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Modelling Tariffs in TINFORGE.

A Methodology Report.

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Imprint

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1 TARIFFS – ON THE ADVANCE?

Studies on foreign trade and its economic impact are numerous. Ricardo's (1817) thesis that the international division of labour is welfare-enhancing, even if a country has comparative disadvantages in the production of all goods, became a basic assumption of economic thought. On this basis, free trade was considered superior to protectionism, although later studies such as Samuelson (2004) and Autor (2016) relativized Ricardo by showing constellations in which international division of labour can also lead to a permanent loss of welfare.

For Germany, foreign trade has developed into one of the most important drivers of economic growth. Since the European Monetary Union, Germany's share of the balance of payments in gross domestic product has risen significantly and exceeded the six-percent mark for the first time in 2007.[1] More than ever, foreign markets determine the success and failure of those sectors that have become – directly and indirectly – dependent on foreign demand (Mönnig & Wolter 2020). However, world trade not only affects the production structure of domestic industry, but also affects demand for employment. The number of people in jobs that are directly or indirectly linked to export flows continues to rise. Looking beyond the labour market, this also results in changes in occupations and qualification requirements (Mönnig et al. 2013, Prognos 2011).

Particularly in the first decade of the post-war period, the sharp increase in world trade and thus its increasing importance can be explained by a reduction in trade barriers (within the framework of GATT/WTO, but also by increasing regional integration, e.g. by the EU or the North American Free Trade Agreement NAFTA[2]) (Morasch & Bartholomae 2017). Regional integration into the EU, but also the number of free trade agreements, has continued to increase. Further free trade agreements (e.g. between the EU and Canada and the EU and Japan) were also negotiated or concluded in 2017/2018. The worldwide average tariff rate declined to 2.6 % (World Development Indicator, value for 2017).

The World Trade Organisation (WTO) sets nowadays the framework of international trade. It currently holds 164 members that all agreed to the rules of the General Agreement on Tariffs and Trade (GATT). The aim of this trade agreement is to reduce tariffs and other trade barriers and to implement a non-discriminatory trade system that grants both the rights and obligations of its member countries. Non-discrimination of WTO members is guaranteed by the principle of the most favoured nation (MFN), in addition to the requirement to

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[1] According to the Scoreboard of the Macroeconomic Imbalance Procedure of the European Commission, a share of the nominal gross domestic product of over six percent is not compatible with an external economic equilibrium (EC 2011).

[2] The NAFTA treaty was newly negotiated. Since July 2020, the new treaty is named USMCA (United States Mexico Canada Agreement).

treat imported and domestic goods equally on the market.[3] In addition to coordinating world trade, the WTO has a dispute settlement function. However, the possibilities for sanctions in the event of misconduct by members are limited.

This can be observed by the present tariff war between USA and China, two members of the WTO. This goes in line with an observable strong current against globalisation and free trade. The failure of the TTIP negotiations, the US import tariffs on steel and aluminium, the escalating trade war between the USA and China and the "abuse of power" of tariffs in political disputes (USA and Turkey) show that free trade in goods and services is under pressure. Even within the European Union, the exit of Great Britain from the EU enhances the likelihood of reintroducing tariffs on European ground.

For an economy like Germany which is strong in exports and which holds close economic linkages within the European Union and beyond, it is crucial to know the effects of free trade on the German economy. In order to be able to map such developments and assess the impact of trade barriers on the domestic labour market, the model TINFORGE (Mönnig & Wolter 2019, 2020, Wolter et al. 2014) has been further developed in such a way that trade barriers in form of tariffs are implemented product-specific and country-specific (Dreuw et al. 2017).

The remainder of the paper is structured as follows: first a brief introduction to trade costs, the measurement of trade costs, the impact of tariffs on the economy as well as the reason for trade are given. Then, the modelling of tariffs in TINFORGE is described in greater detail. The methodology is then tested on a scenario of an increase in US import tariffs on EU motor vehicles. The paper closes with a summary and conclusion.

2 TARIFFS AND TRADE

2.1 TRADE COSTS

Trade costs are all costs incurred during foreign trade. Trade costs can be divided into (1) trade costs incurred within the global trade chain, (2) trade costs incurred when crossing the border, and (3) trade costs incurred behind the border.

(1) Trade costs within the global trade chain refer mainly to **transport costs**. To keep these particularly low, a good transport as well as a good logistics infrastructure is required.
(2) After transport, further costs arise at the border. Costs are incurred for documentation and compliance with **tariff barriers** to trade, time-consuming administrative processes, and various other delays. Tariff barriers to trade are trade barriers in the

[3] If a country reduces or increases customs duties for another country, it must do the same for all other WTO members. Exceptions to the principle of most-favoured-nation treatment are only permitted through free trade agreements or customs unions, through market opening for developing countries or through barriers (punitive tariffs) for unfairly traded goods or violations of the GATT by trading partners.

form of customs duties. Duties can be levied in the form of ad valorem duties or quantitative duties.

(3) Finally, there are several other costs behind the border which are caused by **non-tariff trade barriers**, market access restrictions, trade financing, general costs or business barriers.

The trade costs as defined in (2) refer to tariff trade barriers as discussed in the follow-up of this paper. Non-tariff trade barriers refer to (3). The following table gives a differentiation between both types of trade barriers and indicates whether modelling option prevail in TIN-FORGE.

Table 1: Trade barriers –examples

Tariff barriers	Short description	Modelling option in TINFORGE
Quantity duty (on imports)	Customs duty paid per imported unit (m³, kg, number of pieces, etc.)	No. TINFORGE only records trade in values not in volumes.
Ad valorem duty (on imported goods)	Percentage duty that is added to the import price.	Yes. See methodology description below.
Export subsidy	Subsidising exports to make domestic products competitive on the world market	No. Requires recoding.
Export duty	Customs duty on exports, either ad valorem or quantity duty	No. Requires recoding.
Non-tariff barriers	**Short description**	**Modelling option in TINFORGE**
Import quota/quota quantity	The granting of import licences limits imports to a certain number to protect domestic products	No. Requires recoding.
Import ban	The strictest variant of an import quota in which imports are completely prohibited.	Yes.
Local-Content quota	Ratio indicating how high the share of domestic value added in the end product must be.	No. Requires IO-table information on country levels.
Import tax	Tax, either per unit or as a tax rate, on imported goods	Yes. If interpreted as ad valorem duties (see above)
Non-tariff barriers which are difficult to quantify	**Short description**	**Modelling option in TINFORGE**
Technical or legal regulations, quality standards, indications of origin, packaging and labelling regulations, environmental and social standards	Regulations, standards, indications of source and various others, are (non-tariff) trade barriers, as they lead to a time delay at the border, to more difficult market access behind the border, to more elaborate production and documentation and other costly efforts, which increase trade costs.	No. Requires recoding.
Non-politically controllable barriers	**Short description**	**Modelling option in TINFORGE**
E.g. geographical barriers (distance to trading partners, no access to the sea), cultural differences	Due to a greater distance between trading partners, trading costs inevitably increase. Distance or access to the sea cannot, of course, be changed, but it still affects trade.	Yes. Captured in the coefficient of the gravity function of trade.

2.2 MEASURING TRADE COSTS

The exact measurement of trade costs is very difficult in practice due to the many indirect influences on trading costs. Estimates of trading costs can be divided into direct and indirect measurements:

The **direct measurement** of trading costs refers to the collection of observable data or proxy variables that are intended to make various components observable. The average time, for instance, it takes for a good to cross the border or the monetary costs incurred in completing and adhering to customs documents incurred at the border. Customs duties and some non-tariff trade barriers such as import quotas can be measured, too. Other non-tariff trade barriers such as regulations or standards are often explicitly measured by simple frequency counts or hedging ratios in certain countries.

The effects of these direct measurements on trading costs are often econometrically estimated using gravitation models (Anderson & van Wincoop 2001, Head & Mayer 2013) or other quantitative approaches (Minford & Xu 2017). Some additional control variables (common language, common border, or distance between two capital cities) are added to the econometric estimation. For the econometric estimation, however, it is elementary that qualitative information is made mathematically measurable.

The advantage of the econometric approach for analysing trade cost effects is its relatively simple methodology. However, according to Anderson & van Wincoop (2004), the method is inaccurate and problematic: Many of the subcomponents of trade costs are either partially or completely unobservable and therefore impossible to quantify. Direct measurement approaches therefore accept sample distortions in the statistical analyses.

Indirect measurements of trade costs aim to measure trade barriers as a whole and then to infer the extent of trade barriers to trade flows. No distinction is made between the individual subcomponents of trade costs. In this measurement approach, trade costs are the difference between the trade volume in a scenario of a "perfect" world without trade costs and the observed trade volume. Here, too, an econometric estimate of the gravitation model is used.

The advantage of indirect measurement is that no explicit definitions of trading costs are required. At the same time, the disadvantage of this method is that policy recommendations can only be given in a very rudimentary form since trade costs are measured globally and thus both observable and non-observable costs are included in the measurement. Therefore, it is not possible to say which policy measures reduces trade costs in the easiest / most / best way.

2.3 IMPACT OF TARIFFS

Foreign trade theory teaches that trade increases welfare. The theories differ in their statements about the distributional effects of trade and reasons for the formation of trade. What all theories implicitly agree on, however, is that free trade is the best possibility among all forms of trade. Moreover, most theories assume that there are no trade costs. At the same time, these theories agree that an increase in trade costs through tariffs would increase import prices and thus lead to lower trade and lower prosperity through trade.

