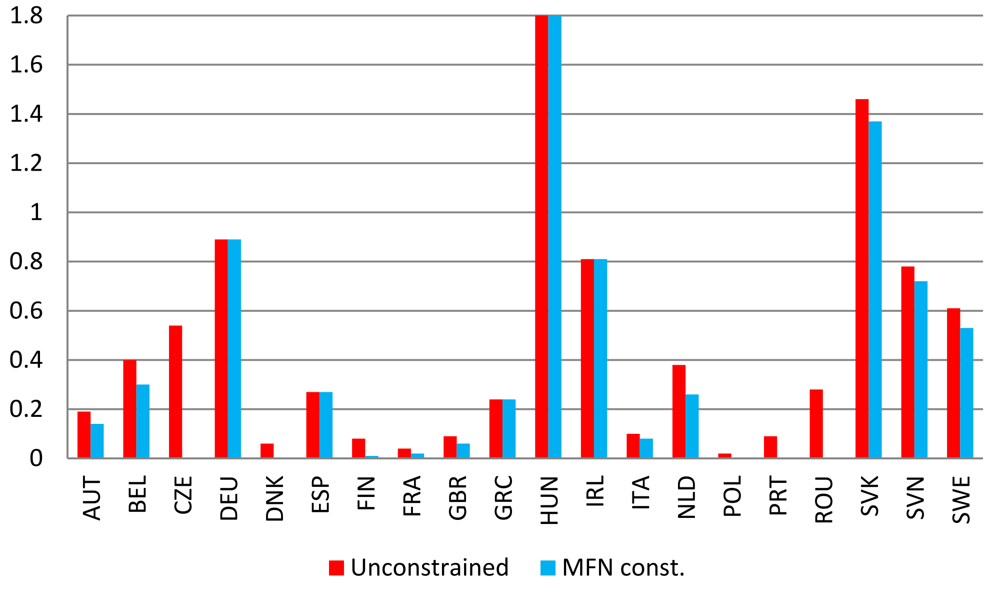


Figure 4d: Individual deviation without retaliation,
tariff rates with & without MFN constraints
% welfare (low trade elast., IRS)

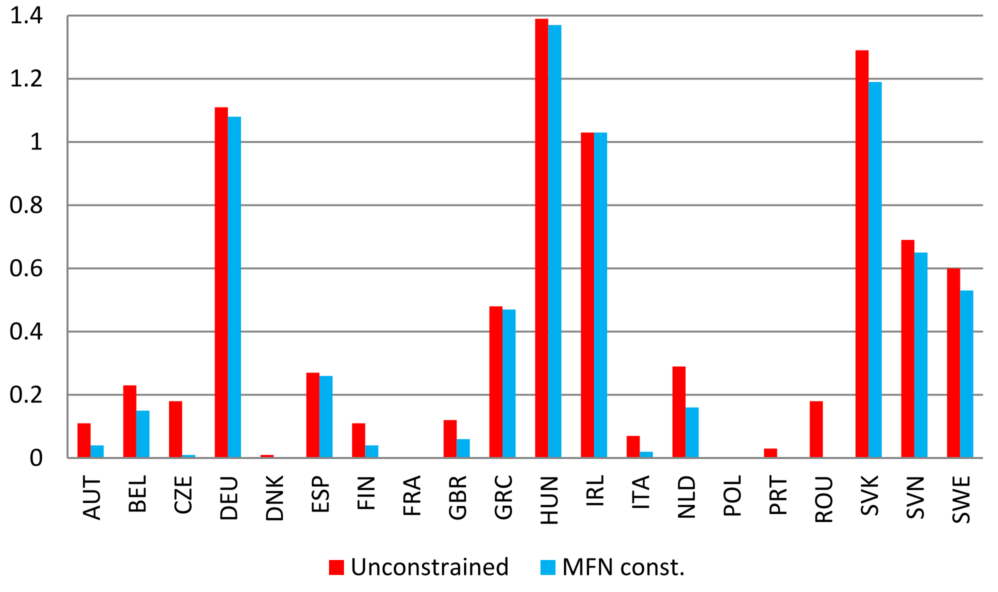


Figure 5a: Individual deviation without retaliation,
contribution of factor mobility and labor market adjustments
% welfare (high trade elast., CRS)

