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Trade Wars: Economic impacts of US tariff increases and retaliations

An international perspective

Johannes Bollen
Hugo Rojas-Romagosa

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Johannes Bollen
Hugo Rojas-Romagosa

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Summary

Effect trade conflict limited, escalation only has losers

In January 2018, the US announced higher trade tariffs on solar panels that are imported mainly from China. They then announced in March 2018 that they would increase trade tariffs on steel and aluminum, including for the EU and NAFTA countries. In response to higher tariffs, China, the EU, Canada and Mexico filed a retaliatory package with the WTO. But the US also announced additional tariffs for other Chinese products in early April 2018. Immediately after that, China reacted again with the publication of a list of goods with a retaliatory 25% tariff increase. Our base case trade conflict scenario

This background document provides information on the economic consequences of the current trade dispute between the US and several countries that announced retaliatory packages or filed them already with the WTO. To this end, we also look at the consequences at the sectoral level, and analyze this from an international perspective. We also use the announced tariff increases by the US and the reported retaliatory tariff packages from China, the EU, Canada and Mexico. To obtain the global, national and sectoral economic impacts of these scenarios, we employ WorldScan, which is the CPB's global CGE model.

The economic effects of this trade conflict are limited, with the exception of a number of sectors in China and the US. The Chinese GDP loss will eventually increase to 1.2% of GDP. The GDP loss for the US will be limited to 0.3% due to the market power that they have. Other countries, including the EU, will even benefit from reduced trade between the US and China, Canada and Mexico. However, the initial indirect EU benefits will largely evaporate when the US decides to also levy import tariffs on cars. At the sector level, the trade conflict will lead to significant shifts, especially in the US and China. These shifts concern sectors like the 'electronic equipment sector', 'other machine equipment' and agriculture.

However, a full blown escalation of the trade conflict to a trade war only has losers. Illustrative simulations show this, with both the US and its trading partners increasing the tariffs on all imports. In that case strong effects will already occur at modest levels of the tariffs. At higher rates the loss will continue to rise, but less quickly, because all sectors are already being priced out of the market. For the US it is crucial how many countries they involve in this trade war. The loss is particularly strong when the conflict is extended to 'other OECD countries', including Canada and Mexico. Anyway, China will be the most hurt economically by a trade war.

1 Introduction

In January 2018, the US announced higher trade tariffs on solar panels that are imported mainly from China. They then announced in March 2018 that they would increase trade tariffs on steel and aluminium, including for the EU and NAFTA countries. These measures were temporarily deferred for some countries (e.g. Canada, Mexico and the EU) but finally imposed on June 1st.[1] After this announcement, most partners reacted to these US tariffs by announcing retaliatory tariffs of their own. For example, the EU has provided the WTO with a list of US products that will face 25% additional tariffs when entering the EU (WTO, 2018). Similar measures have been announced by Canada and Mexico.

Moreover, in a separate policy action in April 2018, the US announced it would impose additional tariffs on Chinese imports for a broader set of products. These US tariffs are on top of the steel and aluminium (S&A) tariffs and respond to different strategic decisions by the US --i.e. reduce it trade deficit with China, and negotiate better market access to US firms and issues related with intellectual property rights. In turn, the Chinese administration announced retaliatory measures (Bown, 2018).

However, the state of the trade policies is still in flux. For instance, the US and Chine where negotiating possible solutions, until on June 15th the US decided to impose the tariffs it announced in April, while China retaliated the day after with its own tariffs on June 16th. The US is also currently involved in trade negotiations regarding changes to the NAFTA agreement it has with Canada and Mexico. After the EU announced its retaliatory measures, the US administration threatened to impose a 25% duty on motor vehicle imports from the EU. Therefore, the final outcome regarding announced and retaliatory tariffs is uncertain and this makes it difficult to design concrete policy scenarios. In addition, there is also the possibility of an escalation of these trade wars.

The objective of this paper is to estimate the global and national economic effects of the different trade conflict scenarios currently developing, as well as scenarios where there is an escalation into a broader trade war. In particular, we want to know: what are the national and sectoral effects for a broad set of countries of the tariff increases associated with these trade conflicts or extended trade wars?

We construct trade policy scenarios based on the underlying trade-weighted average tariffs from the official country announcements. This includes the US tariff increases in steel and aluminium, and the unilateral increase of tariffs to imports from China, as well as the responses by its trading partners: the EU, China, Canada and Mexico. This is our base case

[1] After bilateral negotiations, some countries were permanently exempted from these tariffs: Argentina, Brazil, Australia and South Korea. These countries negotiated import quotas and other trade measures with the US to avoid the tariff increases.

trade conflict scenario, which is taken from the proposals mentioned or filed at the WTO.[2] This scenario is the basic scenario in the June projection of CPB (2018). Then, we also explore a slightly more speculative trade conflict scenario, which includes tariffs for motor vehicles from the EU to the US.

In our last set of scenarios, we analyse the economic consequences of an escalation in bilateral and multilateral trade wars between the US and its trading partners. For these scenarios, we run a large number of simulations in which we increase tariffs uniformly for all agriculture and manufacturing goods. We run multiple simulations with uniform tariff increases starting at 2.5%, with discrete tariff raises until an upper limit of a 40% uniform tariff is reached. These simulations, therefore, assess the potential economic impact of a trade war escalation where the number of targeted products is very wide and the tariff rates --in this case the average tariff by sector -- are rising. In addition, we simulate a sequential trade war escalation: first the US enters a trade war with both the EU and China, and then we add a trade war between the US and the rest of OECD countries --i.e. Canada, Mexico, Japan and Korea, among others.

To estimate the economic impacts of these scenarios, we employ a computational general equilibrium (CGE) model of the world economy: WorldScan (see Lejour et al., 2006 and Appendix 1). This global trade model allows us to assess the impact of tariff increases between bilateral partners, but also, the general equilibrium effects to other countries indirectly affected by the policies. In addition, WorldScan provides detail outcome results on national changes in GDP, consumption, and sectoral production and employment, for a wide set of countries and sectors. This allows us to obtain a broad view of the global and national impact of the tariff increases associated with these trade conflicts.

[2] The list of products included in the June announcements by both the US and China is very similar, but not the same as those announced on April. However, due to time constraints, in this paper we evaluate only the tariffs proposed in April 2018.

2 Methodology and design of the trade policy scenarios

The estimation of large trade policy shocks in a global environment requires the use of a global general equilibrium modelling framework. In this study, we employ WorldScan, which is the CPB in-house computational general equilibrium (CGE) model (Lejour et al, 2006). In this section we first detail the main characteristics of the WorldScan version we use. Then we explain how we simulate the trade policy changes associated with the announced tariffs increases by the US administration, the retaliatory measures by its trade partners, and possible trade war escalation scenarios.

2.1 WorldScan

As a CGE model, WorldScan allows to analyse the global, regional and national macroeconomic effects at the sectoral (industry) level. The structure of WorldScan and its underlying database are part of the GTAP-class CGE models.[3] By using a global input-output table with trade data between all countries, it allows to assess the impact of country- and region-specific trade policy shocks. It is the standard tool to assess trade policy changes, and is widely used by international organisations.

The key features of a CGE framework are: i. the model that describes economic activity and behaviour, given a set of parameters that drive responses of agents to any given perturbation to the initial equilibrium (e.g. trade elasticities); ii. the underlying database that accounts for initial equilibrium of the global economy (i.e. the GTAP database). By employing a balanced and internally consistent global database, in tandem with an economic model that describes economic activity for a variety of sectors and agents in the global economy, any change in exogenous variables --for example, a tariff increase-- can be assessed to understand the effects on the endogenous variables in the model. For example, trade policies are assessed by imposing changes in bilateral tariffs or non-tariff measures (NTMs) to a baseline scenario. The resulting counterfactual scenario is then compared with the baseline to obtain the potential economic effects of the policy shock.[4]

The particular WorldScan model employed in this paper uses the latest version available of the GTAP database (version 9 with base-year 2011) and distinguishes 29 goods and services sectors, and 30 countries and regions (see Tables A.1-A.2 in the Appendix). The US, Canada, Mexico, China, Japan and most EU-15 (old member states) are modelled separately, to

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[3] The main characteristics and references to the standard GTAP model can be found at: www.gtap.agecon.purdue.edu/models/current.asp, while Hertel (2013) and Rutherford and Paltsev (2000) provide a detailed discussion of the GTAP-class models.
[4] A more detailed and technical explanation of the WorldScan CGE model is provided in Appendix.

account for the main countries affected by potential tariff increases by the US. The sectoral aggregation reflects some of the main goods that have been targeted for US tariff increases (e.g. steel and aluminium).

The model departs from the standard GTAP model by incorporating a monopolistic competition setting and endogenous labour supply mechanisms. In addition, it is a recursive dynamic model that provides year-to-year estimations between 2011 and 2030. In our sensitivity section we analyse what are the effects of using instead a model with perfect competition and an exogenous labour supply.

2.2 Design of trade policy scenarios

Our departing point to construct the trade policy shocks are the officially announced tariff increases by different countries. It is important to keep in mind, however, that tariffs are applied to individual products. Since we are modelling at an aggregated sectoral level (including tens or hundreds of products), we need to take provisions to account for this aggregation problem. We do so by estimating sectoral trade-weighted average tariff, which provide an estimation of the relative importance of individual product tariffs within the sector based on the current trade values. In particular, we use the UN Comtrade database available through the World Bank's World Integrated Trade Solutions (WITS) website (wits.worldbank.org) to obtain the 2017 import values at the product level in current US$. We obtain the import value of the products targeted for tariff increases, as well as the total import values for each GTAP sector. Using the announced product tariff in combination with the share of imports of the targeted products in the total imports of that sector, we obtain the sectoral trade-weighted average tariff.

2.2.1 Scenario 1: US unilateral steel and aluminium (S&A) tariffs[5]

In March 2018 the US administration, through Presidential Proclamations 9704 and 9705 officially determined the steel products that will face a 25% tariff increase and the aluminium products that will have a 10% tariff increase. We use the specified targeted products identified in these official documents, which uses the Harmonized System (HS), at the 4- and 8-digit level. Combining this data with the UN Comtrade data and the concordances between the HS and the GTAP classification, we calculate the sectoral trade-weighted average tariffs (see Table 2.1). Here we observe that the targeted sectors, in which steel and aluminium products are aggregated (I_S, NFM and FMP) represent around 7% of total US imports.[6] But the specific weight of the targeted products is 75% of the steel sector (I_S), 31% of the NFM sector (which also includes other mineral) and just 3% of the FMP sector of fabricated metal products. This means that the proposed 25 and 10% tariffs are much lower in trade-weighted terms: 18.9% for the steel sector, 3% and 0.3% for the sectors with aluminium products. In total, the targeted steel and aluminium products represent just

[5] The abbreviations used for sectors are explained in Appendix 2.