According to Baldwin und Wyplosz (2015), the effect of an import duty on the welfare of the country collecting the duty remains unclear, since divergent effects are active at the same time: on the one hand, the state makes a tariff profit and companies in this country also gain welfare through higher domestic prices. Consumers, on the other hand, lose welfare through higher prices and lower demand. Also, the rest of the world loses welfare because less profit can be made from exports. Globally, customs have a welfare-reducing effect according to these welfare analyses (Baldwin and Wyplsoz 2015, pp. 127-131).

In principle, two main effects can be identified on trade: (i) trade creation/ destruction and (ii) trade diversion/ concentration – depending on the decrease or increase of tariffs.

(i) Trade creation/ destruction

A decline/ increase of tariffs lowers/ increases import prices. Price advantages/ disadvantages lead to more or less trade. This is the price and volume effect of tariffs.

(ii) Trade diversion/ concentration

At the same time, due to changing trading conditions, trade shifts occur. An increasing in tariffs redirect trade flows to other countries and trade is getting more divert. A decline in tariffs attracts trade flows to the country with lower tariffs than before – trade is getting more concentrated.

2.4 REASONS FOR TRADE AND THE EFFECT OF TARIFFS

The theoretical effect of tariffs is as described. However, in standard trade theory, trade costs and therefore also costs of tariffs are neglected. How do tariffs effect the reasons for trade? This question is raised in the following by discussing the main reasons for trade as discussed in trade theory and by combining them with the effects of tariffs.

1. Non-availability of products in importing country

Trade can be necessary just because a country cannot produce a certain product by itself. Maybe because there is a lack of knowledge or a lack in sufficient endowment of capital, labour, technology etc. A distinction is made here between absolute unavailability and relative unavailability of a good. Whereas in the former situation, the importing country cannot produce the required goods at all, the latter situation describes a situation where the importing country cannot produce the required goods in a sufficient quantity or quality.

In both cases, the price is not relevant for trade decisions. **Quality**, **availability,** and the possibility of **substitution** of the product (within the importing country or by other trading partners) are decisive in such a situation.

2. Comparative and absolute cost advantage

Smith (1776) and Ricardo (1817) are the founders of the trade theory on cost advantages. Smith (1776) argued that countries that have **absolute cost advantages** for certain goods (one country can produce a good with less resources than others) should specialise in the production of these goods and sell the surplus produced abroad. Ricardo (1817) extended Smith's theory by introducing the principle of **relative production efficiency**. According to Ricardo's two-goods-two-country example, trade can be advantageous for both countries if each country specializes in those goods for which it has a comparative cost advantage.

In both cases, prices are also not decisive for trade decisions, as long as a relative production efficiency can be maintained. Production efficiency is determined as output over input or – put differently – outcome over expenses and mainly refers in the context of Ricardo to labour productivity.

3. Choice of product

The reason for trade is to extent the goods selection option (Linder 1961). A tariff does not effect this trade reason, because the choice of product is not changed.

4. Market situation

Specific market situation can also decide about the extent to which trade may take place and to which extent price effects have an impact on trade. **Price elasticities** and firm's **market position** as well as a **firm's strategy** determine trade as well. Price elasticities determine to which extent price changes change the demand for a certain product. The more inelastic, the less strong are expected demand reactions on price shifts. If a firm's market position is strong – e.g. in a monopolistic market situation – price changes have no effect on the demand. The more competitive the market, the higher the price effect. Last, a firm's strategy decides to which extent a company is willing to internalize price changes. For example, if a firm wants to increase or maintain its market share it may be willing to absorb price shifts induced by tariffs instead of passing them through to their customers.

Table 2: Summary of trade reasons and their implementation possibilities in TINFORGE

Non-availability				Cost advantage	Choice of product	Market situation		
Quality	Availability	Substitution		Relative production efficiency		Price elasticity	Firm's market position	Firm's strategy
		Within	Between					
Yes	Yes	Yes	No	Yes	No	Yes	Yes	No
Captured in existence and magnitude of trade flows between countries						Captured in the coefficient of trade flow estimates		

3 TARIFFS IN TINFORGE

TINFORGE (Trade in Interindustry Forecasting Germany) is a world trade model which was initially developed to forecast world trade dynamics as an input factor for the export projections in the INFORUM Input-Output-model INFORGE[4] (Interindustry Forecasting Germany). The extension of TINFORGE with tariff information is a huge step in improving the forecasting and simulation options of the model. Chapter 3.1 gives a brief overview about the general structure of TINFORGE. In chapter 3.3 the tariff extensions are described in more detail.

3.1 MODELLING TRADE AND TARIFFS

Two main streams in trade modelling can be observed: (i) classical trade models and (ii) gravity models (Minford & Xu 2017). A rough comparison of both types of models are given in

[44] The INFORGE-Model is described completely in Ahlert et al. 2009. INFORGE belongs to the group of INFORUM Models (Almon 1991) and is part of the inforum-group (www.inforum.edu.us). INFORGE is applied among others to project structural changes and shifts in skills and occupations (www.qube-projekt.de).

Table 3. In general, the two types are fundamentally different. Whereas the gravity model is a demand-driven approach where trade is determined via import demand between trading partners, distances, and cost factors such as trade costs or border costs, the classical trade model is supply-driven. Trade is determined through the supply endowment in each country and its productivity. Generated income is spent according to home demand. Exports takes place when domestic supply exceeds domestic demand.

These fundamental differences are mirrored in some other features of the model: while classical models usually assume perfect competition across the world, gravity models assume imperfect market conditions. Similar with prices: gravity models assume mark-up pricing by producers, while classical models assume perfectly flexible prices around the world.

Table 3: Classical and gravity model in comparison

	Gravity model	Classical model
Determinants	Demand, distance, trade costs, border costs etc.	Supply factors (e.g. labour and land), productivity
Markets	Limited competition across world, imperfect,	High competition across world, perfect
Prices	Mark-up pricing by producers	Average world prices
Drivers	Demand-driven	Supply-driven
	Work-intense, high number of regressions	

Source. According to Minford & Xu 2017

Table 4 gives an overview of German studies related mostly to the analysis of free trade agreements. Some studies concentrate on the analysis of tariff effects alone, but mostly tariff and non-tariffs effects are considered. Apart from Prognose (2010), all studies have used a gravity model to estimate trade effects. The results are implemented in general in a Computable General Equilibrium (CGE) model (Pollitt et al. 2019) based on the GTAP[5] databank to analyse the impact on countries. Data on tariffs and non-tariffs are usually taken from the GTAP databank, from Market Access Map or other studies. Non-tariff data is proxied with the OECD's restrictiveness indicator. Tariffs are mostly measured indirectly, hence, also direct measure approaches are applied. Some studies combined their quantitative approaches with qualitative surveys.

[5] The Global Trade Analysis Project (GTAP) is a global network of researchers and policy makers conducting quantitative analysis of international policy issues.

Table 4: Overview of tariff related studies

	Research		Data			Method	
	Subject	Focus	Trade	Tariff	Non-tariff	Tools	Measure
Prognos 2010	EU - Mercosur	Tariffs	COMTRADE; UN Service Trade Data-bank	Market Access Map	None	Survey Estimation of import elasticities	Indirect
Felbermayr 2013	EU – USA	Tariffs and non-tariffs	OECD, UNCTAD, GTAP	Market Access Map	Market Access Map	Survey Gravity model CGE	Indirect
CEPR 2013	EU – USA	Tariffs and non-tariffs	GTAP	GTAP	OECD restrictiveness indicator Surveys	Gravity model CGE	Direct
ECORYS 2009	EU – USA	Non-tariffs	GTAP	GTAP	OECD restrictiveness indicator Surveys	Gravity model CGE	Direct
Felbermayr 2019	EU – Japan	Tariffs and non-tariffs	WIOD GTAP	Falbermayr 2018 and others	?	Gravity model CGE	Indirect
TINFORGE	-	Tariffs	OECD EUROSTAT ILO WORLD BANK	UNCTAD	-	Similar to gravity model	Direct

Source: different studies; * Oxford Economics Global Economic Model

Overall, there are considerable differences in the approaches. However, the combination of of CGE models and gravity models seems to be superior. Survey methods are especially used to capture non-tariff trade barriers and to evaluate the quantitative results.