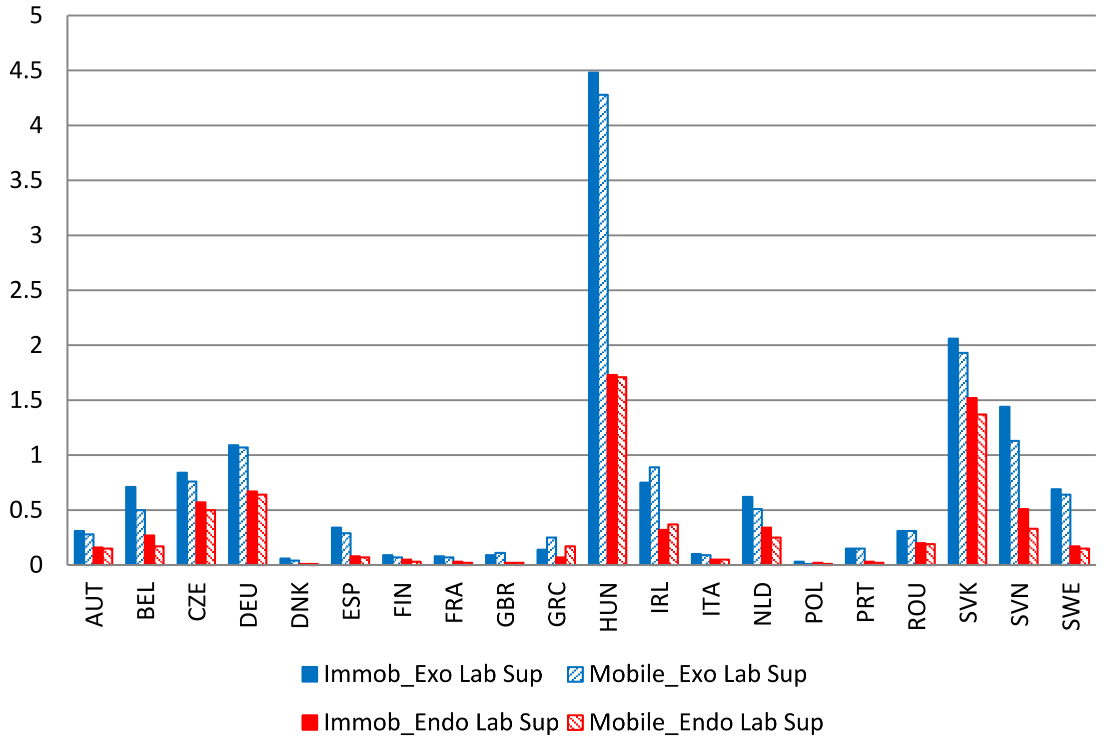


Figure 5b: Individual deviation without retaliation,
contribution of factor mobility and labor market adjustments
% welfare (high trade elast., CRS)

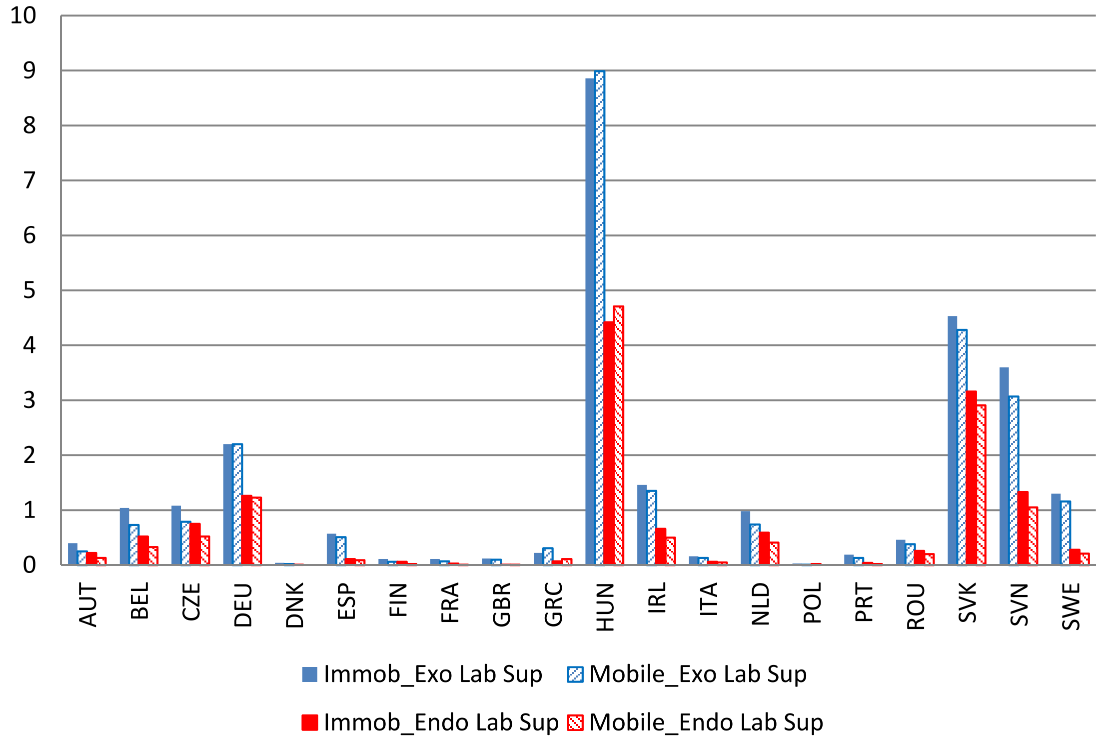


Figure 5c: Individual deviation without retaliation,
contribution of factor mobility and labor market adjustments
% welfare (high trade elast., IRS)

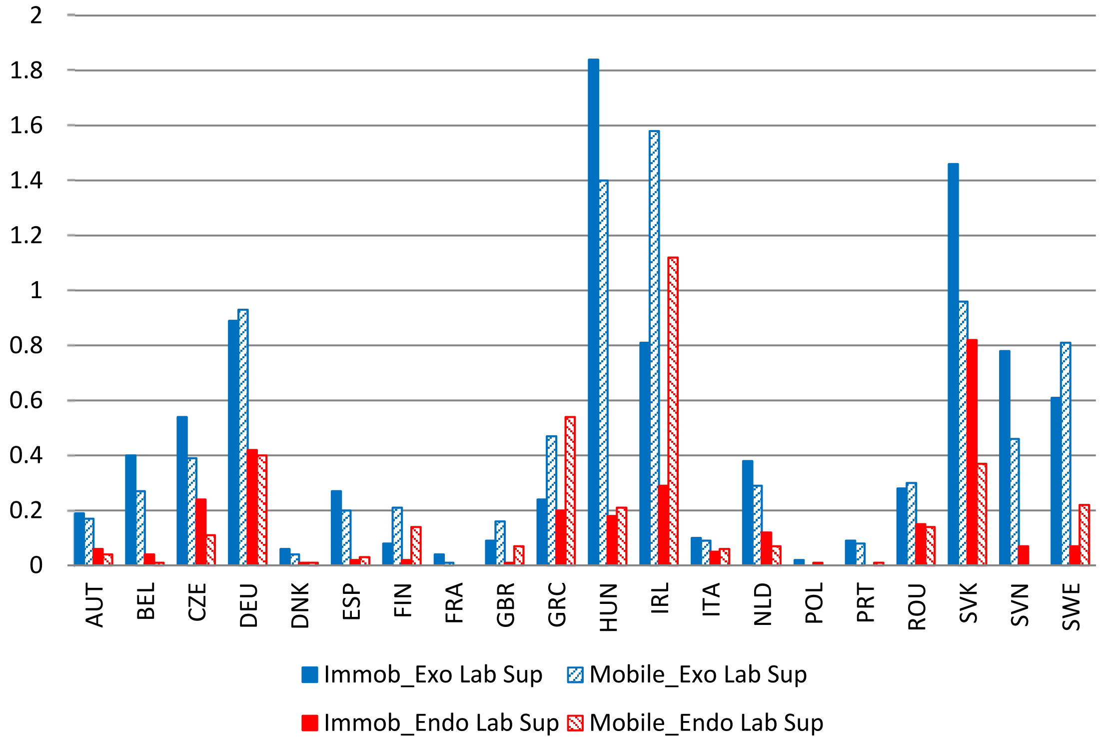


Figure 5d: Individual deviation without retaliation,
contribution of factor mobility and labor market adjustments
% welfare (low trade elast., IRS)