[6] All steel products targeted are aggregated into the GTAP iron and steel (I_S) sector. The aluminium products are mostly part of the non-ferrous metal (NFM) sector and some are part of the fabricated metal products (FMP) sector.

2.2% of total US imports, and the announced tariffs are equivalent to a 0.41% tariff on total imports.

Table 2.1 Estimated trade-weighted average tariffs for the US tariff announcements, 2017

	US total imports			
sector	Total imports	targeted % trade	nominal tariff	trade-weighted average tariff
1 AGR	2,2%			
2 OIL	6,0%			
3 ENG	2,8%			
4 OMN	0,3%			
5 PFO	4,5%			
6 TAP	5,2%			
7 LEA	1,7%			
8 LUM	2,8%			
9 PPP	1,1%			
10 CRP	12,3%			
11 NMM	1,1%			
12 I_S	1,8%	75,4%	25%	18,86%
13 NFM	2,5%	30,5%	10%	3,05%
14 FMP	2,4%	3,0%	10%	0,30%
15 MVH	13,2%			
16 OTN	2,6%			
17 ELE	14,2%			
18 OME	19,5%			
19 OMF	3,9%			
Total	**100,0%**	**2,2%**		**0,41%**

Our first scenario assumes the unilateral increase of steel and aluminium tariffs by the US to all its partners --excluding exempted countries: Argentina, Australia, Brazil and South Korea.

2.2.2 Scenario 2: Retaliation over US steel and aluminium tariffs

After the US announced the tariff increases, several of the main trading partners of the US reacted with retaliatory tariffs of their own. First, China notified the WTO in March 2018 of the products it will target to retaliate (WTO, 2018a). In total, China targeted 128 products, including fruits, processed food and alcoholic beverages, besides steel and aluminium products. Most products have an additional tariff of 15%, with the exemption of steel and pork products, which are taxed at 25%. We use the information provided in the Annex II of this WTO notification with trade data for 2014, to estimate the share of trade by the targeted products with respect to the total trade by sector (using UN Comtrade for 2014). Thus we can estimate the trade-weighted average tariffs (Table 2.2.2). China targeted products worth around 2.7 billion US$ of imports from the US (about 1.8% of the total Chinese imports from the US). The sectoral trade-weighted average tariffs are below 10%, since the targeted products represent less than 30% of the total imports of each related sector. The overall tariff increase is equivalent to a 0.4% tariff in all US exports to China. This is similar to the overall trade-weighted average tariff from the US tariff increase (0.47%). This relates to the WTO provision that the retaliatory action should be proportional to the initial tariff increase.

Table 2.2 Estimated trade-weighted average tariffs for the Chinese retaliation, 2017

	Chinese imports from US			
sector	Total imports	targeted % trade	nominal tariff	trade-weighted average tariff
1 AGR	15.3%	1.8%	15%	0.3%
2 OIL	0.0%			
3 ENG	1.3%			
4 OMN	1.5%			
5 PFO	3.8%	14.6%	24%	3.5%
6 TAP	0.8%			
7 LEA	0.3%			
8 LUM	1.1%			
9 PPP	3.5%			
10 CRP	14.9%			
11 NMM	1.1%			
12 I_S	0.5%	29.7%	15%	4.5%
13 NFM	3.2%	25.3%	25%	6.3%
14 FMP	1.1%			
15 MVH	9.5%			
16 OTN	12.1%			
17 ELE	8.7%			
18 OME	21.2%			
19 OMF	0.3%			
Total	**100.0%**	**1.8%**		**0.40%**

Second, after the US did not extend the temporary exemptions of the tariffs granted to the EU, Canada and Mexico, these countries announced retaliatory tariffs of their own. So far, other countries affected by the US steel and aluminium tariffs, such as Japan and India, have not lodged formal retaliation measures. However, it is possible they can do this in the future. For this study, we only estimate the retaliatory tariffs officially notified until June 4th. [7]

The EU already sent a notification to the WTO on May (WTO, 2018b), in which it identifies more than 200 US products (at the HS 8-digit level) to be targeted with a 25% additional tariff (and 10% tariffs for a few products).[8] The targeted products represent around 3.8 billion US$ of EU imports from the US. From Table 2.3 we observe that this accounts for 1.9% of the total EU imports from the US and the targeted products represent less than a third of the total sectoral imports. This generates sectoral trade-weighted average tariffs of less than 7% and an overall average tariff of 0.47%.

[7] Recall that Argentina, Australia, Brazil and South Korea where permanently exempted from the US steel and aluminium tariffs.

[8] Annex I of WTO (2018) presents the list of US products that will have a tariff increase in mid-June 2018, while Annex II present an additional list of products that can be targeted, with tariffs varying from 10 to 50%, in 2021.

Table 2.3 Estimated trade-weighted average tariffs for the EU retaliation, 2017

	EU imports from US			
sector	Total imports	targeted % trade	nominal tariff	trade-weighted average tariff
1 AGR	3.4%	3.4%	25%	0.9%
2 OIL	2.7%			
3 ENG	6.5%			
4 OMN	0.7%			
5 PFO	2.8%	15.1%	25%	3.8%
6 TAP	0.9%	4.7%	25%	1.2%
7 LEA	0.2%	1.5%	25%	0.4%
8 LUM	0.8%			
9 PPP	1.9%			
10 CRP	28.3%	0.7%	25%	0.2%
11 NMM	1.4%			
12 I_S	0.8%	26.8%	25%	6.7%
13 NFM	4.4%	2.4%	25%	0.6%
14 FMP	2.5%	11.9%	25%	3.0%
15 MVH	6.7%			
16 OTN	2.3%	15.8%	25%	4.0%
17 ELE	5.1%			
18 OME	25.4%	0.2%	25%	0.1%
19 OMF	3.3%	1.9%	10%	0.2%
Total	**100.0%**	**1.9%**		**0.47%**

Third, on May 31st, the Canadian government notified its retaliatory tariffs on more than 100 US products (Canada Department of Finance, 2018). They define two groups of products; the first will face additional tariffs of 25% and the second 15%. Using the UN Comtrade data, we calculate that the targeted products represent 7.2% of the total US exports to Canada. Note that this is a much larger percentage share than the retaliatory measures by the EU and China, which can be related to Canada being proportionally more affected by the US tariffs. Consequently, the overall trade-weighted average tariff is 1.07%, which is also almost double of previous countries. In particular, from Table 2.4, we see that the targeted steel products (I_S) represent up to 82% of the steel imports from the US, which yields a sectoral trade-weighted average tariff of 20.4%. In addition, the targeted aluminium and processed food products (NFM and PFO) account for 34 and 22%, respectively, of the total imports of their sectors.

Table 2.4 Estimated trade-weighted average tariffs for the Canadian retaliation, 2017

	Canadian imports from US			
sector	Total imports	targeted % trade	nominal tariff	trade-weighted average tariff
1 AGR	2.8%			
2 OIL	3.1%			
3 ENG	5.7%			
4 OMN	1.0%			
5 PFO	7.0%	22.2%	10%	2.2%
6 TAP	1.1%			
7 LEA	0.1%			
8 LUM	1.6%	3.4%	10%	0.3%
9 PPP	3.2%	12.5%	10%	1.3%
10 CRP	16.2%	9.1%	10%	0.9%
11 NMM	1.5%			
12 I_S	2.8%	81.6%	25%	20.4%
13 NFM	2.2%	33.6%	10%	3.4%
14 FMP	2.9%	13.9%	13%	1.8%
15 MVH	23.7%			
16 OTN	3.9%			
17 ELE	2.3%			
18 OME	17.9%	1.7%	10%	0.2%
19 OMF	0.9%	3.4%	10%	0.3%
Total	**100.0%**	**7.2%**		**1.07%**

Finally, Mexico announced on June 4th that it will also respond to the US tariffs (Diario Oficial de la Federación, 2018). They target around 50 products with additional tariffs that vary from 7 to 25%. As with the other countries retaliating to the US, these targeted products also include steel and aluminium, but additionally comprise other products such as processed foods (pork, cheese), fruits and vegetables and even some transport equipment (mainly boats). Overall, the targeted products account for around 4.4 billion US$ of US exports to Mexico. In Table 2.5 we calculate that this represents 2.3% of the total Mexican imports of US goods (based on the UN Comtrade data). The targeted products account for less than 30% of their respective sectoral imports, and thus, the sectoral trade-weighted average tariffs are below 7%. The overall average tariff is 0.47%, which is in line with the retaliation magnitude from other countries, with the exemption of Canada.

Our second scenario, therefore, employs the previously calculated sectoral trade-weighted average tariffs related to the retaliation measures by China, the EU, Canada and Mexico. In particular, we combine these tariffs increases with the previous increase of US tariffs as the policy shocks for this scenario.

Table 2.5 Estimated trade-weighted average tariffs for the Mexican retaliation, 2017

	Mexican imports from US			
sector	Total imports	targeted % of trade	nominal tariff	trade-weighted average tariff
1 AGR	4.2%	3.4%	20%	0.7%
2 OIL	0.0%			
3 ENG	16.2%			
4 OMN	0.3%			
5 PFO	5.7%	22.7%	19%	4.4%
6 TAP	1.9%			
7 LEA	0.2%			
8 LUM	1.1%	3.6%	7%	0.3%
9 PPP	2.8%			
10 CRP	17.9%			
11 NMM	0.9%			
12 I_S	2.7%	26.1%	25%	6.5%
13 NFM	2.6%			
14 FMP	3.6%	0.3%	15%	0.0%
15 MVH	14.4%			
16 OTN	1.1%	0.5%	15%	0.1%
17 ELE	3.4%			
18 OME	20.7%	0.6%	11%	0.1%
19 OMF	0.4%			
Total	**100.0%**	**2.3%**		**0.47%**

2.2.3 Scenario 3: US-China trade sanctions

Besides the steel and aluminium tariff increases, the US announced in early April 2018 an additional set of tariff increases specifically targeted at China. The US published a list of Chinese products that will face a 25% tariff increase. This separate trade policy action by the US was the result of an investigation of Chinese unfair trade practices (under Section 301 of the Trade Act of 1974) that was launched in August 2017 (Bown, 2018). Almost immediately, the Chinese reacted by publishing a list of their own that details US imports that will face a 25% tariff increase. As explained above, both governments officially imposed these tariff changes on June 15th (US) and June 16th (China). Due to time constraints, we do not estimate these new measures nor compare them with the previously announced targeted sectors in April. However, we expect that both sets of tariffs are very similar, since the overall level of affected bilateral trade --US$ 50 billion-- is equivalent in both cases.