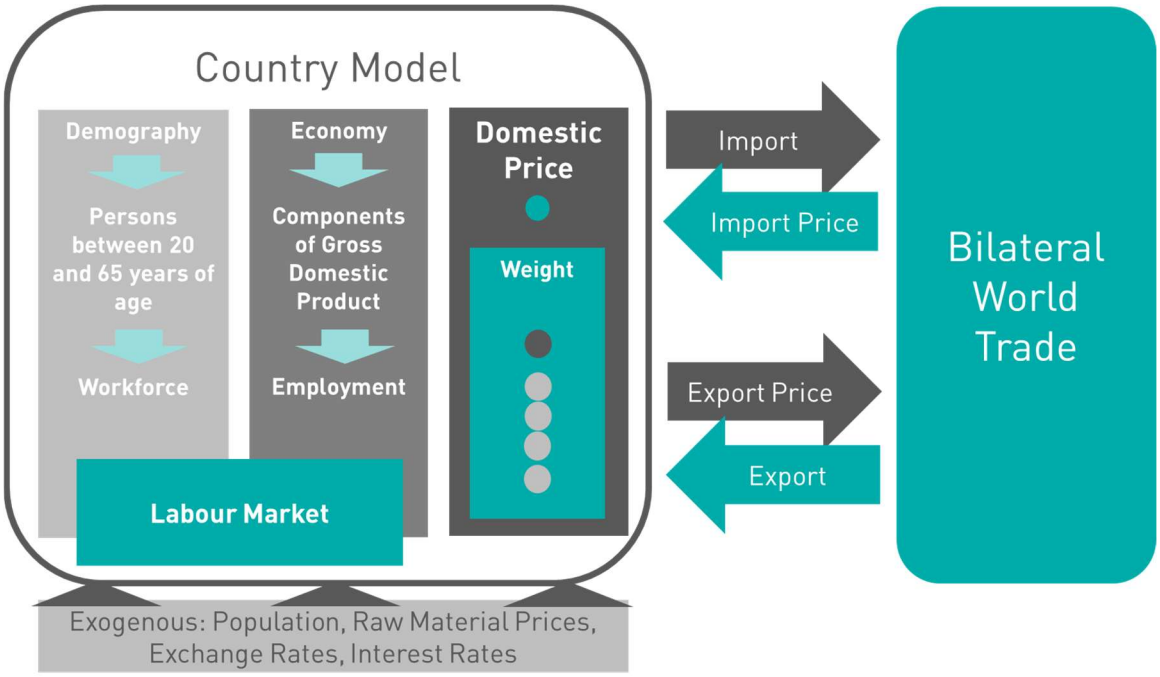
In contrast, the current version of TINFORGE is only able to process tariffs product- and country-specific. It uses a wide range of different official and international data sources. The bilateral trade data is published by the OECD. Individual country data is taken from Eurostat,

OECD, ILO and World Bank where available. Tariff information are taken from the UNCTAD databank. TINFORGE is constructed like a gravity model by estimating world trade as a function of import demand and trading costs. Changes in tariffs can be addressed directly. The following chapter 3.2 describes in full detail the construction of tariffs in TINFORGE.

3.2 THE WORLD TRADE MODEL TINFORGE

TINFORGE has been described in its first version in Wolter et al (2014). The updated version is documented in Mönnig & Wolter (2019). The complete TINFORGE system is shown in Figure 1. There are 84 country models, which are pure macro models with a similar structure. The gross domestic product is determined on the demand side. As a principle, price-adjusted values and the corresponding price indices are estimated. The nominal values are derived by definition. Exogenous parameters are the population (UN 2019), world commodity prices and exchange rates.

Figure 1: Overview TINFORGE



Quelle: GWS

The bilateral trade module determines import prices and export demand. It connects exporting and importing countries through trade flows. Currently 154 countries and one region - Rest of World - are represented. Trade links are again differentiated according to 33 economic sectors (ISIC Rev. 4). In world trade, each country is price taker for its imports and offers export goods on the world market. The sum of import demand of the respective trading partners determines the export demand of a country.

The gravity equation of TINFORGE is a very simple one: The world trade shares $WBXTQ$ between exporting ec and importing ic countries and by 33 economic sectors i are moved with a 4-year moving average approach. This means that trade shares are fluctuating towards a long-term average that is somewhere between the historical highest and lowest

observed shares. That indicates that trade shares are – yet – independent of trade distortion.

[1] $WBXTQ_{t,i,ec,ic} = \left(WBXTQ_{t-1,i,ec,ic} + WBXTQ_{t-2,i,ec,ic} + WBXTQ_{t-3,i,ec,ic} + WBXTQ_{t-4,i,ec,ic}\right)/4$

The export of a country corresponds to the sum of the imports of its trading partners. The same applies to the import price: The import price of a country is made up of the export prices of its trading partners.

The import demand of the trading partners is the result of domestic production. This is determined for 84 countries in country models. In addition to the nominal and real values, the country models also determine the corresponding prices of the gross domestic product used.

The distribution of trade flows in traded values is presented in a bilateral trade interdependence matrix WBX. The columns of this matrix show the importing ic countries and the rows show the exporting ec countries. Export demand xc_{ec} is finally determined by

[2] $xc_{ec,t} = \sum_{ec=1}^{155} \sum_{i=1}^{33} WBX_{i,ec,ic,t}$

$with\ WBX_{i,ec,ic,t} = \frac{WBXQ_{i,ec,ic,t}}{100} * mc_{i,ic,t}\ with\ ec, ic\ \in (1,..,155), i \in (1,..,33)$

The domestic price development is determined by wage development and import prices. The latter in turn corresponds to the weighted export prices of the trading partners. If these trading partners (e.g. Norway) are countries rich in raw materials, their export prices are more strongly influenced by the development of raw material prices, as they primarily export this raw material (e.g. crude oil). Norway's export prices, in turn, are import prices for its trading partners. In contrast, the export price of a country like Germany that is poor in raw materials is only indirectly affected by raw material prices via import prices. The import price $ixigssp_{ic}$ of a country results from the weighting of the export prices $lcegssp_{ec}$ of those countries from which goods and services are purchased. By weighting the imports with the export (sales) prices, an average import (purchase) price (always converted into USD) is formed for the respective importer.

[3] $ixigssp_{ic,t} = WBXTQ_{ec,ic,t} * \frac{lcegssp_{ec}}{bexr_{ec}}\ with\ ec, ic \in (1,..,155)$

3.3 METHODOLOGICAL EXTENSION BY BILATERAL, GOODS-SPECIFIC TARIFFS

The methodological extension of TINFORGE is related to the reformulation of the gravity equation [1]. In chapter 3.3.1 data and design of the databank is explained. Chapter 3.3.2 than introduces the new gravity equation. What follows are some stylized facts about tariffs and trade are presented (chapter 3.3.3).

3.3.1 DATA AND DESIGN OF DATABANK

In principle, different data sources are available for custom records. The following table gives an overview of the different properties.

Table 5: Overview databanks

	Aggregation level	Bilaterale structure	Tariffs	Volume	Classifi-cation
Market Access Map (free access)	High (21 sectors)	No	Yes	No	HS 2012
World Development Indicator Datenbank der World Bank	High	No	Yes	Yes	HS 2012
WTO Tariff Download Facility	Low (6-digit)	Yes, by FTA not by signle countries	Yes	No	HS 2012
Comtrade Datenbank	Low (6-digit)	Yes	No	Yes	HS 2012
UNCTAD Datenbank der Weltbank	Low (6-digit)	Yes	Yes	Yes	HS 2017

TINFORGE uses the World Bank's UNCTAD database because of its high level of detail, information on both tariffs and volumes traded, and because the databank also gives bilateral information. As in all databases, the classification follows the product group classification of the HS nomenclature[6].

However, two challenges are associated with the UNCTAD databank.

1. Data coverage is not all inclusive
2. Classification mismatch

Concerning the data coverage: For 48 countries out of 154 countries in TINFORGE, no tariff data as reporting country is available. No information is available for these countries on the duties they apply to trading partners. For instance, it is not known how high the Indian duty rate is on EU products, but how high the EU duty rate is on Indian products. The following table lists those countries with no tariff data.

[6] Harmonised Commodity Description and Coding System (HS). The Harmonised System (HS) is a nomenclature of the World Customs Organisation (WCO) for the classification of goods (services not included) mainly for tariff purposes and for the classification of external trade data. It has been in force worldwide since 1988, revisions have been made with the HS 1996, HS 2002, HS 2007, HS 2012 and HS 2017. Since 1.1.2017 the HS 2017 has been in force. A revision takes place every five years (www.wcoomd.org).

Table 6: List of reporting countries with no tariff data

	TINFORGE position	3-digit country code	Country name
1	35	SRB	Serbia
2	36	TUR	Turkey
3	42	MEX	Mexico
4	47	HKG	Hong Kong, China
5	50	MAC	Macau
6	53	IDN	Indonesia
7	54	MYS	Malaysia
8	55	MMR	Myanmar
9	56	MNG	Mongolia
10	57	PHL	Philippines
11	61	BGD	Bangladesh
12	62	BTN	Bhutan
13	63	IND	India
14	64	MDV	Maldives
15	68	GEO	Georgia
16	72	IRN	Iran
17	80	SYR	Syria
18	82	YEM	Yemen
19	84	ABW	Aruba
20	87	CHL	Chile
21	90	GUY	Guyana
22	93	SUR	Suriname
23	99	HND	Honduras
24	101	PAN	Panama
25	105	SDN	Sudan
26	106	TUN	Tunisia

27	111	CPV	Cape Verde
28	113	GHA	Ghana
29	114	GIN	Guinea
30	119	GMB	The Gambia
31	122	CAF	Central African Republic
32	123	GAB	Gabon
33	125	ETH	Ethiopia
34	130	SYC	Seychelles
35	138	ZMB	Zambia
36	139	ZWE	Zimbabwe
37	141	CUB	Cuba
38	142	DOM	Dominican Republic
39	143	DMA	Dominica
40	144	JAM	Jamaica
41	145	MSR	Montserrat
42	146	VCT	Saint Vincent and the Grenadines
43	147	KNA	Saint Kitts and Nevis
44	148	TTO	Trinidad and Tobago
45	149	FJI	Fiji
46	150	NCL	New Caledonia
47	153	PNG	Papua New Guinea
48	154	TON	Tonga

The list covers a large list of small states and islands and missing data is mostly not problematic for the intended purposes. However, also some bigger and economically more important states are listed, e.g. Mexico, Hong Kong, or India. The overall trade share of those countries listed in

Table 6 is around 12 percent.

The second problem with the UNCTAD databank refers to the classification mismatch with TINFORGE. UNCTAD reports in HS but TINFORGE works with ISIC[7]. Therefore, to be compatible with the bilateral trade module of TINFORGE a transition from the classification of products to the classification of economic activities must be made. For this purpose, a transition matrix based on the HS-2 digits and for product group 27 ("Mineral fuels" and others) based on the HS-4 digits has been created. Altogether 111 product groups of the HS classification (all 97 HS-2 digits except product group 27 plus the 16 HS-4 digits of product group 27) are assigned to 33 economic activities of the ISIC Rev-4 classification. The allocation of HS goods groups to ISIC activities follows the official conversion table provided by the OECD.[8] Table 7 summarizes the applied transition between HS and ISIC classification.