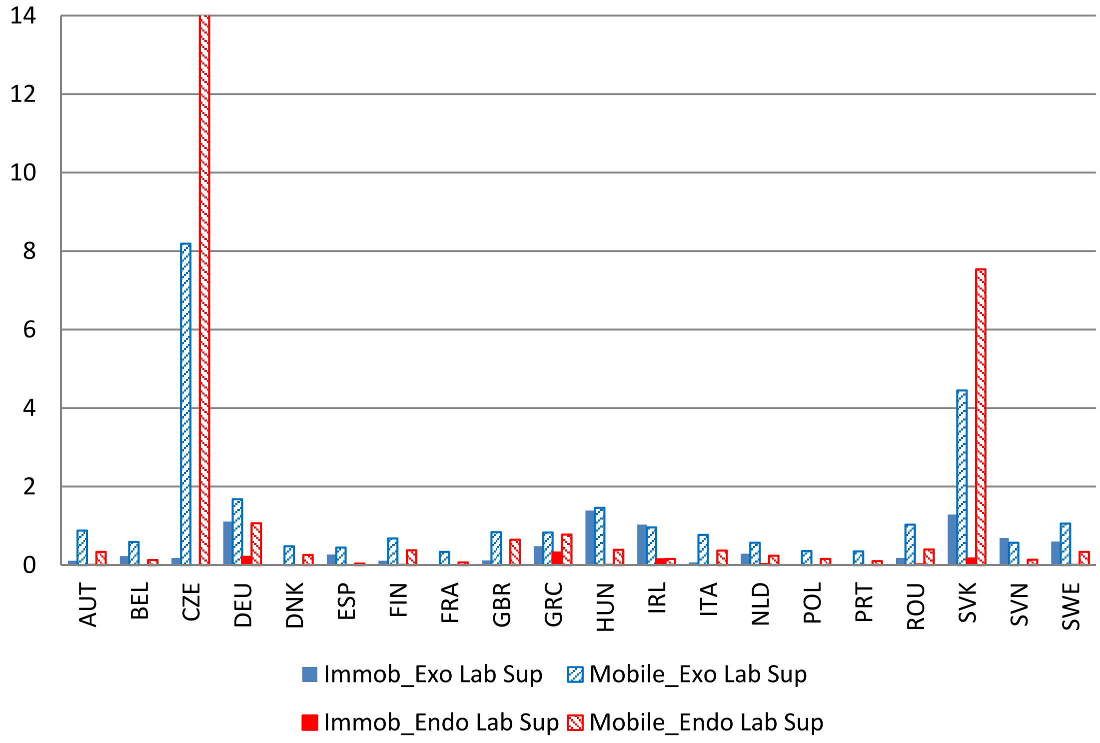


Figure 6: Individual deviation
with and without coordinated retaliation, % welfare
(low trade elast, immob factors, exo labor sup, CRS)