Using the same procedure to estimate trade-weighted average tariffs, Table 2.6 presents the estimation of the tariff increases associated with this US-China trade sanctions.[9] The US targeted Chinese imports by an estimated value of 46.2 billion US$, which represents 8.9% of the total US imports from China. Hence, the 25% tariff at the targeted product level translates into an overall trade-weighted average tariff of 2.2%. This is a major escalation of

[9] In this case we use the product-level trade values of the targeted products compiled by Bown (2018), for both the US and the Chinese product list.

the tariff increase with respect to the previous steel and aluminium tariff increase, which had an overall average tariff of 0.47%.

Table 2.6 Estimated trade-weighted average tariffs for US-China trade sanctions

	US imports from China				Chinese imports from US			
sector	Total imports	targeted % trade	nominal tariff	trade-weighted average tariff	Total imports	targeted % trade	nominal tariff	trade-weighted average tariff
1 AGR	0.2%				14.1%	78.3%	25%	19.6%
2 OIL	0.0%				0.1%			
3 ENG	0.1%				1.5%	83.3%	25%	20.8%
4 OMN	0.1%				1.1%			
5 PFO	1.1%				3.8%	3.0%	25%	0.7%
6 TAP	8.7%				0.6%			
7 LEA	4.3%				0.3%			
8 LUM	5.5%	1.3%	25%	0.3%	1.3%			
9 PPP	1.2%				3.8%			
10 CRP	7.2%	2.1%	25%	0.5%	15.7%	26.4%	25%	6.6%
11 NMM	1.6%				1.0%			
12 I_S	0.4%	5.6%	25%	1.4%	0.4%			
13 NFM	0.5%	46.3%	25%	11.6%	3.9%			
14 FMP	3.9%	2.1%	25%	0.5%	1.1%			
15 MVH	2.8%	12.6%	25%	3.1%	10.7%	81.8%	25%	20.4%
16 OTN	0.7%	35.0%	25%	8.8%	12.0%	98.8%	25%	24.7%
17 ELE	33.6%	5.5%	25%	1.4%	7.7%			
18 OME	21.2%	27.8%	25%	7.0%	20.6%			
19 OMF	7.0%				0.4%			
Total	**100.0%**	**8.9%**		**2.2%**	**100.0%**	**37.2%**		**9.3%**

In retaliation, the Chinese targeted products worth 49.8 billion US$ of US exports or a 37.2% of the total US exports into China. Although the targeted absolute trade values of both policy measures are very similar, there are large differences in the targeted share of total trade. This reflects the large trade surplus that China has with the US. In 2017, China imported around 135 billion US$ from the US, while it exported around 520 billion US$ to the US: a trade surplus of roughly 385 billion US$. Given the large share in total US imports of the targeted products by China, its 25% tariff increase is translated into an overall trade-weighted average tariff of 9.3%. This is almost five times higher than the overall average tariff implicit in the initial US tariff change.

For our third scenario, we assume the initial tariff increases are applied, plus these reciprocally tariffs by both the US and China. Thus, in this scenario we estimate the economic effects of the initial stages of a more serious US-China trade conflict.

2.2.4 Scenario 4: US tariffs on motor vehicles

After the EU reacted to the US steel and aluminium tariffs with a list of US imports to face retaliatory tariffs in March 2018, the US counteracted with the threat to impose additional tariffs on EU motor vehicles. This threat was made more likely when the US started an investigation under Section 232 on automobile trade. In our fourth scenario, we assume that the US unilaterally imposes a 25% tariff on all automobile products, which translates into a uniform increase in the tariff of the sector (MVH) of 25%. Hence this scenario has the reciprocal tariff increases associated with the steel and aluminium tariffs (i.e. scenario 2), in addition to reciprocal 25% tariffs on the MVH sector between the US and the EU.

2.2.5 Other Scenarios: Trade war escalations

One of the main characteristics of the previous tariff increases is the almost immediate retaliatory process. The affected countries immediately react with threats of counterbalance trade measures, which are usually of the same magnitude but sometimes even higher than the initial tariff increase. This process could further escalate through internal dynamics in more tariff increases. To capture the process where the number of targeted products and the level of the tariffs are bilaterally raised, we create a final set of scenarios where bilateral tariffs are raised for all non-services sectors at increasingly higher tariff rates. We model this by imposing uniform tariff increases (i.e. for all traded products), which captures the tendency of the escalation to include more products in each stage. Note that this scenario is for illustrative purposes only and is not meant to be a projection of future tariffs.

We have two scenarios related to trade war escalations:

i. The US, china, and the EU engage in a trade war with uniform tariffs increasing from 2.5% to 25% (each uniform tariff level is a simulation in the context of this scenario)
ii. In addition to the two previous trade war variant, the US in these scenarios also has trade wars with all remaining OECD countries (i.e. Canada, Mexico, Japan, South Korea, Australia and the rest of the OECD).

2.2.6 Summary of the trade policy scenarios

Based on the descriptions and explanations above, we thus define the following scenarios:

Trade Conflict scenarios: announced tariff changes:

- Scenario 1: Unilateral steel and aluminium tariffs by the US
- Scenario 2: Scenario 1 plus retaliatory tariffs by China, the EU, Canada and Mexico.
- Scenario 3 Scenario 2 plus US-China trade war (our base case scenario)
- Scenario 4: Scenario 3 plus 25% tariff increase by the US on motor vehicles (MVH) imports from the EU.

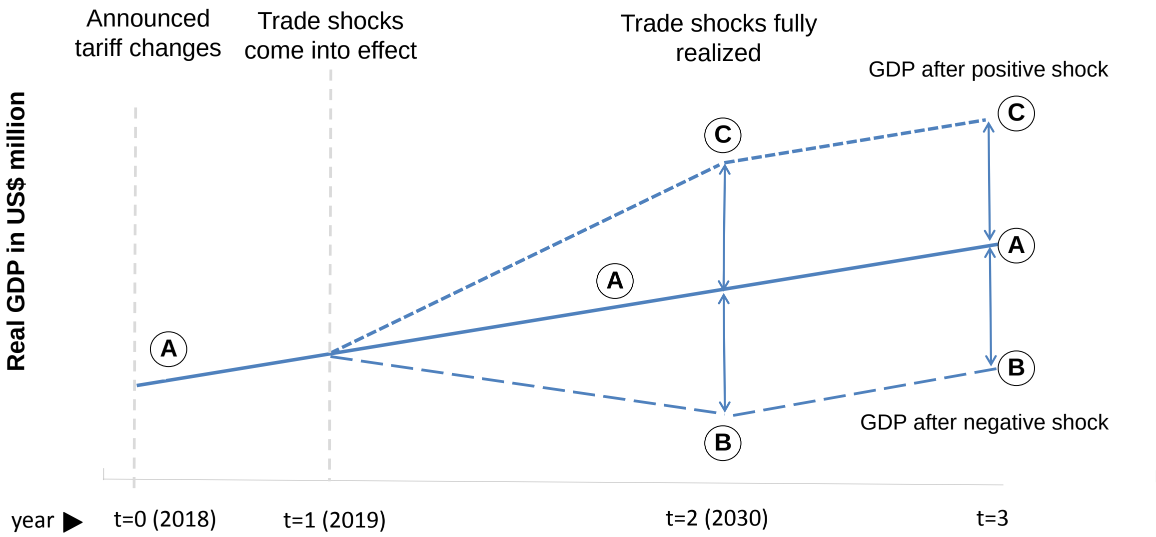
Trade war escalation scenarios:

- Scenario 5: US-EU plus US-China trade war escalation
- Scenario 6: Scenario 5 plus a trade war between the US and the rest of OECD countries.

3 Results

In this section, we present the results of the trade conflict scenarios from the WorldScan simulations. To illustrate how the results must be interpreted, Figure 3.1 shows how the simulation results compare with the baseline values. In this figure, the A line represents the baseline (business as usual scenarios with no trade policy changes). The line B is a trade shock with negative GDP effects (e.g. tariff increases). In our results we report the difference between B (depending on the shock) with respect to A in 2030 (t = 2). Hence, the economic losses represent a permanent level effect of GDP, but only a transitional increase in GDP growth. As Figure 3.1 illustrates, after t = 2, GDP continues growing at the same baseline levels and the final impact of the trade shock is to permanently increase (decrease) the GDP levels. A similar approach is followed for countries experiencing positive effects of the trade shock, as represented by the evolution of GDP on line C.

Figure 3.1 Changes in GDP levels related to different trade policy shocks



In what follows, we present each of the scenario results, which we divided into the announced trade policies (trade conflict) and the trade escalation scenarios (trade war).

3.1 Announced policies

Table 3.1 presents the main macroeconomic results of the first four scenarios, for the main countries involved: US, China, Europe (EU), the Netherlands (NLD), Canada (CAN), Mexico (MEX), Japan, and the entire World.