[7] The International Standard Industrial Classification (ISIC) is a UN classification for the classification of economic activities and industrial sectors. It has also been adopted by the EU with the Statistical System of Economic Activities (NACE). ISIC Revision 4 corresponds to NACE Rev.2 of the statistical classification of economic activities in the European Community and the classification of economic activities 2008 (WZ-2008) in Germany (see classification server of the statistical offices of the Federal Government and the Länder www.klassifikationsserver.de).

[8] Available online: https://www.oecd.org/sti/ind/ConversionKeyBTDIxE4PUB.xlsx

Table 7: Transition between HS and ISIC

Seq. No.	ISIC Rev.4	Seq. No.	HC Code
1	D01: Crop and animal production, hunting and related service activities	1	01: Live animals
1	D01: Crop and animal production, hunting and related service activities	7	07: Edible vegetables and certain roots and tubers
1	D01: Crop and animal production, hunting and related service activities	8	08: Edible fruit and nuts, peel of citrus fruit or melons
1	D01: Crop and animal production, hunting and related service activities	9	09: Coffee, tea, maté and spices
1	D01: Crop and animal production, hunting and related service activities	10	10: Cereals
1	D01: Crop and animal production, hunting and related service activities	12	12: Oil seeds and oleaginous fruits, miscellaneous grains, seeds and fruit
1	D01: Crop and animal production, hunting and related service activities	14	14: Vegetable plaiting materials, other vegetable products
2	D02: Forestry and logging	6	06: Live trees and other plants, bulbs, roots
3	D03: Fishing and aquaculture	3	03: Fish and crustaceans, molluscs and other aquatic invertebrates
4	D05: Mining of coal and lignite	98	2701: Coal, briquettes, ovoids and similar solid fuels manufactured from coal
4	D05: Mining of coal and lignite	99	2702: Lignite, whether or not agglomerated (excl. jet)
5	D06: Extraction of crude petroleum and natural gas	106	2709: Petroleum oils and oils obtained from bituminous mineral
5	D06: Extraction of crude petroleum and natural gas	111	2714: Bitumen and asphalt, natural, bituminous or oil-shale and tar sands
6	D07: Mining of metal ores	26	26: Ores, slag and ash

7	D08: Other mining and quarrying	25	25: Salt, sulphur, earths and stone, plastering materials, lime and cement
7	D08: Other mining and quarrying	100	2703: Peat, incl. peat litter, whether or not agglomerated
8	D10: Food products	2	02: Meat and edible meat offal
8	D10: Food products	4	04: Dairy produce, birds' eggs, natural honey, edible products of animal origin
8	D10: Food products	5	05: Products of animal origin, not elsewhere specified or included
8	D10: Food products	11	11: Products of the milling industry, malt, starches, inulin, wheat gluten
8	D10: Food products	13	13: Lac, gums, resins and other vegetable saps and extracts
8	D10: Food products	15	15: Animal or vegetable fats and oils and their cleavage products
8	D10: Food products	16	16: Preparations of meat, of fish or of crustaceans, molluscs
8	D10: Food products	17	17: Sugars and sugar confectionery
8	D10: Food products	18	18: Cocoa and cocoa preparations
8	D10: Food products	19	19: Preparations of cereals, flour, starch or milk, pastrycooks' products
8	D10: Food products	20	20: Preparations of vegetables, fruit, nuts or other parts of plants
8	D10: Food products	21	21: Miscellaneous edible preparations
8	D10: Food products	23	23: Residues and waste from the food industries, prepared animal fodder
9	D11: Beverages	22	22: Beverages, spirits and vinegar
10	D12: Tobacco products	24	24: Tobacco and manufactured tobacco substitutes

11	D13: Textiles	50	50: Silk
11	D13: Textiles	51	51: Wool, fine or coarse animal hair, horsehair yarn and woven fabric
11	D13: Textiles	52	52: Cotton
11	D13: Textiles	53	53: Other vegetable textile fibres, paper yarn and woven fabrics of paper yarn
11	D13: Textiles	54	54: Man-made filaments, strip and the like of man-made textile materials
11	D13: Textiles	55	55: Man-made staple fibres
11	D13: Textiles	56	56: Wadding, felt and nonwovens, special yarns, twine, cordage, ropes and cables
11	D13: Textiles	57	57: Carpets and other textile floor coverings
11	D13: Textiles	58	58: Special woven fabrics, tufted textile fabrics, lace, tapestries
11	D13: Textiles	59	59: Impregnated, coated, covered or laminated textile fabrics
11	D13: Textiles	60	60: Knitted or crocheted fabrics
11	D13: Textiles	63	63: Other made-up textile articles, sets, worn clothing and worn textile articles
12	D14: Wearing apparel	61	61: Articles of apparel and clothing accessories, knitted or crocheted
12	D14: Wearing apparel	62	62: Articles of apparel and clothing accessories, not knitted or crocheted
12	D14: Wearing apparel	65	65: Headgear and parts thereof
13	D15: Leather and related products	41	41: Raw hides and skins (other than furskins) and leather

13	D15: Leather and related products	42	42: Articles of leather, saddlery and harness, travel goods, handbags
13	D15: Leather and related products	43	43: Furskins and artificial fur, manufactures thereof
13	D15: Leather and related products	64	64: Footwear, gaiters and the like, parts of such articles
14	D16: Wood and products of wood and cork, except furniture, articles of straw and plaiting materials	44	44: Wood and articles of wood, wood charcoal
14	D16: Wood and products of wood and cork, except furniture, articles of straw and plaiting materials	45	45: Cork and articles of cork
14	D16: Wood and products of wood and cork, except furniture, articles of straw and plaiting materials	46	46: Manufactures of straw, of esparto or of other plaiting materials
15	D17: Paper and paper products	47	47: Pulp of wood or of other fibrous cellulosic material, recovered paper
15	D17: Paper and paper products	48	48: Paper and paperboard, articles of paper pulp, of paper or of paperboard
16	D18: Printing and reproduction of recorded media	49	49: Printed books, newspapers, pictures and other products
17	D19: Coke and refined petroleum products	101	2704: Coke and semi-coke of coal, of lignite or of peat
17	D19: Coke and refined petroleum products	103	2706: Tar distilled from coal, from lignite or from peat, and other mineral tars
17	D19: Coke and refined petroleum products	107	2710: Petroleum oils and oils obtained from bituminous mineral
17	D19: Coke and refined petroleum products	108	2711: Petroleum gases and other gaseous hydrocarbons
17	D19: Coke and refined petroleum products	109	2712: Petroleum jelly, paraffin wax, micro-crystalline petrole
17	D19: Coke and refined petroleum products	110	2713: Petroleum coke, petroleum bitumen and other residues of

18	D20: Chemicals and chemical products	28	28: inorganic chemicals, organic or inorganic compounds of precious metals
18	D20: Chemicals and chemical products	29	29: Organic chemicals
18	D20: Chemicals and chemical products	31	31: Fertilisers
18	D20: Chemicals and chemical products	32	32: Tanning or dyeing extracts, tannins and their derivatives, dyes, pigments
18	D20: Chemicals and chemical products	33	33: Essential oils and resinoids, perfumery, cosmetic or toilet preparations
18	D20: Chemicals and chemical products	34	34: Soap, organic surface-active agents, washing preparations
18	D20: Chemicals and chemical products	35	35: Albuminoidal substances, modified starches, glues, enzymes
18	D20: Chemicals and chemical products	36	36: Explosives, pyrotechnic products, matches, pyrophoric alloys
18	D20: Chemicals and chemical products	37	37: Photographic or cinematographic goods
18	D20: Chemicals and chemical products	38	38: Miscellaneous chemical products
18	D20: Chemicals and chemical products	104	2707: Oils and other products of the distillation of high temp
18	D20: Chemicals and chemical products	105	2708: Pitch and pitch coke, obtained from coal tar or from oth
19	D21: Basic pharmaceutical products and pharmaceutical preparations	30	30: Pharmaceutical products
20	D22: Rubber and plastics products	39	39: Plastics and articles thereof
20	D22: Rubber and plastics products	40	40: Rubber and articles thereof
21	D23: Other non-metallic mineral products	68	68: Articles of stone, plaster, cement, asbestos, mica or similar materials
21	D23: Other non-metallic mineral products	69	69: Ceramic products

21	D23: Other non-metallic mineral products	70	70: Glass and glassware
21	D23: Other non-metallic mineral products	112	2715: Bituminous mixtures based on natural asphalt, on natural
22	D24: Basic metals	72	72: Iron and steel
22	D24: Basic metals	73	73: Articles of iron or steel
22	D24: Basic metals	74	74: Copper and articles thereof
22	D24: Basic metals	75	75: Nickel and articles thereof
22	D24: Basic metals	76	76: Aluminium and articles thereof
22	D24: Basic metals	78	78: Lead and articles thereof
22	D24: Basic metals	79	79: Zinc and articles thereof
22	D24: Basic metals	80	80: Tin and articles thereof
22	D24: Basic metals	81	81: Other base metals, cermets, articles thereof
23	D25: Fabricated metal products except machinery and equipment	82	82: Tools, implements, cutlery, spoons and forks, of base metal
23	D25: Fabricated metal products except machinery and equipment	83	83: Miscellaneous articles of base metal
23	D25: Fabricated metal products except machinery and equipment	93	93: Arms and ammunition, parts and accessories thereof
24	D26: Computer, electronic and optical products	90	90: Optical, photographic, cinematographic, measuring, checking, precision
24	D26: Computer, electronic and optical products	91	91: Clocks and watches and parts thereof
25	D27: Electrical equipment	85	85: Electrical machinery and equipment, sound recorders and reproducers
26	D28: Machinery and equipment n.e.c.	84	84: Nuclear reactors, boilers, machinery and mechanical appliances