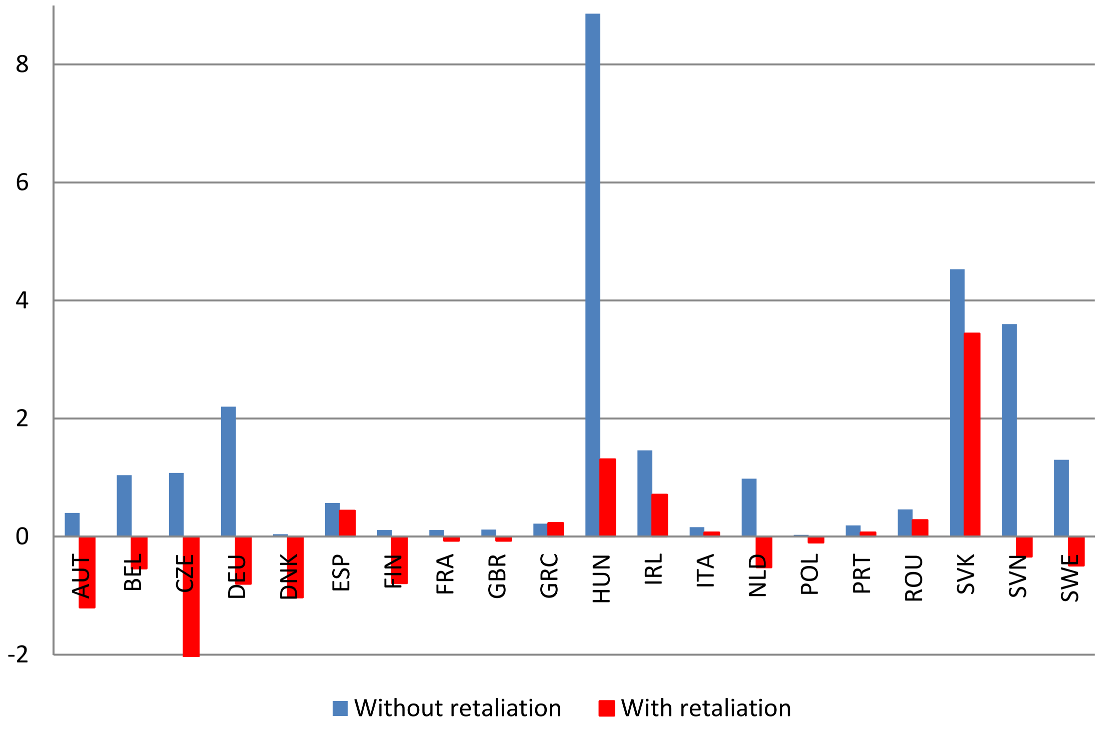


Figure 7a: Nash game in tariffs within the EU
% welfare, CRS

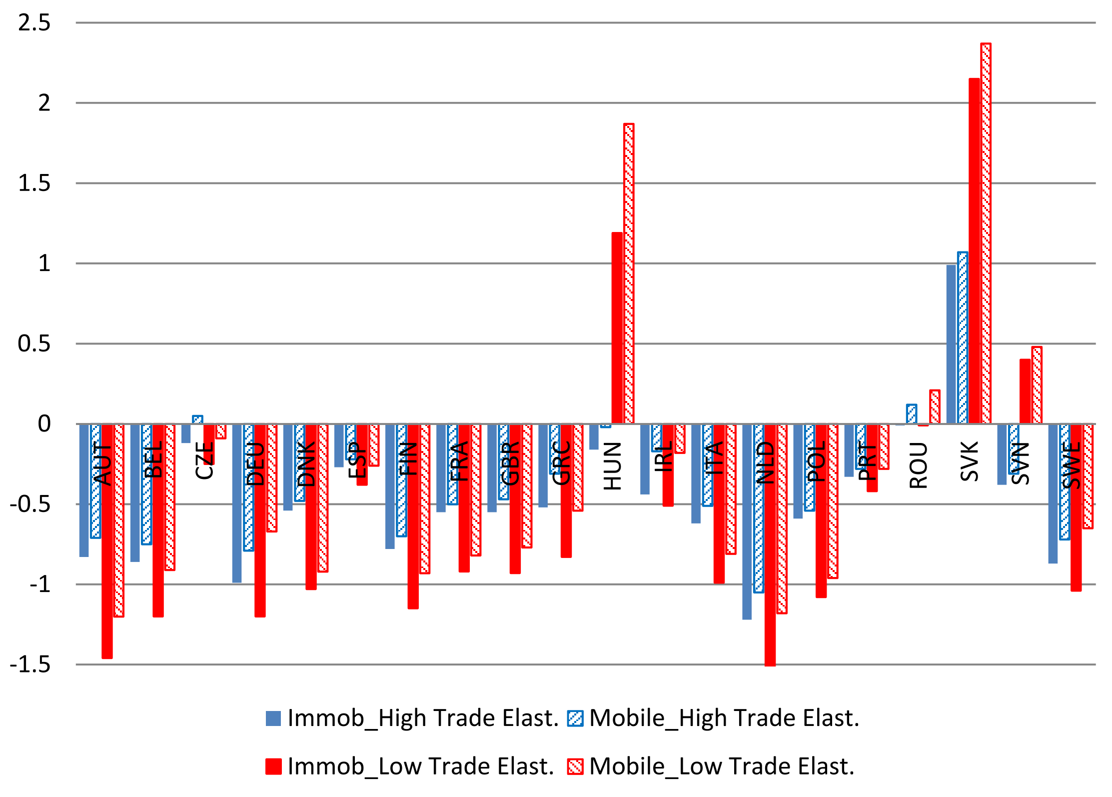
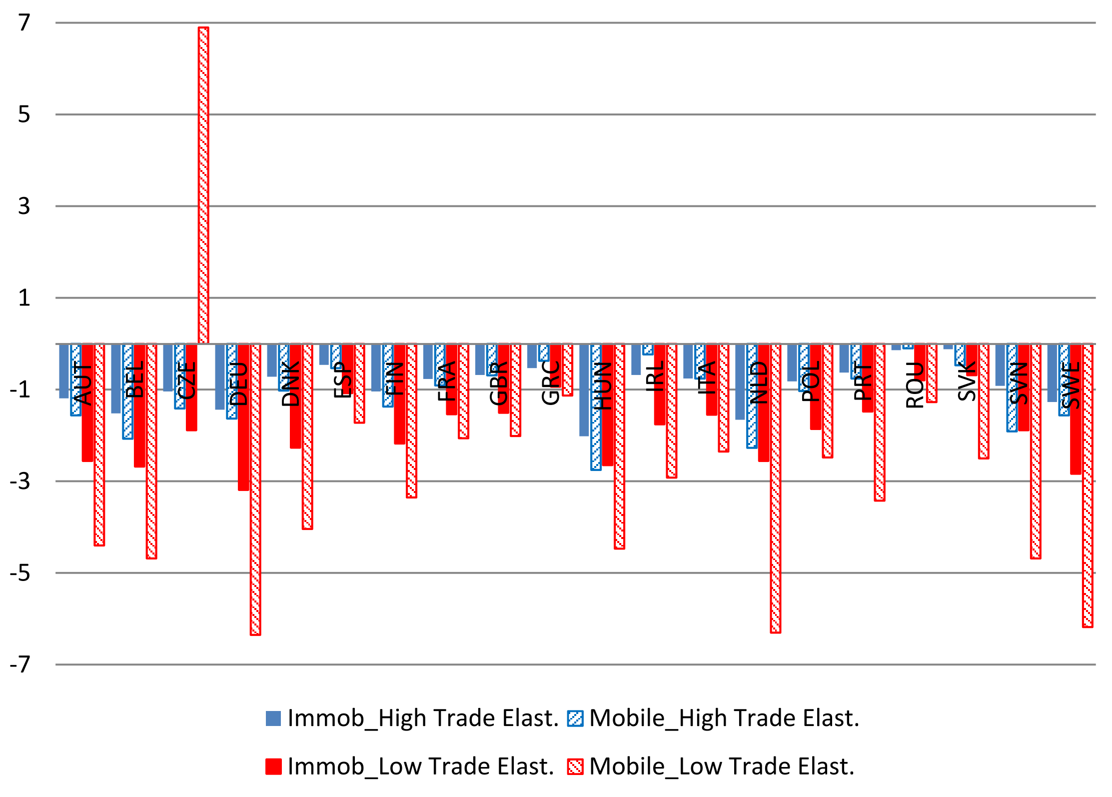


Figure 7b: Nash game in tariffs within the EU
% welfare, IRS



Appendix for the referee

Cooperation vs. Exit: a Quantitative Exploration of Euroscepticism in Trade

Formal Description of the calibrated GE Model

Note: As this appendix is not intended for publication, notations here do not strictly match those in the text (where they have been simplified).