Table 3.1 Simulation results, main macroeconomic effects (%) compared to the baseline in 2030

	USA	China	EU	NLD	CAN	MEX	Japan	World
Scenario 1: Unilateral US tariffs on steel and aluminium								
GDP (%)	0,0	0,0	-0,1	-0,1	-0,3	-0,2	0,0	-0,1
Export volume (%)	-1,6	0,0	-0,1	-0,1	-1,3	-1,0	-0,1	-0,3
Import volume (%)	-1,0	0,0	-0,1	-0,2	-1,5	-1,4	-0,1	-0,3
Terms-of-trade (%)	0,4	0,1	0,0	0,0	-0,3	-0,5	0,0	0,0
Real average wage (%)	0,0	0,0	-0,1	-0,1	-0,3	-0,1	0,0	0,0
Scenario 2: Reciprocal US Steel and aluminium tariffs and retaliations from China, the EU, Canada and Mexico								
GDP (%)	-0,4	0,2	0,2	0,3	-0,1	-0,2	0,2	0,1
Export volume (%)	-6,3	-0,9	-0,1	0,0	-7,3	-4,8	0,2	-1,0
Import volume (%)	-4,8	-0,9	-0,2	0,0	-6,1	-5,5	0,1	-1,0
Terms-of-trade (%)	-0,4	-0,1	0,1	0,1	1,1	0,1	0,0	0,0
Real average wage (%)	-0,3	0,1	0,2	0,3	-0,1	-0,2	0,2	0,0
Scenario 3: Steel and aluminium tariffs and retaliations, plus a US-China trade war*								
GDP (%)	-0,3	-1,2	0,4	0,4	0,2	0,5	0,4	-0,1
Export volume (%)	-13,5	-8,2	0,0	0,1	-6,4	-2,0	0,3	-2,5
Import volume (%)	-10,5	-8,4	0,0	0,0	-5,6	-2,7	0,3	-2,5
Terms-of-trade (%)	-0,6	-0,8	0,1	0,1	0,9	0,3	0,2	0,0
Real average wage (%)	-0,1	-1,1	0,3	0,4	0,2	0,4	0,4	-0,1
Scenario 4: Steel and aluminium tariffs and retaliations, US-China trade war plus US automobile tariff increases								
GDP (%)	-0,3	-1,3	0,2	0,2	0,3	0,6	0,4	-0,1
Export volume (%)	-14,0	-8,3	-0,5	-0,1	-5,7	-1,4	0,5	-2,7
Import volume (%)	-10,9	-8,4	-0,5	-0,2	-5,1	-2,1	0,5	-2,7
Terms-of-trade (%)	-0,5	-0,8	0,0	0,1	0,8	0,3	0,2	0,0
Real average wage (%)	0,0	-1,1	0,1	0,2	0,3	0,5	0,4	-0,1

Source: WorldScan simulations using sectoral trade-weighted average tariffs from Section 2. Note: *Base case in CPB (2018).

Scenario 1: Unilateral US tariffs on steel and aluminium

In this first scenario (see table 3.2 and figure 3.2), the unilateral imposition of steel and aluminium tariffs by the US has a very limited impact on the US economy and that of its trading partners. Nevertheless, there are no winners. The effects are slightly negative or very close to zero. In general, the imposition of tariffs has negative effects on exports to the US (first column Table 3.2), while the other changes result from a sub-optimal adjustment of resources to alternative activities in the world. It can also be seen that mostly Canadian and European exports will decline. [10] As a result, as exports to the US drop, production in the same "iron and steel" (I_S) sector is mildly positively affected in the US as they aim to maintain consumption (Figure 3.2), thereby attracting resources from other sectors in which the US has relatively less comparative advantage, such as "electric equipment" (ELE), "other machinery equipment" (OME) and "other transport" (OTN).

As with any tariff, its first and direct effect is to hinder trade, and we observe in Table 3.1 that trade is decreasing for all countries, except China. Tariffs imposed on the other countries

[10] The losses to Canada and Mexico are explained by the larger integration of these countries within the North-American Free Trade Agreement (NAFTA). Since NAFTA is currently being renegotiated, the implications for Canada and Mexico will be far greater if the current status-quo in NAFTA is changed. For a recent analysis of the potential economic effects of the NAFTA renegotiation, see Robison and Thierfelder (2018).

are more damaging, and China is capable of filling the gap created by export reductions by other countries (EU, Canada, and Mexico). This is related to over-capacity in the steel and aluminium sectors in China, which can still be competitive at lower prices. From Table 3.1 it is also important to note, that the unilateral imposition of the tariffs by the US grants them a favourable terms-of-trade (ToT) effect, with a small gain of 0.4%. This ToT gains offset the consumption and production losses in the US.[11] However, these terms-of-trade gains are lost the moment that its trade partners retaliate.

Overall, the negative effects on aggregate production are caused by distortions in the economy that result in a sub-optimal assignment of resources to different activities. Moreover, they also impose higher prices on consumers and users of intermediate goods. In the case of steel and aluminium products, which are mainly intermediate inputs for many industries, these additional tariffs increase the cost of production of downstream industries that employ these products as inputs. As can be seen, in the lower production by the "electric equipment" (ELE) and "other machinery equipment" (OME) sectors.

Table 3.2 Scenario 1: Real export value changes compared to the baseline in 2030, in US$ billion

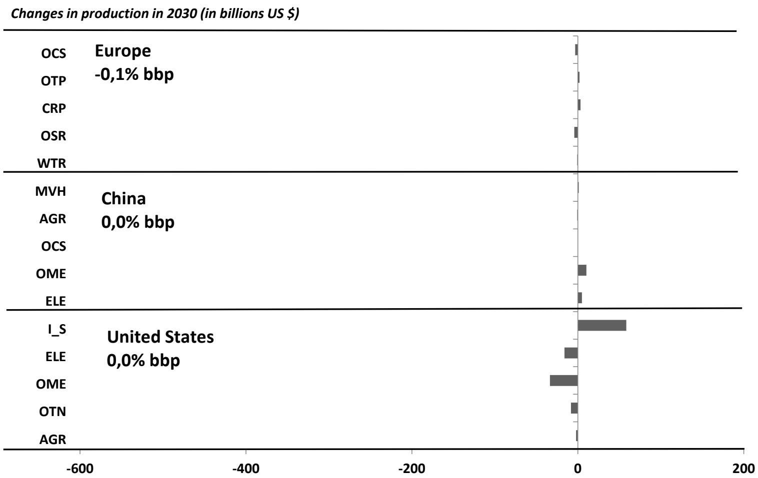
	Country of destination						
	USA	China	EU27	Netherlands	Canada	Mexico	Japan
Country of origin:							
USA		-3	-5	0	-5	-3	-1
China	4		0	0	0	0	0
EU27	-4	0		0	0	0	0
Netherlands	0	0	0		0	0	0
Canada	-5	0	0	0		0	0
Mexico	-3	0	0	0	0		0
Japan	0	0	0	0	0	0	

Source: WorldScan simulations using sectoral trade-weighted average tariffs from Section 2. Note: EU 27 =EU28 –Netherlands.

However, the economy-wide effects are limited because the steel and aluminium sectors are relatively small and its production is just part of a broader set of inputs required by its downstream industries. For most countries there is no aggregate real GDP effect or it is negative but small. This is also reflected in the changes in real wages, which are very similar to those of real GDP for most scenarios.

[11] The terms-of-trade is a macro-indicator based on the average export price to the average import price. Hence, sector-switches and a price change in a particular sector (because of changes in market power) can change the terms-of-trade.

Figure 3.2 Scenario 1: GDP (%) and Production (bn US$), changes compared to the baseline in 2030



Source: WorldScan simulations using sectoral trade-weighted average tariffs from Section 2.
Notes: We only report sectors with the largest changes.

Scenario 2: Reciprocal US Steel and aluminium tariffs and retaliations from China, the EU, Canada and Mexico

Once we account for the retaliatory tariffs by the US trading partners, we find that the US incurs a small real GDP loss, together with Canada and Mexico –although Canada reduces its initial losses from scenario 1.Other partners (China, EU and Japan) even gain in this scenario, although it is only a small positive gain, see Table 3.1 and Figure 3.3. The main reason why there is a GDP gain for this countries, is that with the tariff retaliation, these countries have a positive ToT effect that drives the small GDP changes. In addition, the multilateral retaliation creates trade diversion effects that partially compensate for the lost trade with the US (Table 3.3).

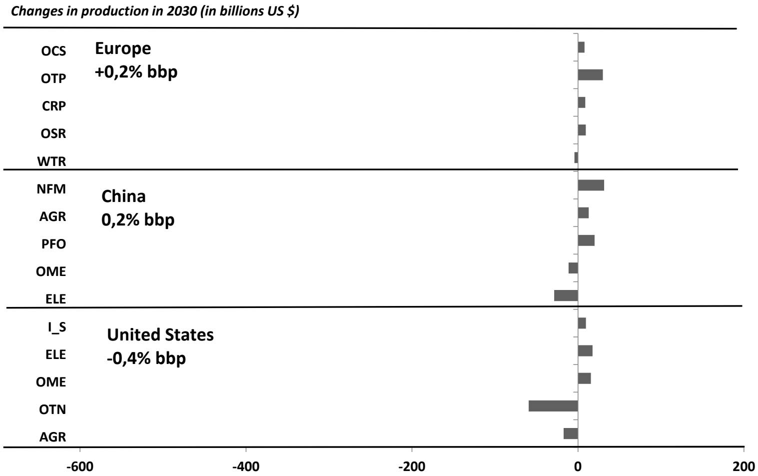
Table 3.3 Scenario 2: Real export values, changes compared to the baseline in 2030, in US$ billion

			Country of destination				
	USA	China	EU27	Netherlands	Canada	Mexico	Japan
Country of origin:							
USA		-49	-78	-3	-67	-22	3
China	-29		3	0	5	0	-2
EU27	-30	0		1	6	0	-1
Netherlands	-2	0	2		0	0	0
Canada	-36	-1	-3	0		0	-1
Mexico	-26	0	1	0	1		0
Japan	-5	3	2	0	1	0	

Source: WorldScan simulations using sectoral trade-weighted average tariffs from Section 2. Note: EU 27 = EU28 –Netherlands.

The retaliation by other countries evaporates the production gains in the US in “iron and steel” (I_S). At the same time, “electronic equipment” (ELE) and “other machinery equipment” (OME) slightly gain, in comparison to the losses from scenario 1. However, the initial gains in terms-of-trade (scenario 1) turn into a loss of equal size in scenario 2. These negative ToT effects, in combination with the larger trade US reductions generate the real GDP losses for the US in this scenario.

Figure 3.3 Scenario 2: GDP (%) and Production (bn US$), changes compared to the baseline in 2030



Source: WorldScan simulations using sectoral trade-weighted average tariffs from Section 2.
Note: We only report sectors with the largest changes.

Scenario 3: Steel and aluminium tariffs and retaliations, plus a US-China trade war[12]

The second set of US policy changes was to impose additional tariffs to China on a broader set of products that go well beyond the initial steel and aluminium products. . The quick response by the China to target US imports worth 50 billion US$ can be viewed as an initial step towards a much more serious trade conflict between both countries.