27	D29: Motor vehicles, trailers and semi-trailers	87	87: Vehicles other than railway or tramway rolling stock
28	D30: Other transport equipment	86	86: Railway or tramway locomotives, rolling stock
28	D30: Other transport equipment	88	88: Aircraft, spacecraft, and parts thereof
28	D30: Other transport equipment	89	89: Ships, boats and floating structures
29	D31T32: Furniture, Other manufacturing	66	66: Umbrellas, sun umbrellas, walking sticks, seat-sticks, whips, riding-crop
29	D31T32: Furniture, Other manufacturing	67	67: Prepared feathers and down and articles, artificial flowers
29	D31T32: Furniture, Other manufacturing	71	71: Natural or cultured pearls, precious or semi-precious stones
29	D31T32: Furniture, Other manufacturing	92	92: Mmusical instruments, parts and accessories of such articles
29	D31T32: Furniture, Other manufacturing	94	94: Furniture, bedding, mattresses, cushions, lamps and lighting fittings
29	D31T32: Furniture, Other manufacturing	95	95: Toys, games and sports requisites, parts and accessories thereof
29	D31T32: Furniture, Other manufacturing	96	96: Miscellaneous manufactured articles
30	D35: Electricity and gas	102	2705: Coal gas, water gas, producer gas and similar gases, oth
30	D35: Electricity and gas	113	2716: Electrical energy. (optional heading)
31	D36T99: Other activities	97	97: Works of art, collectors' pieces and antiques

Source: based on OECD conversion table

As more than one product group is allocated to some economic activities, the HS nomenclature tariff rates must be weighted by the trade volumes of the HS nomenclature. The formula is shown in equation [4] that represents the import duty rate for one reporting country:

[4] $tariff(ISIC)_{i,ec,t} = \frac{\sum tariff(HS)_{h,ec,t} * volume(HS)_{h,ec,t}}{\sum volume(HS)_{h,ec,t}}$ $with\ i \in (1,..,33), ec \in (1,\dots,155), h \in (1,..,111)$

Equation [4] is applied for all 155 reporting countries. This results in a 33×155 tariff matrix for each country, which represents the bilateral tariff rate by 33 product groups with the corresponding trading partners. Altogether, 792,825 single combinations are considered in this approach.

This weighted import duty rate can now be associated with the trade data in the OECD database, allowing a weighted duty rate to be calculated by industry division, allowing the impact of duties at industry level to be analysed.

3.3.2 TARIFFS IN THE PROJECTION

Price effect

The decisive factor in the analysis of customs duties is the price effect of the goods traded. The effect on demand is implicitly controlled by price. To calculate the influence of the import duty rate on the price, TINFORGE offers two options:

(i) either the import duty can be calculated as a percentage of the export price

(ii) or the import duty is deducted from the import price.

Since the import price is the "final" price, which includes all costs of trade, production and distribution – also referred to as cif[9]-valuation (whereas the export price does not include costs due to tariff and non-tariff barriers to trade – also referred to as fob[10]-valuation), the second possibility is used: the exclusion of the duty from the import price. The import price adjusted by the customs rate $ixigssp\_z$ is calculated as follows, whereby $tariff$ is the custom duty on an imported good.

[5] $ixigssp\_z_{ic,t} = \frac{ixigssp_{ic,t}}{tariff_{ic,t}} with\ ic \in (1,..,155)$

In order to capture tariff changes in general, tariff-adjusted import priced $ixigssp\_z$ is multiplied with a new tariff $tariff\_n$.

[6] $ixigssp\_n_{ic,t} = ixigssp\_z_{ic,t} * tariff\_n_{ic,t}\ with\ ic \in (1,..,155)$

Three cases can be distinguished:

---

9 cif – cost, insurance, freight

10 fob – free on board

(i) Unchanged tariff rates ($tariff\_n = tariff$): adjusted import price corresponds to the new import price $ixigssp\_n$ and thus also to the original import price $ixigssp$.

(ii) If the new duty is higher than the previous duty ($tariff\_n > tariff$): the new import price will be higher than the original import price ($ixigssp\_n > ixigssp$).

(iii) If the new duty is lower than the previous duty ($tariff\_n < tariff$): the new import price will be lower than the original import price ($ixigssp_n < ixigssp$).

Volume effect

Customs duties only affect prices. However, they also imply a price-induced volume effect. The construction of TINFORGE, which is based on nominal world trade, allows this only to a limited extent. Therefore, a second channel must be established for capturing the total tariff effect. In addition to the price effect in the domestic market of the country collecting the duty, volume effects are to be expected for its trading partners. In other words, tariffs have a reciprocal effect on the export demand of the trading partners of the importing country.

For doing this, the gravity equation [1] in TINFORGE is changed. The future development of world trade shares is no longer directly determined by a four-year moving average –, rather absolute trade flows are now estimated as a function of the import demand of the trading partner and the implemented tariff rate. The import demand mc is positively and the tariff rate $tariff$ is negatively included in the estimation function. The regression function is estimated in logs and by using the Ordinary Least Square (OLS) method. With respect to the large number of bilateral trade flows – 154x154 bilateral trade flows for 33 economic sectors result in 782,628 individual interdependencies – only the 3,000 largest trade relations are estimated. Together, they capture 58% of total world trade. Dummy variables for 2009, 2005, 2000 are included.

$$[7]\ WBXT_{t,i,ec,ic} = f\{mc_{t,i,ic}, tariff_{t,i,ic}, DUMMY\} \text{ for 3,000 largest trade flows}$$

Estimates are made using an automated algorithm which takes into account common test measures such as the Durbin-Watson (DW) test[11] (criteria 1<DW<3), the t-statistic (|1.0|)[12] or the R^2 quality measure. For import demand mc, parameters measuring “demand”-elasticity are allowed to range from 0 to 1.2. For tariff rates, “price”-elasticity values can range from 0 to -1.0. Dummy variables can have parameters from 5 to -5. Estimates that do not meet the criteria are manually estimated for the first 1,000 trade flows. The following table summarizes the tested regression equations:

[11] The Durbin Watson test tests a regression on auto correlation. A DW of 2 indicates no auto correlation. A DW of 0 indicates a perfect positive auto correlation, a DW of 4 a perfect negative auto correlation.

[12] With a probability error of 10%, the results are significant if t-statistics has a value of at least |1.78|.

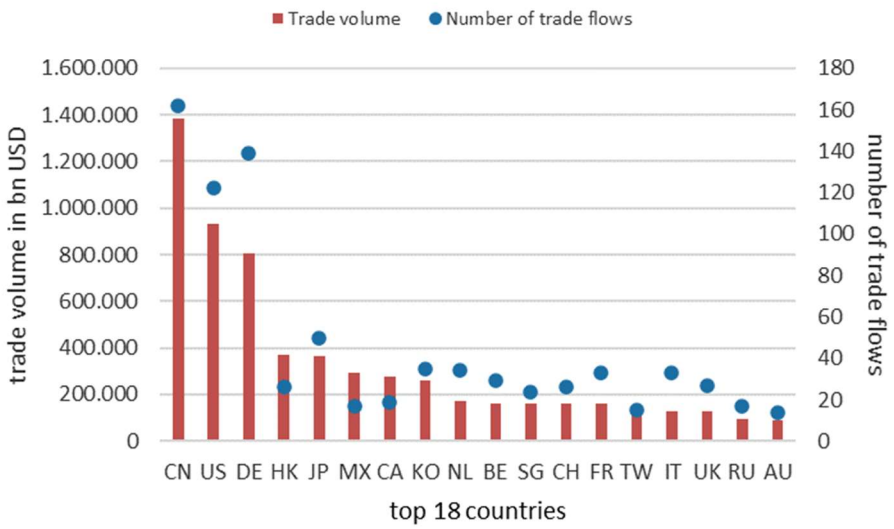
Table 8: Summary of tested regression equations

	Intercept	1st explanatory	2nd explanatory	Dummy
[1]	Yes	mc	tariff	--
[2]	Yes	mc	tariff	D109FF
[3]	Yes	mc	tariff	D105FF
[4]	Yes	mc	tariff	D100FF
[5]	No	mc	tariff	--
[6]	No	mc	tariff	D109FF
[7]	No	mc	tariff	D105FF
[8]	No	mc	tariff	D100FF

The gravity function [1] explains the development of absolute trade flows. This is due to the fact, that we could not find enough explanatory power for tariffs on trade shares. In most cases, either the explanatory power was very weak or had the wrong sign. The explanatory power on absolute trade flows, instead, was in general good and if a correlation was identified it always showed the correct sign. This approach is in line with most of the other work related to gravity models (McCallum 1995, Anderson & Wincoop 2001, Silva, J.M.C.S. & Tenreyro, S. 2006, Fally, Th. 2015, Head & Mayer 2013).