Endogenous countries belong to the set $E27$ which includes the 27 member states of the European Union in 2007, our base year; the model is closed by a "rest-of-the-world" (here after RoW) that is kept exogenous except for the volume of its bilateral trade which is price responsive. The prices of the RoW serve as numeraire. Countries are indexed by $i, i' \in E27 \cup RoW$. All European countries have identical structures; in the description of the individual national economy that follows, we therefore drop the country subscript where no confusion can arise.

1 Households and Assets

The focus is not on within country distribution issues between income classes, so we aggregate all national households into a single agent. This representative agent is endowed with two types of labor, skilled and unskilled, indexed l in amount L^{Hou}_l. She endogenously allocates both type of labor services to different sectors of activity: $L^{sup}_{l,s}$ denotes the supply of labor type l to sector s. The household's allocation of labor across sectors is price-responsive resulting from labor income maximization subject to a constant elasticity of transformation (hereafter CET) frontier: a rising relative wage in one sector will therefore induce an inflow of labor to the sector, the size of which will depend on the value of an elasticity of transformation $\sigma^{L^{sup}}_l$; immobility can be imposed by setting the value of this parameter to zero. Solving the household's optimal labor allocation problem immediately yields the following supply system derived from first order conditions:

$$L^{sup}_{l,s} = \alpha^{L^{sup}}_{l,s} \left[\frac{p^{L^{sup}}_{l,s}}{p^{L^{Hou}}_{l}}\right]^{\sigma^{L^{sup}}_{l}} [1-UR_l]\ L^{Hou}_l \tag{1}$$

$$\left[p^{L^{Hou}}_l\right]^{1+\sigma^{L^{sup}}_l} = \sum_s \alpha^{L^{sup}}_{l,s} \left[p^{L^{sup}}_{l,s}\right]^{1+\sigma^{L^{sup}}_l} \tag{2}$$

where $p^{L^{sup}}_{l,s}$ is the price of labor type l earned by workers in sector s , $p^{L^{Hou}}_l$ is the ideal price aggregator over sectors for labor type l, and the αs are (simple transforms of) the CET share parameters; labor endowments are multiplied by a factor $[1-UR_l]$ that reflects the possible existence of unemployment at rate UR_l.

Households also own three types of assets: physical capital (K^{Hou}), local government bonds (B^{Gov}) and foreign bonds (B^{For}). The model is static and these stocks remain constant; furthermore, bonds are valued at RoW prices and bear interest at world rates which are both exogenous. The household therefore earns income by supplying labor and capital services, possibly earns unexpected super-natural profits from firms ($Prof^{Hou}$), benefits from government transfers (a flow denoted $Tr^{Gov\rightarrow Hou}$ assumed constant in real terms though valued at public consumption prices $p^{Con^{Gov}}$), and earns interests (at world rate r^{RoW}) on its holding of bonds. Finally, tariff revenues from all sectors (T^{Imp}) are rebated to him lump-sum by the Government. Collecting these terms, the household income writes as:

$$Inc^{Hou} = \sum_l p^{L^{Hou}}_l [1-UR_l]\ L^{Hou}_l + p^{K^{Hou}} K^{Hou} + Prof^{Hou} + p^{Con^{Gov}}\ Tr^{Gov\rightarrow Hou} + r^{RoW} p^{RoW} \left[B^{Gov} + B^{For}\right] + T^{Imp} \tag{3}$$

where $p^{K^{Hou}}$ is the rental price of physical capital services. Income taxes $T^{Inc^{Hou}}$ are collected by the Government at rates $\tau^{Inc^{Hou}}$:

$$T^{Inc^{Hou}} = \tau^{Inc^{Hou}} Inc^{Hou} \tag{4}$$

and household income, net of these taxes and of (local-CPI valued) fixed transfers abroad ($p^{Con^{Hou}} Tr^{Hou \to RoW}$) is shared between consumption and saving at base-year proportions:

$$\begin{aligned} Sav^{Hou} &= SavR \left\{ Inc^{Hou} - Tx^{Inc^{Hou}} - P^{Con^{Hou}} Tr^{Hou \to RoW} - StVar \right\} & (5) \\ Con^{Hou} &= (1 - SavR) \left\{ Inc^{Hou} - Tx^{Inc^{Hou}} - P^{Con^{Hou}} Tr^{Hou \to RoW} - StVar \right\} & (6) \end{aligned}$$

where $SavR$ is a parameter, and $StVar$ acknowledges base-year data on inventory adjustments, which are kept constant in terms of the numeraire.

The optimal composition of the aggregate consumption basket Con^{Hou}, as well as the ideal cost of living index $p^{Con^{Hou}}$ are jointly determined from intra-period utility maximization assuming CES preferences; from rearranging first order conditions, we obtain:

$$c_s^{Hou} = \alpha_s^{c^{Hou}} \left[\frac{p^{Con^{Hou}}}{p_s} \right]^{\sigma^{Con^{Hou}}} Con^{Hou} \tag{7}$$

$$\left[p^{Con^{Hou}} \right]^{1-\sigma^{Con^{Hou}}} = \sum_s \alpha_s^{c^{Hou}} \; [\, p_s]^{1-\sigma^{Con^{Hou}}} \tag{8}$$

where $\sigma^{Con^{Hou}}$ is the substitution elasticity, and the αs are (simple transforms of) the CES share parameters.

2 Producers

Production sectors are indexed s or $s\prime$. Some of these industries are perfectly competitive with firms making use of constant returns to scale (hereafter CRS) production functions, others operate increasing returns to scale (hereafter IRS) technologies within an imperfectly competitive market structure. These two subsets of industries are identified respectively as S^{CRS} and S^{IRS}.