Table 3.4 Scenario 3: Real export value changes compared to the baseline in 2030, in US$ billion

			Country of destination				
	USA	China	EU27	Netherlands	Canada	Mexico	Japan
Country of origin:							
USA		-249	-87	-3	-68	-17	2
China	-406		15	1	7	3	1
EU27	-3	-13		2	8	1	-1
Netherlands	0	0	3		0	0	0
Canada	-29	-1	-3	0		0	-1
Mexico	-4	-1	-1	0	1		0
Japan	7	-9	3	0	1	1	

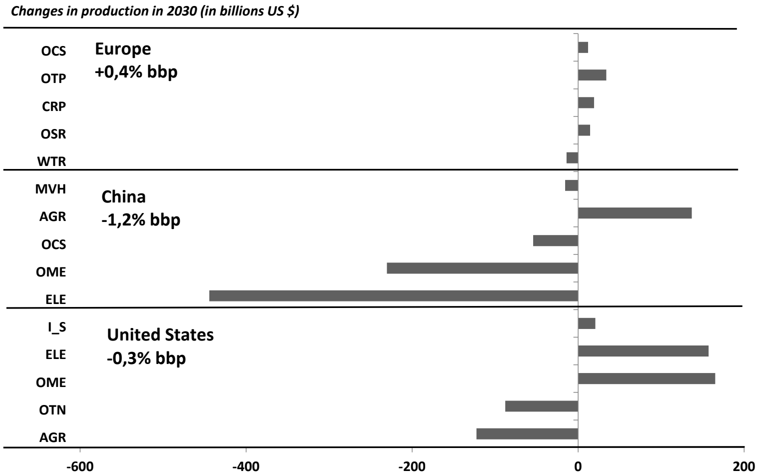
Source: WorldScan simulations using sectoral trade-weighted average tariffs from Section 2. EU 27 = EU28 –Netherlands.

From Table 3.4 we clearly observe that trade between China and USA is being significantly affected. For example USA exports to China decline by US$ 249 billion (compare with US$49 billion in scenario 2). Also, we can see that the EU's exports to the USA decline by only 3 billion, which is much less than in scenario 2 (-32 billion) . Thus, the the China-US trade conflict diverts trade to other partnes, and this enables the EU to regain the initial lost exports to the US, even though the EU is still confronted with the US tariffs on steel and aluminium. The reason is that the EU countries (including the Netherlands) step in the gap from lower Chinese exports to the US. At the same time the EU's exports to China declines, due to reductions on Chinese demand (China's GDP drops with 1.2%). Overall, the exports by

[12] This is the base case scenarios presented in CPB (2018).

the EU27 and the Netherlands increase from the trade conflict between US and China, exports go back to the baseline BAU level or become even larger than the BAU. This is also reflected in EU's small production gain (compare Figure 3.4 with Figure 3.3).

Figure 3.4 Scenario 3: GDP (%) and Production (bn US$), changes compared to the baseline in 2030



Source: WorldScan simulations using sectoral trade-weighted average tariffs from Section 2.
Notes: We only report sectors with the largest changes.

From Table 3.1 and Figure 3.4, we observe that China bears also the largest losses at the macro-economic level, with a permanent real GDP loss of 1.2% and a decrease in its total exports of around 9%. The US is also negatively affected (0.3% real GDP loss), but significantly less than China and less than with the reciprocal steel and aluminium tariffs. But the accumulated effect of both policies is a reduction of its overall trade by around 14%. The asymmetric outcome between China and the US is a result of the market power of the US, which consumes relatively a large share of Chinese exports. This outcome is also explained by the large trade deficit that the US has with China. Concluding, retaliation by China has a relatively small impact on US exports. On the contrary, the other OECD countries analysed (including the EU), experience some small gains by increasing their exports to the US (and/or China) to compensate for the lost bilateral trade between these countries. At the macro level, they also greatly benefit from ToT gains.

Scenario 4: Steel and aluminium tariffs and retaliations, US-China trade war plus US automobile tariff increases

Our final scenario from the group of announced tariffs aggregates all the previous scenarios: unilateral US steel and aluminium tariffs, the corresponding retaliation by the affected countries and the US-China trade war, Finally, it includes the US unilateral 25% tariff increase for automobile (MVH) imports from the EU. We find the additional effects of these MVH tariffs to be limited, where mainly the EU is negatively affected: a GDP decline of 0.2% when compared with scenario 3 (see table 3.1).

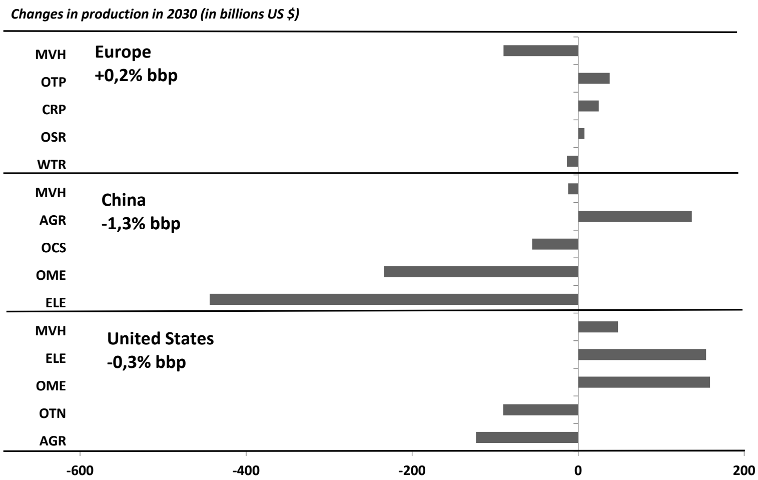
Tabel 3.5 Scenario 4: Real export value changes compared to the baseline in 2030, in US$ billion

			Country of destination				
	USA	China	EU27	Netherlands	Canada	Mexico	Japan
Country of origin:							
USA		-250	-93	-4	-68	-17	1
China	-403		10	1	7	3	2
EU27	-46	-12		2	8	2	0
Netherlands	-1	0	1		0	0	0
Canada	-24	-1	-3	0		0	-1
Mexico	0	-1	-1	0	1		0
Japan	11	-9	2	0	1	1	

Source: WorldScan simulations using sectoral trade-weighted average tariffs from Section 2. Note: EU 27 = EU28 -Netherlands

However, for this scenario the sectoral impacts are particularly important, with the “motor vehicles” (MVH) sector being significantly affected in the EU. On the other hand, other sectors, such as “other transport equipment” (OTN) benefit, but do not compensate for the MVH sector losses. Here, also the country-specific results within the EU are less homogenous than before. In particular, Germany experiences significant losses in the “motor vehicles” (MVH)sector. Germany’s initial real GDP gains from scenario 3drop to zero, whereas the gains in for example the Netherlands and the EU drop but by less (and still remain positive at around 0.2%.

Figure 3.5 Scenario 4: GDP (%) and Production (bn US$), changes compared to the baseline in 2030



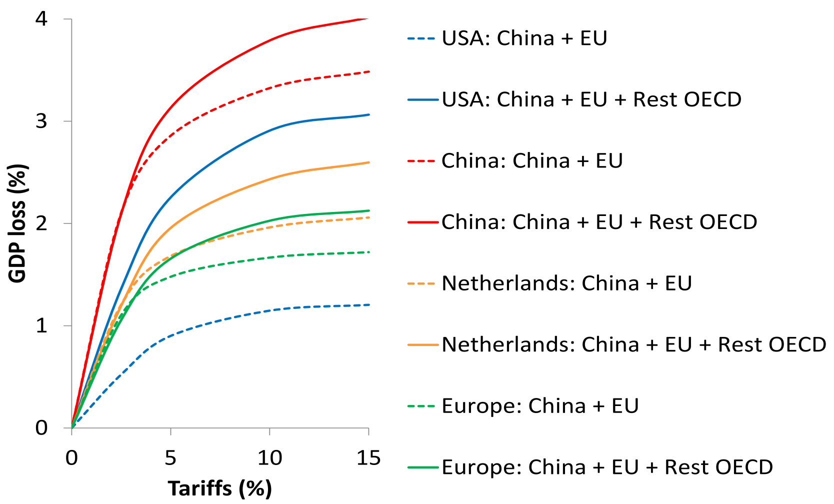
Source: WorldScan
Notes: We only report sectors with the largest changes

3.2 Trade war escalation scenarios

In our second group of trade war scenarios, we analyse the potential economic impacts of trade wars escalations. This escalation is illustratively modelled as affecting all traded good (non-services sectors) and with rising uniform tariff increases from 0 to 40%. However, for reporting reasons, we only present the tariff increase range from 0 to 15%, since the GDP effects level out after this level. Figure 3.6 shows the real GDP losses in four regions/countries by different uniform tariff rate increases. The continuous lines represent a trade war of the US with both the EU and China and the dotted lines represent an extended trade war by also including the rest of OECD countries. In Appendix 3 we present the detailed results of these scenarios.

The main result here is that initial tariff increases (i.e. from 0 to 5% uniform tariffs) have a much larger relatively impact than further increases in tariffs (e.g. from 5% to 10%). Also, the US losses increase as the number of countries with whom it has bilateral trade wars increases. China is the main loser from a bilateral trade war with the US given the large share of its trade that goes to the US and the large trade surplus it has with the US. Both elements (large share of trade and the surplus) generate asymmetric effects where China loses disproportionally more than the US.

Figure 3.6 Trade war escalation effects



Source: WorldScan.

3.3 Sensitivity analysis

The final step in our analysis is to assess how different parameters and specifications of our CGE model affect the results. First, we analyse how the average trade elasticities impact on the main outcome of the third trade conflict scenario and both the trade wars.[13] Second, we assess how sensible our results are to alternative model specifications using combinations of perfect and imperfect competition and endogenous and exogenous labour markets. Recall that our main CGE model uses imperfect competition and endogenous labour markets.

3.3.1 Trade elasticity changes

[13] The full set of sensitivity analyses are available upon request.

The values of the sector-specific trade elasticities are very important parameter that affects the real GDP outcome of quantitative GE models (see Bekker and Rojas-Romagosa, 2018). The trade-weighted sectoral average trade elasticity in our CGE model is 5.64. Therefore, we use a lower average trade elasticity of 3.5 and a higher value of 7.5 to check the sensitivity of our main results to the value of this parameter. The general picture that emerges on our base case trade conflict scenario is that lower (higher) elasticities generate larger (smaller) changes and higher (lower) GDP losses. On the one hand, higher (lower) elasticities are associated with larger (smaller) trade changes. On the other hand, larger (smaller) elasticities allow countries to have greater export and import substitution possibilities and this is associated with smaller (larger) ToT effects. However, the results are country specific, which reflects the underlying trade diversion effects that can affect ToT in different ways. The impacts seem symmetric, although China and the US are outliers, because China's GDP losses respond sharper to low than high elasticities, while USA's GDP losses are hardly affected.