The 1,000 largest (0.13 % of all 782,628 trade flows) trade flows cover 42% of total world trade. In total, the 3,000 trade relationships account for about 53% of world trade. Figure 2 shows the trade volumes and the number of bilateral trade flows of the 18 largest exporting countries for 2017 of the 1,000 largest trade relations. China has the largest number of export flows and the largest trade volume. Germany follows in number of trade flows but not in trade volume. Despite a lower number of export relations, the USA holds a higher trade volume compared to Germany. With distance, Hong Kong and Japan follow in terms of number of export flows and export volume.

Figure 2: Trade volume and number of trade flows of the 18 largest trade connections in 2017



Source: OECD STAN Databank, own calculation

What happens with the rest of the trade flows that do not belong to the 3,000 largest trade flows? They should also change over time and they should also be affected of possible changes in import demand or tariffs. A relatively simple solution is the assumption, that those remaining trade flows develop like the estimated import demand of partner countries over all traded goods $mcvec$.

$$[8]\ WBXT_{t,i,ec,ic} = WBXT_{t,i,ec,ic} * {}^{mcvec_{t,ic}}/_{mcvec_{t-1,ic}} \text{ for all non-estimated trade flows}$$

The trade shares $WBXQ$ result from the definition of the column sum. By definition, the shares cannot be less than 0 % or greater than 100 %, which is why no further correction of the estimates is necessary.

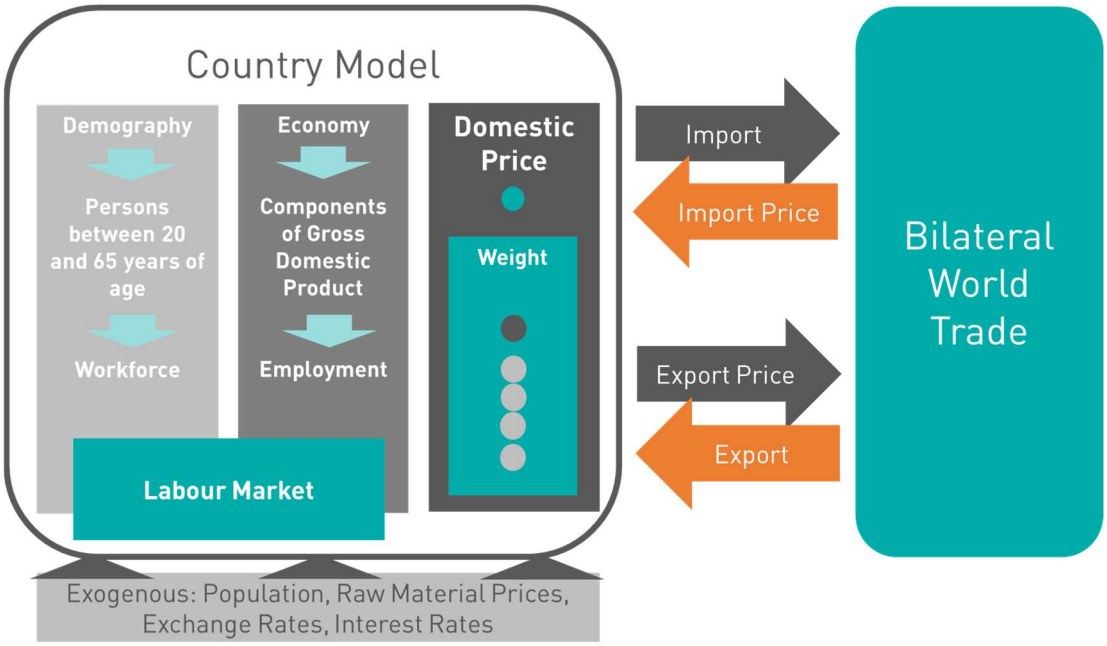
$$[9]\ WBXQ_{t,i,ec,ic} = {}^{WBXT_{t,i,ec,ic}}\Big/_{\sum_{ec=1}^{155} WBXT_{t,i,ec,ic}}$$

In summary, this proposed approach considers (i) domestic price effects and (ii) volume effects on trading partners. Looking back to chapter 2.3, trade creation and trade destruction can be simulated. What it cannot capture in its current status is trade diversion and trade concentration: Trade shifts between (competing) trading partners are only insufficiently considered. A higher tariff for e.g. European cars leads to a decline in car demand in the US and not to a shift in demand towards e.g. Chinese cars. Instead, the falling demand in cars also impacts the export of Chinese cars, or Mexican cars etc.

Other effects like quality, availability, price elasticities etc. (compare Table 1) are captured in the coefficients of trade volume estimates. Depending on the coefficients, tariffs have a higher or lower impact on trade flows which can be interpreted that other factors determine trade than tariffs.

The orange arrows in Figure 3 illustrate the position where tariffs are activated: the price effect of tariffs influence import prices, the volume effect of tariffs influence export demand.

Figure 3: TARIFF impact in TINFORGE



3.3.3 TARIFF REVENUES

Tariff revenues $tariffrevenue$ can be calculated for the 84 country models by multiplying total average tariffs $TARIFF$ with real import demand $IGSSR$. Adjusted by exchange rate $BEXR$ gives total tariff revenues in billion US dollar.

$$[10] \qquad tariffrevenue_{t,ec} = \mathrm{TARIFF}_{t,ec} * {IGSSR_{t,ec}}/{BEXR_{t,ec}}$$

In TINFORGE, tariff revenues are used for consolidation purposes only. The received income is not redistributed in the economy.

3.3.4 SOME STYLIZED FACTS ON TARIFFS AND FREE TRADE

The European Union exists now of 27 countries. Great Britain has left the European Union in January 31, 2020. Yet, the trade agreement between the EU and Great Britain still has to be negotiated. Trade agreements are negotiated on European level. The EU holds free trade agreements with 64 countries (out of 154 TINFORGE countries). No free trade agreements (FTA) exist with 54 countries (out of 154 TINFORGE countries). For example, with USA, Australia, New Zealand or China.

Figure 4: Existing free trade agreements of the EU

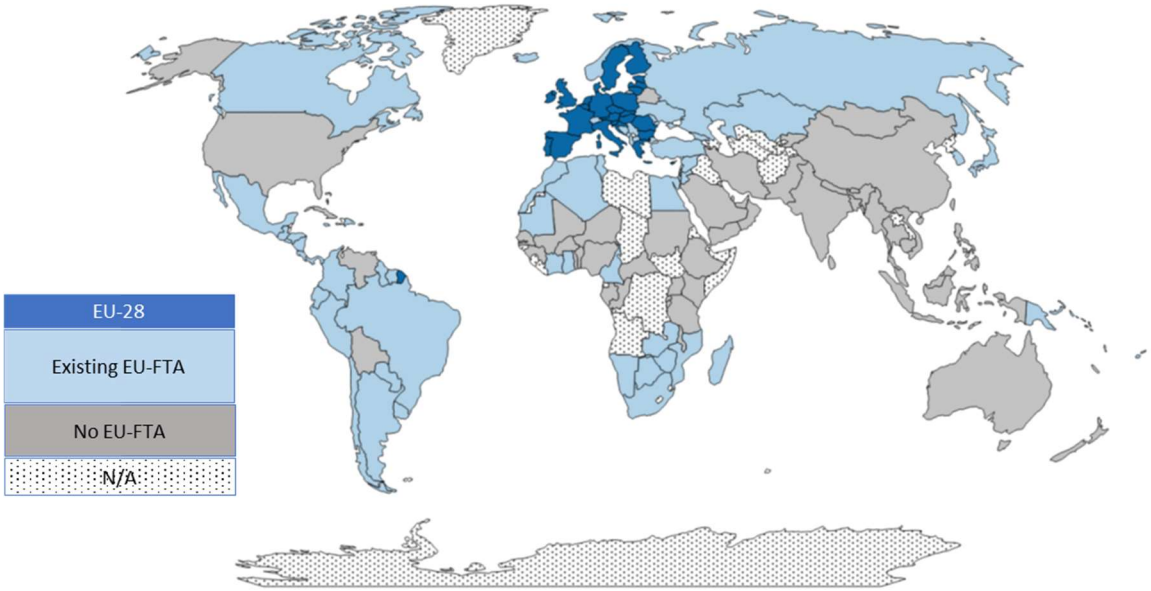
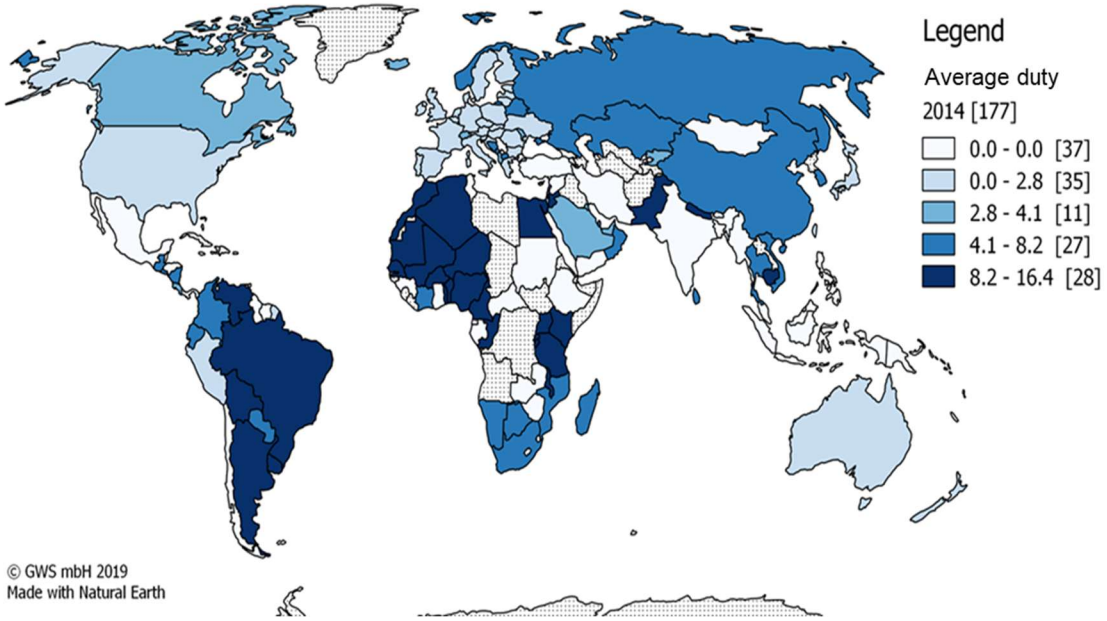


Figure 5 shows the average duty levied by each country on imports from the world. Average world duty was 3.53 % in 2014. Average duty levied by the EU on world imports are with 2.81 % slightly below world average. Also, other OECD countries like Canada, Mexico or the USA show average duties well below world average. Other economies like India, China or South Africa, instead, have average import tariffs well above world average.