In sectors $s \in S^{IRS}$, firms are assumed symmetric within national boundaries. We describe the individual producer's behavior so that all variables refer to a single firm. A firm faces a fixed production cost which we assume in the form of a real amount of foregone output denoted Fx_s; we then write the firms total production as $Z_s{+}Fx_s$ where Z_s represents the volume of sales. The presence of fixed costs introduces a wedge between average and marginal costs, respectively noted Av_s^{cost} and Ma_s^{cost}, which we formalize with the following relation:

$$Av_s^{cost} Z_s = Ma_s^{cost} \left[Z_s + Fx_s \right] \qquad s \in S^{IRS} \tag{9}$$

Large group monopolistic competition (i.e., competition in the form of a Nash game in prices) prevails so that the individual firm's optimal pricing strategy consists to mark-up its price p_s^Z over its marginal production cost:

$$\frac{p_s^Z - Ma_s^{cost}}{p_s^Z} = \frac{1}{\sigma_s^A} \qquad s \in S^{IRS} \tag{10}$$

where σ_s^A is the price elasticity of the demand curve that the firm faces. The definition of super-natural profits then immediately follows:

$$Prof_s = \left[p_s^Z - Av_s^{cost} \right] Z_s \qquad s \in S^{IRS} \tag{11}$$

We make the Chamberlinian assumption of cost-less entry/exit so that the number of competitors in each industry (N_s, $s \in S^{IRS}$), is endogenously determined to ensure these super-natural profits do not exist in equilibrium:

$$p_s^Z = Av_s^{cost} \qquad s \in S^{IRS} \tag{12}$$

In the other industries, those that belong to S^{CRS}, we set $Fx_s = 0$; perfect competition prevails and profit maximization imposes to firms to price their output at marginal cost:

$$p_s^Z = Ma_s^{cost} \qquad s \in S^{CRS} \tag{13}$$

In these industries, because of CRS, the scale of firms and their number are immaterial so we may set $N_s = 1$ for $s \in S^{CRS}$ without loss of generality: this proves convenient as many equations below will then be written identically for all sectors.

Marginal costs result from choosing optimal bundles of various variable inputs conditional on multilevel CES technical constraints that have common architecture for all $s \in S^{IRS} \cup S^{CRS}$; we therefore drop the sector subscript s in what follows to lighten expressions. At the upper level of this nested structure, a material input aggregate is combined with value added to produce output $Z + Fx$. Cost minimization yields the following optimal choice system:

$$X = \alpha^X \left[\frac{Ma^{cost}}{p^X}\right]^{\sigma^Z} [Z + Fx] \tag{14}$$

$$Q = \alpha^Q \left[\frac{Ma^{cost}}{p^Q}\right]^{\sigma^Z} [Z + Fx] \tag{15}$$

$$\left[\, Ma^{cost}\right]^{1-\sigma^Z} = \alpha^X \left[\, p^X\right]^{1-\sigma^Z} + \alpha^Q \left[\, p^Q\right]^{1-\sigma^Z} \tag{16}$$

where X and Q denote respectively volumes of material and value-added input aggregates, p^X and p^Q their associated prices, σ^Z the substitution elasticity, and the αs are (simple transforms of) CES share parameters. Aggregate material inputs are themselves CES bundles of goods from sectors $s\prime$ available locally at market prices $p_{s'}$; cost minimization yields the firm's intermediate demands:

$$XX_{s'} = \alpha_{s'}^{XX} \left[\frac{p^X}{p_{s'}}\right]^{\sigma^X} X \tag{17}$$

$$\left[\, p^X\right]^{1-\sigma^X} = \sum_{s'} \alpha_{s'}^{XX} \left[\, p_{s'}\right]^{1-\sigma^X} \tag{18}$$

with $XX_{s\prime}$ the firm's demand for goods from industry $s\prime$, σ^X a substitution elasticity parameter and the αs share parameters. Value added results from combining services from capital (Kap) and an aggregate labor (Lab) entrants, respectively priced p^{Kap} and p^{Lab}; these are imperfect substitutes with the technology imposing constant substitution elasticity; under cost minimization the optimal amount of services used for production is determined by:

$$Kap = \alpha^{Kap} \left[\frac{p^Q}{p^{Kap}}\right]^{\sigma^Q} Q \tag{19}$$

$$Lab = \alpha^{Lab} \left[\frac{p^Q}{p^{Lab}}\right]^{\sigma^Q} Q \tag{20}$$

$$\left[\, p^Q\right]^{1-\sigma^Q} = \alpha^{Kap} \left[\, p^{Kap}\right]^{1-\sigma^Q} + \alpha^{Lab} \left[\, p^{Lab}\right]^{1-\sigma^Q} \tag{21}$$

Lab is an aggregate factor that combines skilled and unskilled labor services supplied by local workers; the CES demand system for these services again immediately follows from cost minimization:

$$L_l^{dem} = \alpha_l^{L^{dem}} \left[\frac{p^{Lab}}{(1+\tau_l^L)\; p_l^L}\right]^{\sigma^{Lab}} Lab \tag{22}$$

$$\left[\, p^{Lab}\right]^{1-\sigma^{Lab}} = \sum_l \alpha_l^{L^{dem}} \left[(1+\tau_l^L)\; p_l^L\right]^{1-\sigma^{Lab}} \tag{23}$$

where τ_l^L are (possibly negative) fixed tax rates affecting the cost of labor services to firms. Similar taxes may also apply to the use of capital services so that:

$$K^{dem} = Kap \tag{24}$$

$$p^{Kap} = (1+\tau^k)\; p^k \tag{25}$$

where τ^k is the (possibly negative) tax rate.