Table 3.6 Scenario 3: main macroeconomic effects (%) compared to the baseline in 2030

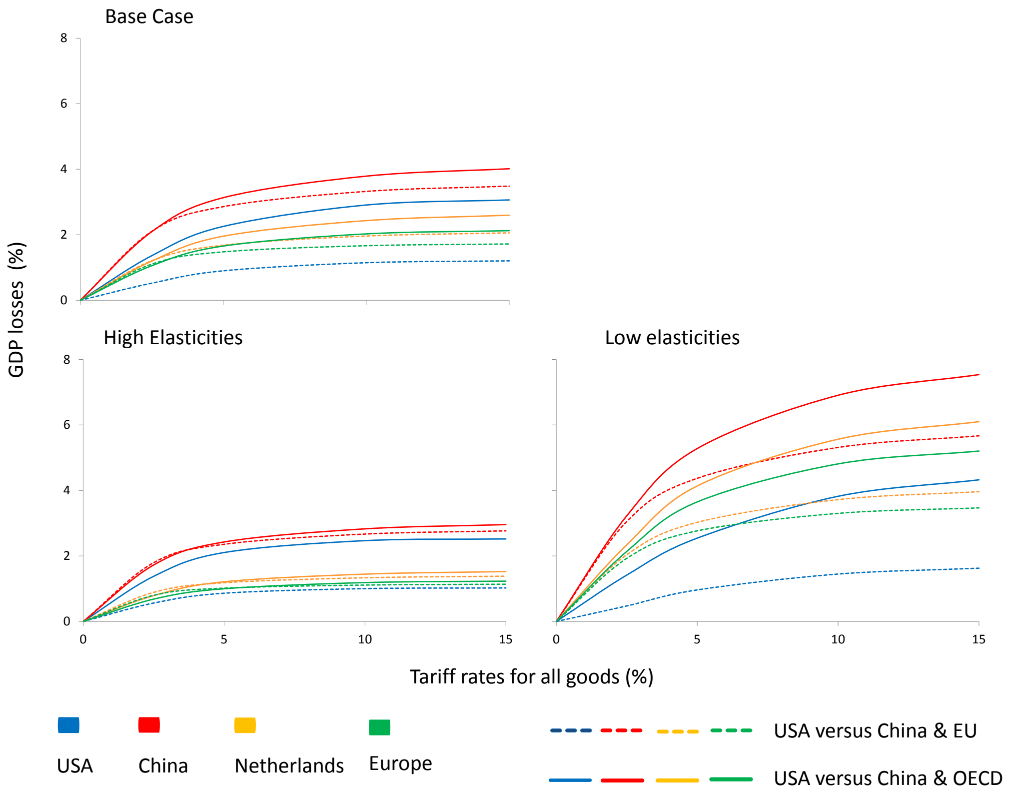
	USA	China	EU	NLD	CAN	MEX	Japan	World
Base case (trade elasticity = 5.6)								
GDP (%)	-0,3	-1,2	0,4	0,4	0,2	0,5	0,4	-0,1
Export volume (%)	-13,5	-8,2	0,0	0,1	-6,4	-2,0	0,3	-2,5
Import volume (%)	-10,5	-8,4	0,0	0,0	-5,6	-2,7	0,3	-2,5
Terms-of-trade (%)	-0,6	-0,8	0,1	0,1	0,9	0,3	0,2	0,0
Real average wage (%)	-0,1	-1,1	0,3	0,4	0,2	0,4	0,4	-0,1
High elasticities (trade elasticity = 7.5)								
GDP (%)	-0,3	-1,1	0,3	0,3	0,0	0,3	0,3	-0,1
Export volume (%)	-14,2	-8,3	0,0	0,1	-6,6	-2,1	0,3	-2,6
Import volume (%)	-11,3	-8,6	0,0	0,0	-5,7	-2,7	0,4	-2,6
Terms-of-trade (%)	-0,8	-0,9	0,1	0,1	1,0	0,4	0,2	0,0
Real average wage (%)	0,0	-1,0	0,2	0,3	0,1	0,2	0,3	-0,1
Low elasticities (trade elasticity =3.5)								
GDP (%)	-0,3	-1,6	0,5	0,6	0,4	0,7	0,5	-0,1
Export volume (%)	-12,2	-7,8	0,0	0,1	-5,8	-1,8	0,3	-2,3
Import volume (%)	-9,2	-7,7	0,0	0,1	-5,0	-2,3	0,3	-2,3
Terms-of-trade (%)	-0,3	-0,6	0,1	0,1	0,8	0,4	0,2	0,0
Real average wage (%)	-0,1	-1,4	0,4	0,5	0,3	0,6	0,4	-0,1

Source: WorldScan simulations using sectoral trade-weighted average tariffs from Section 2.

When we look at our trade war scenarios, then a similar pattern emerges. China is strongly affected by the low elasticity assumption. Their lack of market power translates into the largest ToT and GDP losses, and this is magnified in the low trade elasticity setting of the simulations. China's GDP losses increase to almost 8% at higher tariff levels, while at the same time it only reduces to about a 2.5% GDP loss in the high elasticity setting. Another interesting result refers to the USA. When using low elasticities their losses increase less than for the EU.

Finally, we can also see that the trade war extension with the rest of the OECD indeed is always bad for all countries regardless of the trade elasticity values.

Figure 3.7 Trade war escalation scenarios with high and low trade elasticities



Source: WorldScan

3.3.2 WorldScan with different model specifications

The results are larger with imperfect competition due to the economies of scale present in this setting. Under these conditions, changes in the production of particular sectors can be more than proportionally affected (both increasing and decreasing) than in a perfect competition setting. For instance, if a sector with relatively large economies of scale is positively affected by the tariff changes (e.g. if that sector is now sheltered by international competition or if it can expand its exports due to less competition from a country that was targeted with tariffs), then its production increase will be proportionally larger than in a perfect competition setting, since average costs decrease faster when there are increasing returns to scale.

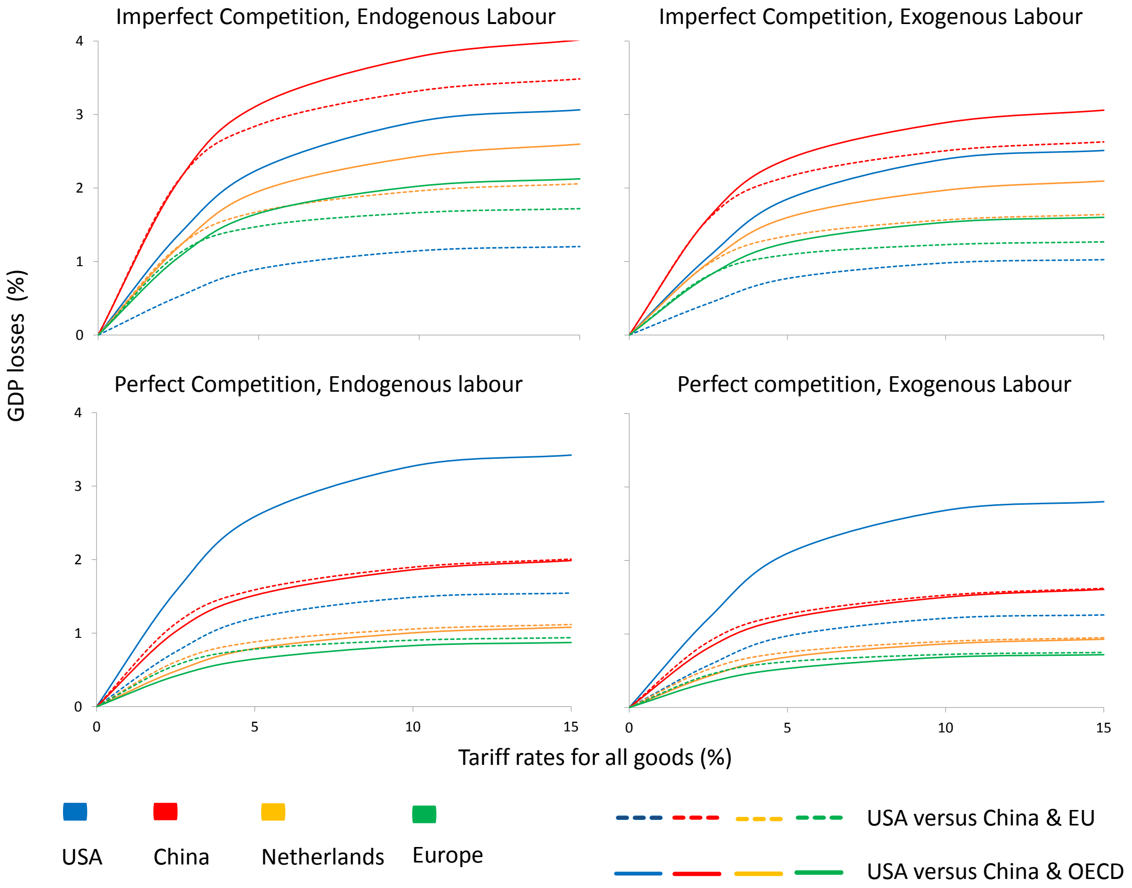
Similarly, the endogenous labour supply setting provides a more flexible economic environment, which generates larger economic effects than in a more constrained exogenous labour supply setting. When the labour supply can react to changes in labour demand, then the initial shocks are greater in magnitude than otherwise. For example, if labour demand is reduced after the tariff increases, this reduces overall production further, since less labour will be available when wages are lower due to lower labour demand. In other words, less factor endowments – labour in this case-- reduces the production possibility frontier of the economy.