Figure 5: Average duty levied by each of the 154 TINFORGE countries, 2014

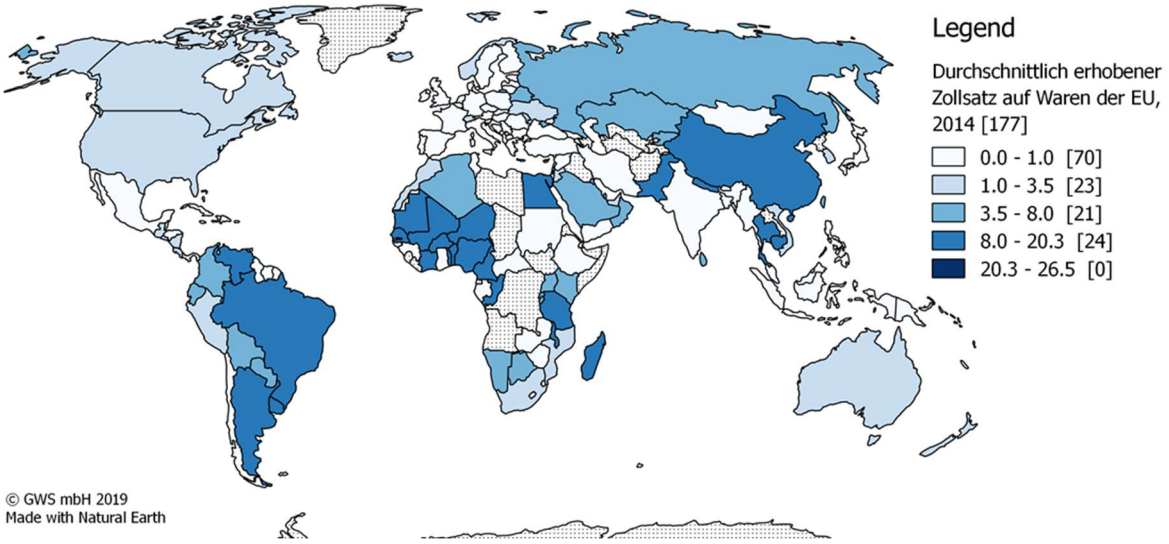


Source: UNCTAD; own calculation

From the EU perspective, products from the EU are levied in many cases above world average. Naturally, EU does not levy products within the European Union. The United States

levy products from the EU with an average tariff from 1.14 %. China, instead, demands an import tariff of 8.73 % for European products – in average. Japan, on the other hand, only levies European products with 0.94 %.

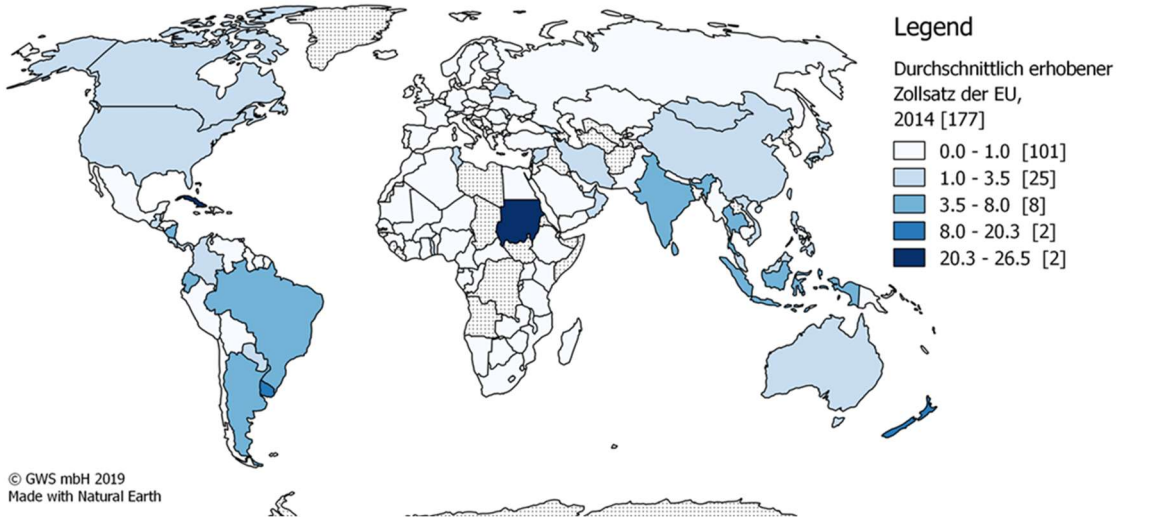
Figure 6: Average duty levied on products from EU, 2014



Source: UNCTAD; own calculation

In turn, the EU also levies imported products from other economies of the world. In general, the import tariff is below world average. US products, for instance, are levied with a rate of 2.05 %, which is slightly higher than the average import tariff for European products in the USA (1.14 % – see Figure 6). Imports from China are levied with 3.55 % which corresponds to world average, but which is slightly lower than the Chinese import tariffs for European products.

Figure 7: Average duty levied by the EU, 2014



Source: UNCTAD; own calculation

4 THE METHODOLOGY AT WORKS: INTRODUCING TARIFFS TO THE AUTOMOTIVE INDUSTRY

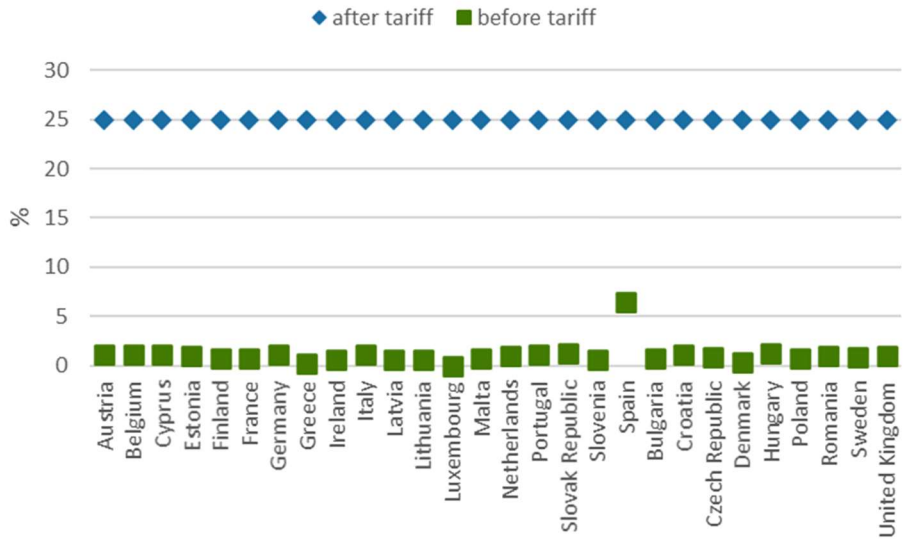
The described methodology in chapter 3 allows now to introduce, change or delete country- and product specific tariffs to the world trade model TINFORGE. Price- and volume-induced feedback loops are implemented. Effects on prices and volumes are the result of estimated bilateral trade flows.

This chapter demonstrates the functioning of the introduced methodology by simulating an automotive-specific tariff of 25% introduced by the United States against car imports from the European Union in 2030 onwards. The simulation runs on a baseline scenario including the Corona-virus effects on world trade (Mönnig & Wolter 2020).

4.1 THE STARTING POINT

Figure 8 shows the average weighted US import tariffs for the automotive industry imported from the EU-28 countries listed on the horizontal axis. The tariffs are all similar low ranging from 0.3 % for Greece and 1.2 % for Belgium, Germany, Portugal, Slovak Republic, and Hungary. Spain is an exception with an average weighted import tariff of 6.4 %.