We next collect the taxes paid by the firm on inputs:

$$T^k = \tau^k \;\; p^k K^{dem} \tag{26}$$

$$T_l^L = \tau_l^L \;\; p_l^L L_l^{dem} \tag{27}$$

and acknowledge existence of indirect taxes at fixed rates levied by national governments on local firms' sales:

$$T^Z = \tau^Z \; p^Z Z \tag{28}$$

3 The Government

Government income (Inc^{Gov}) includes capital rental revenues, income taxes payed by households, taxes payed on primary inputs by firms, as well as indirect taxes on products; formally:

$$Inc^{Gov} = p^{K^{Gov}} \; K^{Gov} + T^{Inc^{Hou}} + \sum_s N_s \left[T^k + \sum_l T_l^L + T^Z \right] \tag{29}$$

where all notations have been previously introduced except K^{Gov} which stands for the country's exogenous Government owned capital stock. This stock is endogenously allocated across sectors of activity using a CET frontier (with elasticity and share parameters denoted respectively $\sigma^{K^{Gov}}$ and $\alpha_s^{K^{Gov}}$). From the producers' viewpoint, this factor is no different than private capital and its rental price is therefore the same (p^k). It follows that:

$$k_s^{Gov^{sup}} = \alpha_s^{K^{Gov}} \; \left[\frac{p_s^k}{p^{K^{Gov}}} \right]^{\sigma^{K^{Gov}}} K^{Gov} \tag{30}$$

$$\left[p^{K^{Gov}} \right]^{1+\sigma^{K^{Gov}}} = \sum_s \alpha_s^{K^{Gov}} \; \left[\, p_s^k \right]^{1+\sigma^{K^{Gov}}} \tag{31}$$

Our interest is here limited to tariff protection policies only and we make assumptions so as to keep the public sector as neutral as possible. For this reason, we assume that the stock of domestic bonds (valued at price p^{RoW}) remains constant and carries the same constant interest rate r^{RoW} as foreign bonds. The government's budget constraint can then be written as:

$$Inc^{Gov} = r^{RoW} p^{RoW} B^{Gov} + p^{Con^{Gov}} Con^{Gov} + p^{Con^{Gov}} Tr^{Gov \rightarrow Hou} \tag{32}$$

which could define public aggregate consumption Con^{Gov} residually. We however want to avoid the possibility that a protectionist policy claims welfare gains that are actually due to its inducing a misleading substitution between public and private consumption at the expense of the former. For this reason, we fix the value of Con^{Gov} to its base-year level, and solve for the household income taxe rate $\tau^{Inc^{Hou}}$ that is consistent with this public consumption level. The sectoral composition of public consumption c_s^{Gov} is then determined by minimizing a CES cost function with low substitution elasticity $\sigma^{Con^{Gov}}$, which yields the following demand system

$$c_s^{Gov} = \alpha_s^{c^{Gov}} \; \left[\frac{p^{Con^{Gov}}}{p_s} \right]^{\sigma^{Con^{Gov}}} Con^{Gov} \tag{33}$$

$$\left[p^{Con^{Gov}} \right]^{1-\sigma^{Con^{Gov}}} = \sum_s \alpha_s^{c^{Gov}} \; \left[\, p_s \right]^{1-\sigma^{Con^{Gov}}} \tag{34}$$

4 The European Private Financial Market

We want to capture two important features of modern capital: first, efficient banking and mobility erase systematic differences in private rates of return on capital essentially protecting capitalists against idiosyncratic risks; second, in spite of this, the rental cost for firms of private physical capital is far from being equalized across countries within the EU. We capture these features by pooling all the physical capital of European households into a single European capital stock; this aggregate EU stock, denoted K^{E27}, is then optimally allocated to each country within the Union, and to each sector within each country, so as to maximize the rental revenues of the pooled capital subject to a two-level nested CET constraint. The value of the elasticities of transformation govern the concavities of the CET allocation frontiers, so that by choosing high or low values for these parameters, every thing else equal, it is possible to quantitatively assess the role of capital mobility; yet, the calibration of the CETs on base year data ensures that the simulated counterfactual equilibrium allocation remains anchored to the initial geographical distribution of EU physical capital. Formally, the optimal allocation of private physical capital services within the European Union will be determined by the following set of nested CET supply equations derived from first order conditions:

$$K_i^{sup} = \alpha_i^{K^{sup}} \left[\frac{p_i^K}{p^{K^{E27}}}\right]^{\sigma^{K^{E27}}} K^{E27} \qquad i \in E27 \tag{35}$$

$$\left[p^{K^{E27}}\right]^{1+\sigma^{K^{E27}}} = \sum_{i \in E27} \alpha_i^{K^{sup}} \left[\, p_i^K\right]^{1+\sigma^{K^{E27}}} \tag{36}$$

$$k_{i,s}^{sup} = \alpha_{i,s}^{K^{sup}} \left[\frac{p_{i,s}^k}{p_i^K}\right]^{\sigma_i^K} K_i^{sup} \qquad i \in E27 \tag{37}$$

$$\left[p_i^K\right]^{1+\sigma_i^K} = \sum_s \alpha_{i,s}^{K^{sup}} \left[\, p_{i,s}^k\right]^{1+\sigma_i^K} \qquad i \in E27 \tag{38}$$

The first equation determines the supply of private capital services to each national economy K_i^{sup} as a share of Europe's aggregate stock K^{E27}; the share adjusts endogenously to changes in relative rental prices within the E27. The second equation defines the ideal service price index of K^{E27}, a function of country specific capital rental prices p_i^K. These two equations are the FOC associated with the upper level CET. The next two equations characterize the optimal supply of physical capital across sectors within each country conditional on the second level CET constraint; here, $p_{i,s}^k$ is the rental price of private capital services payed by firms in sector s country i, and $k_{i,s}^{sup}$ is the amount of these services made available on that specific factor market.