Table 3.7 Simulation results, main macroeconomic effects (%) compared to the baseline in 2030

	USA	China	EU	NLD	CAN	MEX	Japan	World
Base case: Imperfect competition, endogenous labour market								
GDP (%)	-0,3	-1,2	0,4	0,4	0,2	0,5	0,4	-0,1
Export volume (%)	-13,5	-8,2	0,0	0,1	-6,4	-2,0	0,3	-2,5
Import volume (%)	-10,5	-8,4	0,0	0,0	-5,6	-2,7	0,3	-2,5
Terms-of-trade (%)	-0,6	-0,8	0,1	0,1	0,9	0,3	0,2	0,0
Real average wage (%)	-0,1	-1,1	0,3	0,4	0,2	0,4	0,4	-0,1
Imperfect competition, exogenous labour market								
GDP (%)	-0,4	0,2	0,2	0,3	-0,1	-0,2	0,2	0,1
Export volume (%)	-6,3	-0,9	-0,1	0,0	-7,3	-4,8	0,2	-1,0
Import volume (%)	-4,8	-0,9	-0,2	0,0	-6,1	-5,5	0,1	-1,0
Terms-of-trade (%)	-0,4	-0,1	0,1	0,1	1,1	0,1	0,0	0,0
Real average wage (%)	-0,3	0,1	0,2	0,3	-0,1	-0,2	0,2	0,0
Perfect competition, endogenous labour market								
GDP (%)	-0,5	-0,9	0,0	0,0	-0,4	0,0	0,1	-0,3
Export volume (%)	-13,3	-7,1	-0,2	-0,1	-7,0	-2,0	0,3	-2,5
Import volume (%)	-10,7	-7,6	-0,2	-0,1	-6,0	-2,7	0,4	-2,5
Terms-of-trade (%)	-0,7	-1,0	0,1	0,1	1,0	0,3	0,2	0,0
Real average wage (%)	-0,3	-0,9	0,0	0,0	-0,3	0,0	0,1	-0,2
Perfect competition, exogenous labour market								
GDP (%)	-0,1	0,0	0,0	0,0	0,0	0,1	0,0	0,0
Export volume (%)	-0,5	0,0	-0,3	-0,1	0,6	0,5	0,1	-0,1
Import volume (%)	-0,4	0,0	-0,4	-0,1	0,4	0,5	0,1	-0,1
Terms-of-trade (%)	0,1	0,0	-0,1	0,0	-0,1	0,0	0,0	0,0
Real average wage (%)	0,0	0,0	-0,1	0,0	0,1	0,1	0,0	0,0

Source: WorldScan simulations using sectoral trade-weighted average tariffs from Section 2.

Figure 3.8 Trade war escalation scenarios with different WorldScan model specifications



Source: WorldScan.

3.4 Concluding remarks

In January 2018, the US announced higher trade tariffs on solar panels that are imported mainly from China. They then announced in March 2018 that they would increase trade tariffs on steel and aluminium, including for the EU and NAFTA countries. In response to higher tariffs, China, the EU, Canada and Mexico filed a retaliatory package with the WTO. The US also announced additional tariffs rates for other Chinese products in early April 2018. Immediately after that, China reacted again with the publication of a retaliatory list of goods with a 25% tariff. After several rounds of trade negotiations, in the latest policy announcements on June 15 and 16, both countries finally announced the implementation of these measures.

In our first scenario, the unilateral imposition of steel and aluminium tariffs by the US has a very low impact on the US and its trading partners. As expected, these effects are negative (since these products are mainly intermediate inputs for many industries, and its related price increase will affect these downstream industries), but limited to specific sectors in China and the US, which will be hit hard. These shifts concern sectors like the 'electronic equipment sector', 'other machine equipment' and agriculture.

In our second scenario, the trading partners retaliate with compensatory tariff increases. We still find limited global impacts, but the results now vary much by region. In general, the economic effects of bilateral trade conflicts are negative for the countries involved. However, when several countries retaliate against the US at the same time, these multilateral tariff changes can have unexpected results for some of the countries involved. One of the main advantages of using a global CGE model is that we can trace the complex trade and economic effects of these multilateral trade conflicts and the indirect effects that are created. For instance, after simulating the retaliatory round of tariffs in response to the US steel and aluminium tariffs, we find that the EU and China experience some positive economic gains, which is mainly due to the general equilibrium (i.e. trade diversion) effects of several countries retaliating against the US at the same time. On the other hand, the US and its NAFTA partners (Canada and Mexico) are negatively affected.

The third scenario shows how these results vary when we add the US-China trade conflict. In this case, China experiences a significant GDP loss of 1.2%, while the GDP loss for the US is still limited to 0.3%. This asymmetric result is due to the market power of the US and the large trade deficit it has with China. China exports roughly US$ 500 billion to the US, while the US only exports around US$ 150 billion to China. This means that the share of US exports to China, relative to its total GDP and total exports, is small. On the other hand, the reciprocal share of China exports to the US is much more important relative to total Chinese exports and GDP. Other OECD countries slightly benefit from the decrease of Chinese exports to the US. Hence, the US-China trade conflict creates some small gains for the EU, China, and other OECD countries. These can be explained by trade diversion, where specific countries can fill in the lost trade between the US and other retaliating countries, and thus, have indirect benefits from the decline in bilateral trade between the US and these countries.

However, in our fourth scenario, the EU benefits associated with the multilateral retaliation tariffs. In that case the MVH sector will be significantly affected in the EU and other sectors, such as other transport equipment (OTN) benefiting. Here, also the country-specific results within the EU are less homogenous than before.

Finally, in our last set of scenarios, we simulate an escalation of the trade conflict to a trade war, by employing larger uniform non-services tariff increases between the US and other countries. In these illustrative simulations, both the US and its trading partners increasing the tariffs on all imports of goods. This full-blown escalation of the trade conflict to a trade war has only losers, and we already find strong negative economic effects even with modest increases in overall tariffs of 5%. The negative shocks rise proportionally to higher tariffs, and at higher tariff rates --above 20%-- GDP losses continue to rise, but at a slower pace. This is explained because most of the associated negative trade effects will have being already assimilated by the different regions and sectors at these relatively high tariff levels. For the US it is crucial how many countries they involve in this trade war. The losses are particularly strong when the conflict is extended beyond the EU and China, and include other OECD countries --particularly Canada and Mexico, which have relatively strong trade ties with the SU. In all scenarios, China will be country that is hurt most by these trade wars.

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Appendix 1: Technical specifications of the WorldScan CGE model[14]

A computational general equilibrium (CGE) model consists of three main elements. The underlying general equilibrium economic model, the multi-regional input-output data and a set of exogenous parameters (being the most import the elasticities). The combination of these three elements yields a general equilibrium (calibrated) baseline in which all the accounting and market clearing conditions are met. Policy experiments consist of a shock to one or several exogenous variables (e.g. tariffs) that generate changes in the price and quantities of the endogenous variables such that a new general equilibrium is reached: the counterfactual scenario. The behavioural equations in the economic model determine how the endogenous variables react, while the underlying baseline data and the exogenous parameters (i.e. the various elasticities in the model) determine the size and scope of the adjustments.[15]

Economic model

General equilibrium models describe supply and demand relations in markets. In these models, prices and quantities of goods and factor inputs (i.e. labour and capital) adjust, such that demand and supply become equal at an equilibrium price and quantity level. These models also describe the interactions between several markets. For instance, firms must determine the factor inputs necessary to produce a final good, given the price and demand of that good. Firms' supply decisions, therefore, depend on the equilibrium product price and in turn they determine the demand for the necessary intermediate and factor inputs required. Consumers preferences and budget constrains will determine the demand for final goods and the supply of factor inputs (mainly labour). The interaction of the optimisation decisions by firms and consumers will ultimately determine the equilibrium prices and quantities of goods and factor inputs. Therefore, the core elements of all CGE models are the micro-economic founded neo-classical conditions: consumer and producer optimisation under budgetary constraints. Hence, economic behaviour drives the adjustment of quantities and prices given that consumers maximise utility given the price of goods and the consumers' budget constraints, while producers minimise costs, given input prices, the level of output and the production technology.[16]

These optimisation conditions are linked with market clearing conditions in the products markets (i.e. equating demand and supply for each production sector). The number of

[14] This section is based on the Supplementary Material from Rojas-Romagosa (2017)
[15] For a broader view of the CGE modelling framework, see Dixon and Jorgenson (2012).
[16] A summary of the general equilibrium equations of WorldScan is provided in Appendix A in Lejour et al. (2006) and in the Supplementary Material from Rojas-Romagosa (2018).

product markets is defined by the number of economic sectors in the database. For instance, the GTAP database identifies 57 sectors. In addition there are market-clearing conditions for the factor markets. Following the example above, the supply of low- and high-skill labour by households must equal the demand of these factor inputs by firms. There are five different factor types in the GTAP database: unskilled and skilled labour, capital, land and natural resources.[17] For instance, the demand of labour (determined from the profit maximisation conditions of firms) must equal the labour supply by households (which in turn is a function of economically active population and labour participation rates.) Consumption is modelled as non-homothetic demand system using the linear expenditure system (LES). All partial elasticities of substitution for composite commodities as well as price and income elasticities drive demand responses to economic shocks. Production is modelled as a nested structure of constant elasticities of substitution (CES) functions. The values of the substitution parameters reflect the substitution possibilities between intermediate inputs and production factors.

Monopolistic competition

WorldScan has the option of using an imperfect competition setting (described below) or a perfect competition setting with constant returns to scale where each sector has one representative price-taking firm that produces one variety (following the description of the supply and private demand equations above). Our main simulations, however, employ the WorldScan version with monopolistic competition and increasing returns to scale (see de Bruijn, 2006, for a detailed description). This version of the model is based on a Dixit-Stiglitz-Armington demand specification. In particular, it uses the love-of-variety –i.e. Dixit-Stiglitz (DS) – preferences for intermediate and final goods for non-agricultural sectors. Within a representative firm, individual varieties are symmetrical in terms of selling at the same price and quantity. However, increases in the number of varieties yield economic benefits because they are perceived to be different by intermediate and final demand agents. This DS approach is then nested within a basic CES demand system that includes both Armington- and DS-type demand systems for individual sectors using Ethier and Krugman-type monopolistic competition models –i.e. differentiated intermediate and differentiated consumer goods. [18]

This imperfect competition version of the model slightly modifies the demand and supply equations from the perfect competition setting, by including the number of varieties by sector and region in the demand and supply equations following Dixit-Stiglitz preferences. Economies of scales are introduced in the supply side as a technical scaling factor in combination with imposing a fixed set-up cost for in the production process. The specific modelling equations can be found in Section 2 in de Bruijn (2006).

[17] The most recent GTAP-9 version identifies five different labour types, but these can be aggregated to the common two labour types used in most CGE models.
[18] This can be done because one can reduce Ethier-Krugman-models algebraically to Armington type demand systems with external scale economies linked to a variety of effects (Francois and Roland-Holst, 1997; Francois and Nelson, 2002).

Endogenous labour supply

A distinctive feature of WorldScan with respect to other CGE models is the use of an endogenous labour supply setting. The endogenous labour market version of WorldScan is thoroughly explained in Boeters and van Leeuwen (2010). In particular, labour supply and unemployment are endogenously determined. Labour supply, moreover, is divided between the intensive margin (hours of work) and the extensive margin (participation). The intensive margin is determined by optimising the consumption-leisure choice of a representative household. The extensive margin is modelled as the equilibrium between the expected utility of participation and a fixed cost of taking up work, which varies between households. Involuntary unemployment is also endogenously modelled using a collective bargaining mechanism. The labour market equations are calibrated using labour tax and welfare payments in OECD countries, combined with different labour elasticities taken from the literature.

Most CGE models, on the other hand, employ a fixed or exogenous labour supply setting. In this setting population projections from United Nations are combined with medium term projections on labour participation rates and long-term unemployment values to produce a baseline value of labour supply over time, which in turn is kept fixed in the simulations.[19] However, there is empirical evidence that the elasticity of labour supply to wages is positive.[20] In a CGE setting that looks mainly at medium- to long-term adjustments in the economy, the possibility that employment participation reacts to different wages is even more plausible. Therefore, we find that a setting with endogenous labour supply and endogenous unemployment is a more adequate mechanism to model the labour market.

International trade

Finally, the model provides an explicit and detailed treatment of international trade, international transport margins and other trade costs (e.g. tariffs, NTBs, export subsidies). Bilateral trade is handled via CES (constant elasticity of substitution) preferences for intermediate and final goods, using the so-called Armington assumption, where the substitution of domestics and imports –as well as product differentiation– is driven by the region of origin (i.e. by import source). This assumption is generic to most CGE models as it is a simple device to account for "cross-hauling" of trade (i.e. the empirical observation that countries often simultaneously import and export goods in the same product category).

[19] Note that a fixed labour supply is different from a full-employment setting, since there is a long-term unemployment rate that prevents full employment.

[20] For example, Kleven and Kreiner (2006) survey the current state of empirical evidence on the elasticity at the extensive margin and find a value of 0.2.

Underlying data and calibration

The primary data input is a global multi-regional input-output (GMRIO) database. In particular, we use the GTAP database, which provides balanced and harmonised input-output matrices, bilateral trade and protection data. For this particular WorldScan simulation we use GTAP-9 database with base-year 2011 (cf. Aguiar et al., 2016). The specific regional and sectoral aggregation we used in this study is presented in Tables A.1 and A.2, respectively. The economic model is then calibrated to the GTAP base year of 2011 using a set of exogenous parameters (mainly consumption and production elasticities). Our baseline scenario runs from 2011 to 2030. To construct this scenario we combine the GTAP9 data with the following additional data:

- GDP growth per capita projections taken from the OECD.
- Total labour supply ($LSup$) is built using a combination of demographic and labour data projections, as:

$$\mathrm{LSup}_t = Pop_t * \mathrm{PR}_t * (1 - \mu_t)$$

where Pop_t is total population in year t with projections taken from the Medium Variant of projections by the United Nations (UN, 2015) (for non-EU countries) and EuroStat population projections for EU countries.

- Labour participation rates (PR) are taken from ILO projections.[21] Long-term unemployment rates (μ) are taken from EuroStat and World Bank projections.
- Trade balances are projected to gradually decrease over time. As an initial benchmark we use the updated 2011 net foreign assets data from Lane and Milesi-Ferreti (2001).

The initial (calibrated) condition of the model is that supply and demand are in balance at some equilibrium set of prices and quantities; where workers are satisfied with their wages and employment, consumers are satisfied with their basket of goods, producers are satisfied with their input and output quantities and savings are fully expended on investments. Adjustment to a new equilibrium, governed by behavioural equations and parameters in the model, are largely driven by price linkage equations that determine economic activity in each product and factor market. For any perturbation to the initial equilibrium, all endogenous variables (i.e. prices and quantities) adjust simultaneously until the economy reaches a new equilibrium. Constraints on the adjustment to a new equilibrium include a suit of accounting relationships that dictate that in aggregate, the supply of goods equals the demand for goods, total exports equals total imports, all (available) workers and capital stock is employed, and global savings equals global investment; unless adjustments to these assumptions are modified for a particular application.

[21] Taken from the Economically Active Population Estimates and Projections (EAPEP).

Appendix 2: Regional and Sectoral Aggregation

Table A.1 Regional aggregation

No.	Code	Country / region
1	AUT	Austria
2	BLU	Belgium and Luxembourg
3	DNK	Denmark
4	FIN	Finland
5	FRA	France
6	DEU	Germany
7	GRC	Greece
8	IRL	Ireland
9	ITA	Italy
10	NLD	Netherlands
11	PRT	Portugal
12	ESP	Spain
13	SWE	Sweden
14	GBR	United Kingdom
15	EEU	Rest of EU: Bulgaria, Croatia, Cyprus, Czech Rep., Estonia, Hungary,
		Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia
16	USA	United States
17	MEX	Mexico
18	CAN	Canada
19	AUS	Australia
20	JPN	Japan
21	KOR	South Korea
22	ROE	Rest of OECD: Chile, Israel, New Zealand, Norway, Switzerland,
		Turkey, Taiwan, Rest of EFTA (Iceland and Liechtenstein)
23	EER	Rest of East Europe: Albania, Belarus, Russia, Ukraine,
		Rest of Eastern Europe (Moldova), Rest of Europe
24	CHH	China and Hong Kong
25	ASE	ASEAN countries
26	IND	India
27	MNA	Middle East and North Africa
28	SSA	Sub-Saharan Africa
29	LAC	Latin America and the Caribbean (excl. Chile and Mexico)
30	ROW	Rest of the World

Table A.2 From GTAP sectors to WorldScan sectors used: the sectoral aggregation

No.	Code	WorldScan sectors	Aggregated GTAP sectors	GTAP codes
1	AGR	Agriculture	Paddy rice, Wheat, Other cereal grains, Veget.& fruits,	pdr, wht, gro, v_f,
			Oil seeds, Sugar cane, Plant-based fibers, Other crops,	osd, c_b, pfb, ocr,
			Bovine cattle, Other animal products, Raw milk, Wool,	ctl, oap, rmk, wol,
			Forestry, Fishing	frs, fsh
2	OIL	Oil	Oil	oil
3	ENG	Energy	Coal, Natural gas, Petroleum & coal products	coa, gas, p_c
			Electricity, Gas manufacture & distribution	ely, gdt
4	OMN	Other mining	Other minerals	omn
5	PFO	Processed foods	Bovine meat products, Other meat products, Veget. oils	cmt, omt, vol,
			Dairy products, Processed rice, Sugar, Other food prod	mil, pcr, sgr, ofd,
			Beverages & tobacco	b_t
6	TAP	Textiles and apparel	Textiles, Wearing apparel	tex, wap
7	LEA	Leather products	Leather products	lea
8	LUM	Wood products	Wood products	lum
9	PPP	Paper prod.& publish.	Paper products & publishing	ppp
10	CRP	Chem.,rubber&plast.	Chemical, rubber & plastic products	crp
11	NMM	Other mineral prod.	Other mineral products	nmm
12	I_S	Ferrous metals	Ferrous metals	i_s
13	NFM	Other metals	Other metals	nfm
14	FMP	Fabr. metal prod.	Fabricated metal products	fmp
15	MVH	Motor veh.& parts	Motor vehicles & parts	mvh
16	OTN	Other transp. Equip.	Other transport equipment	otn
17	ELE	Electronic equip.	Electronic equipment	ele
18	OME	Other mach.& equip.	Other machinery & equipment	ome
19	OMF	Other manuf.	Other manufactures	omf
20	CNS	Construction	Construction	cns
21	WTP	Water transport	Water transport	wtp
22	ATP	Air transport	Air transport	atp
23	OTP	Other transport	Other Transport	otp
24	CMN	Communication	Communication	cmn
25	OFI	Finance	Other financial services	ofi
26	ISR	Insurance	Insurance	isr
27	OCS	Other comm. serv.	Trade, Other business services	trd, obs
28	ROS	Recreat. & oth. serv.	Recreational & other services	ros
29	OSR	Gov. & public serv.	Water, Public administration & public serv.; Dwellings	wtr, osg, dwe

Appendix 3: Macro results of a trade war

Table A.3 Simulation results, main macroeconomic effects (%) compared to the baseline in 2030

	USA	China	EU28	NLD	JPN	KOR	CAN	MEX
2.5% on all goods between US and the OECD								
GDP (%)	-1,4	-2,1	-1,1	-1,2	-4,3	-6,4	-1,1	-1,2
Export volume (%)	-47,7	-10,1	-2,7	-2,0	-33,0	-39,8	-7,1	-8,8
Import volume (%)	-36,7	-11,1	-2,6	-2,8	-31,0	-45,0	-7,2	-8,8
Terms-of-trade (%)	1,0	-1,7	-0,1	-0,2	-2,3	-2,9	-0,6	-0,1
Real average wage (%)	-0,6	-1,8	-0,7	-0,9	-3,7	-6,1	-1,1	-1,0
5% on all goods between US and the OECD								
GDP (%)	-2,3	-3,1	-1,7	-2,0	-6,4	-9,3	-1,8	-1,9
Export volume (%)	-55,9	-12,5	-3,4	-2,6	-39,1	-48,1	-8,9	-10,5
Import volume (%)	-43,7	-14,0	-3,3	-3,5	-37,1	-53,3	-8,9	-10,6
Terms-of-trade (%)	0,8	-2,3	-0,2	-0,3	-3,3	-2,9	-0,9	-0,1
Real average wage (%)	-0,9	-2,6	-1,1	-1,4	-5,1	-8,4	-1,6	-1,5
10% on all goods between US and the OECD								
GDP (%)	-2,9	-3,8	-2,0	-2,4	-7,7	-11,1	-2,1	-2,3
Export volume (%)	-58,6	-13,6	-3,7	-2,9	-41,3	-51,3	-9,6	-11,2
Import volume (%)	-46,3	-15,3	-3,6	-3,9	-39,3	-56,1	-9,7	-11,3
Terms-of-trade (%)	0,0	-2,6	-0,2	-0,4	-3,4	-2,1	-1,1	-0,1
Real average wage (%)	-1,1	-3,2	-1,4	-1,8	-6,1	-9,7	-1,9	-1,8
15% on all goods between US and the OECD								
GDP (%)	-3,1	-4,0	-2,1	-2,6	-8,1	-11,6	-2,2	-2,5
Export volume (%)	-59,0	-13,8	-3,8	-3,0	-41,7	-51,8	-9,8	-11,4
Import volume (%)	-46,8	-15,6	-3,7	-4,0	-39,7	-56,5	-9,9	-11,5
Terms-of-trade (%)	-0,4	-2,6	-0,2	-0,4	-3,3	-1,7	-1,2	-0,1
Real average wage (%)	-1,2	-3,3	-1,4	-1,9	-6,4	-10,0	-2,0	-1,9

Source: WorldScan simulations using sectoral trade-weighted average tariffs from Section 2.

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CPB Netherlands Bureau for Economic Policy Analysis
P.O. Box 80510 | 2508 GM The Hague
T +31 88 984 60 00

info@cpb.nl | www.cpb.nl

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