We still have to define the aggregation process that determines K^{E27}; we formalize this as follows:

$$K^{E27} = \sum_i^{E27} K_i^{Hou} \tag{39}$$

Observe that with such a definition of the aggregate European capital stock, we have to reward each national household for its capital ownership at the same unit price $p^{K^{E27}}$ so that:

$$p_i^{K^{Hou}} = p^{K^{E27}} \qquad i \in E27 \tag{40}$$

Pooling capital also requires pooling savings, which determines Europe's real gross capital formation Inv^{E27} :

$$p^{Inv^{E27}} \, Inv^{E27} = \sum_{i \in E27} Sav_i^{Hou} \tag{41}$$

where $p^{Inv^{E27}}$ is the unit aggregate price of investment. To determine the composition of this investment good and its price, we assume a two-level CES technology, and write its cost-minimizing input structure as:

$$Inv_i = \alpha_i^{Inv} \left[\frac{p^{Inv^{E27}}}{p_i^{Inv}}\right]^{\sigma^{Inv^{E27}}} Inv^{E27} \tag{42}$$

$$\left[p^{Inv^{E27}}\right]^{1-\sigma^{Inv^{E27}}} = \sum_{i \in E27} \alpha_i^{Inv} \left[\, p_i^{Inv}\right]^{1-\sigma^{Inv^{E27}}} \tag{43}$$

$$I_{i,s} = \alpha^{I}_{i,s} \left[\frac{p^{Inv}_i}{p_{i,s}}\right]^{\sigma^{Inv}} Inv_i \tag{44}$$

$$\left[p^{Inv}_i\right]^{1-\sigma^{Inv}} = \sum_s \alpha^{I}_{i,s} \left[\, p_{i,s}\right]^{1-\sigma^{Inv}} \tag{45}$$

The upper level defines the composition of the European aggregate Inv^{E27} in terms of national sub-aggregate flows Inv_i , and the lower level the composition of the latter in terms of local goods from different sectors $I_{i,s}$; associated to each are the ideal price indices respectively $p^{Inv^{E27}}$ and p^{Inv}_i ; as usual, the σs and the αs are the substitution elasticities and share parameters respectively.

5 Trade

We collect all country i's demands for good s into a real variable $A_{i,s}$ (an acronym reminiscent of country i's absorption):

$$A_{i,s} = \sum_{s'} N_{i,s'}\ XX_{i,s,s'} + c^{Hou}_{i,s} + c^{Gov}_{i,s} + I_{i,s} \qquad i \in E27 \tag{46}$$

We make this good a cost minimizing CES aggregate of goods produced in the same industry by firms worldwide, and write the first order conditions as follow:

$$Exp_{i',i,s} = \alpha^{Exp}_{i',i,s} \left[\frac{p_{i,s}}{(1+\tau^{Imp}_{i',i,s})\ (1+\tau^{Z}_{i',s})\ p^{Z}_{i',s}}\right]^{\sigma^A_s} A_{i,s} \qquad i', i \in E27 \cup RoW \tag{47}$$

$$p_{i,s}^{1-\sigma^A_s} = \sum_{i'} N_{i',s}\ \alpha^{Exp}_{i',i,s} \left[\ (1+\tau^{Imp}_{i',i,s})\ (1+\tau^{Z}_{i',s})\ p^{Z}_{i',s}\right]^{1-\sigma^A_s} \qquad i', i \in E27 \cup RoW \tag{48}$$

Here, $Exp_{i',i;s}$ is the total demand by country i of goods produced by an individual producer of sector s in country $i\prime$; the good is sold at price $(1+\tau^{Z}_{i',s})p^{Z}_{i',s}$ but bought at this price increased by the import tariff at rate $\tau^{Imp}_{i',i,s}$; in this system, if $i \in RoW$, $N_{i,s} = p_{i,s} = p^{Z}_{i,s} = 1$ and $A_{i,s} = \overline{A_{i,s}}$ for all s, because the rest of the world is assumed exogenous. Observe that these equations also apply if $i = i'$, defining therefore for each endogenous country the domestic demand functions for the domestically produced goods.[1] Observe also that, in perfectly competitive industries where there is a single aggregate producer ($N_{i\prime,s} = 1,\ s \in S^{CRS}$) this is a specification that captures the Armington assumption; in imperfectly competitive industries we have a form of Dixit-Stiglitz-Ethier specification. We can now define the tariff revenues that show in household i's budget constraint:

$$T^{Imp}_i = \sum_{i',s} N_{i',s}\ Exp_{i',i;s}\ \tau^{Imp}_{i',i,s}\ (1+\tau^{Z}_{i',s})\ p^{Z}_{i',s} \tag{49}$$

6 Equilibrium conditions

On each market for good s, equilibrium requires that quantities supplied by a firm is indeed demanded:

$$Z_{i',s} = \sum_i Exp_{i',i,s} \tag{50}$$

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[1] The parameters $\alpha^{Exp}_{i',i,s} = 0$ for $i\prime, i \in RoW$ by calibration to base year data.

Sector specific wages ensure that supply and demand balance, so that

$$L_{l,s}^{sup} = N_s \ L_{l,s}^{dem} \tag{51}$$

where for each type of labor l, the short term unemployment rate is either assumed fixed to its base year level, or endogenized by use of a reduced form wage curve:

$$\text{Ln}\left[\frac{p_l^{L^{Hou}}}{p^{Con^{Hou}}}\right] = -\varepsilon_l \ \ \text{Ln}\left[\frac{UR_l}{UR_{0l}}\right] \tag{52}$$

Market equilibrium for physical capital services requires that:

$$k_{i,s}^{sup} + k_{i,s}^{Gov^{sup}} = N_{i,s} \ K_{i,s}^{dem} \tag{53}$$

All European agents satisfy their budget constraints, and equilibrium is imposed on each market, therefore we know from Walras' law that the *RoW* budget constraint is redundant as should automatically be satisfied; we check that this is indeed the case:

$$\begin{aligned} &\sum_{i \in E27} \left\{ p_i^{Con^{Hou}} Tr_i^{Hou \to RoW} \ + \ \sum_s p_{RoW,s}^Z \ N_{RoW,s} \ Exp_{RoW,i,s} \right\} \\ &= \sum_{i \in E27} \left\{ \sum_s \ (1 + \tau_{i,s}^Z) \ p_{i,s}^Z \ N_{i,s} \ Exp_{i,RoW,s} \right\} + \ r^{RoW} \ p^{RoW} B^{RoW} \end{aligned}$$