Figure 8: Average weighted US import duties on automobiles against EU-28 countries



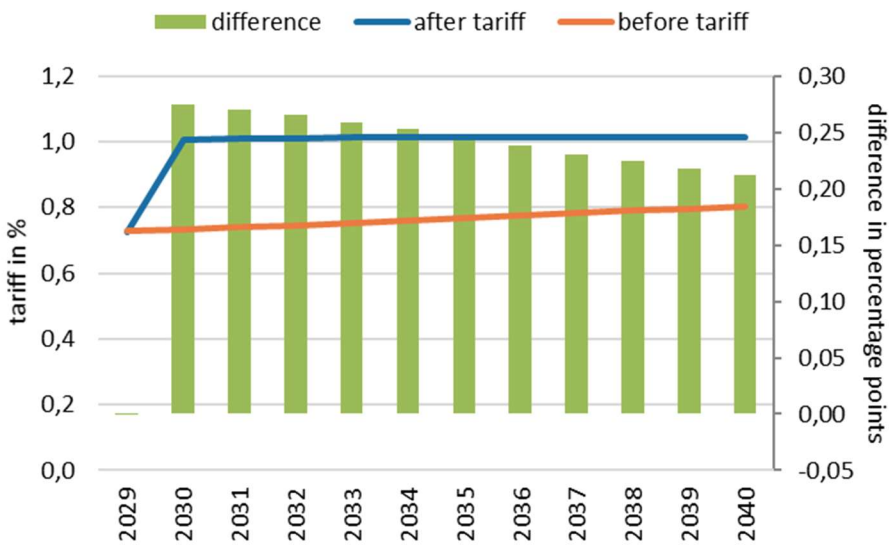
Source: TINFORGE, own calculation

The scenario assumes that in 2030, all single average weighted US import tariffs increase to a uniform 25 % tariff rate. The tariff remains on this level until end of the projection horizon in 2040.

The increase in import duties on vehicles changes the average weighted import tariffs of the United States in total. The change is shown in Figure 9. The increase of car tariffs for the 28 European economies of more than 20 percentage points leads to an overall increase in import duties – weighted by traded volumes – of around 0.3 percentage points in the shock year. In the years after, the increase declines.

This implies, that the increase in total average import tariffs of the United States is far lower than the initial effect on the specific good automobiles. This is the case, because the United States are not only importing automobiles but a lot of other products from a lot of other countries as well.

Figure 9: Average weighted US import duties in total



Source: TINFORGE; own calculation

4.2 EFFECT ON PRICES

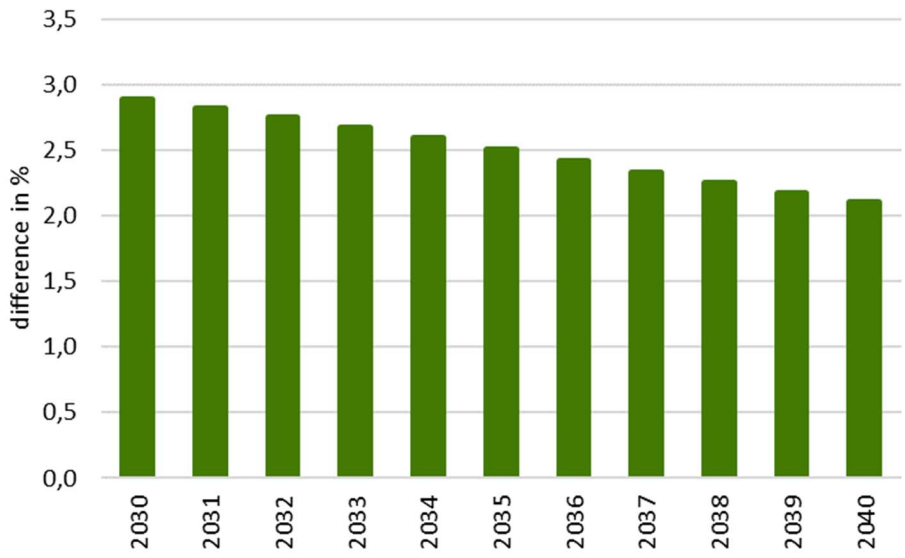
Changes in tariffs changes the prices for the imported good (compare 3.3.2). Therefore, the increase in tariffs on automobiles from the EU increases the price of imported vehicles from the European Union.

Because cars from the EU are only a part of the total US import basket, the overall impact of this increased tariff on the overall import price is much smaller. The percentage difference between the overall import price before and the overall import price after the tariff shock is shown in Figure 10.

The increased import price, however, is not transmitted to the same extent to domestic price development. The effect on consumer prices depend among other impacts on competition and market position. Studies on the impact of auto tariffs on the US price level are ambitious: While Fajgelbaum et al. (2020) argue in favour of a total passing through of import price increase to the domestic consumers, Opie & Fischer (2019) argue differently: Due to strong competition and the fear to loose market shares, European automakers will not pass through the tariff-induced price increases (“automakers prefer volume over margin” (Opie & Fischer 2019: 3).

In TINFORGE, both arguments are valid. In the short run, domestic prices increase with growing import prices, however, to a much lower extent. Price increases are only marginally implemented at the expense of returns. In the long run, the price effect declines due to adjustment processes that took place.

Figure 10: Percentage difference of overall import price of the US

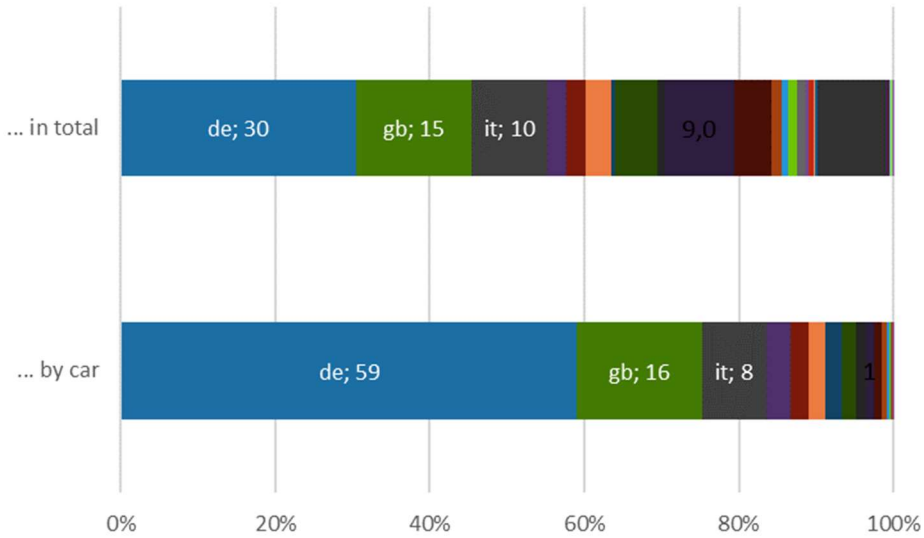


Source: TINFORGE; own calculation,

4.3 EXKURS: EU-28 TRADE STRUCTURE WITH USA

The EU-28 countries are all differently strong interrelated with the United States. Figure 11 summarizes the distribution of the 28 countries of the EU to the US in total as well as by car industry. Among all EU-28 countries, Germany holds in both cases the strongest relation to the United States. 30% of total EU-28 exports to the United States come from Germany. With respect to the automotive industry, the share increases to nearly 60%. Great Britain and Italy follow with distance.

Figure 11: Distribution of EU-28 exports to the US in total and by car, 2017



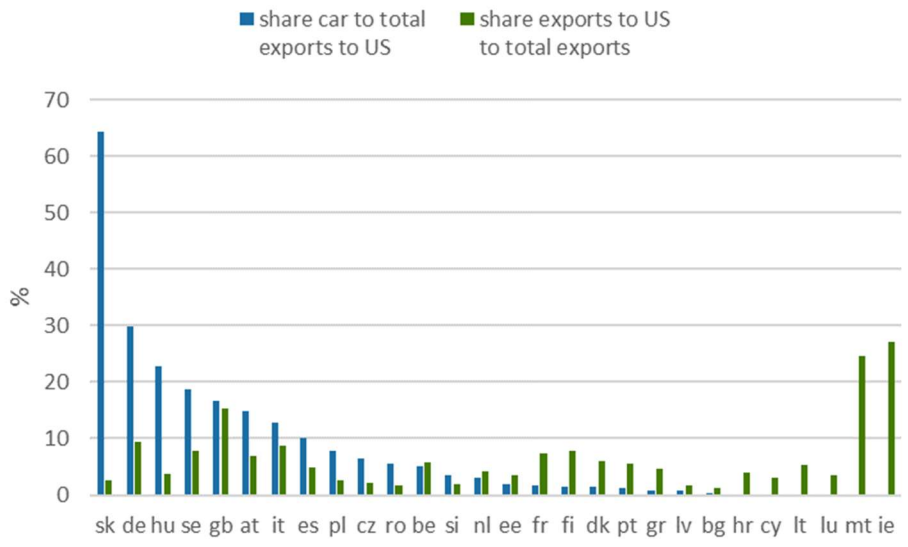
Source: OECD STAN Bilateral Trade Matrices; own calculation

The extent to which a special US-tariff on imported cars from the EU-28 countries effects one economy depends, however, on the degree to which car exports to the US determine

total exports to the US. This is shown by the blue pillars in Figure 12**Fehler! Verweisquelle konnte nicht gefunden werden.** that represent the share of car exports to total exports to the US. Interestingly, it is not Germany with the highest share, but the Slovak Republic. Relative to Slovak's overall exports to the US, the export of cars in the US dominates with 65%. For Germany, this share is only 30%.

The tariff is likely to have even more impact, if US exports determine a large share of overall exports of an economy. This is indicated with the green shaded pillars in Figure 12. This, in turn, illustrates, that Slovakia despite a high share of US car exports on total exports to the US, US exports itself only have a minor impact on total export demand in Slovakia. US exports only determine 2.4% of total Slovakian exports. In case of Germany, the share increases to 9%. Great Britain's overall export is determined by 15% of US exports. The highest share of exports to the US to total exports can be observed for Malta and Ireland. Both countries do not trade cars with the US, but other goods. Therefore, the special tariff on cars can only impose indirect effects for Malta and Ireland.

Figure 12: Share of car exports to total exports to the US and share of US exports tot total exports by EU-28 countries, in 2017



Source: OECD STAN Bilateral Trade Matrices; own calculation

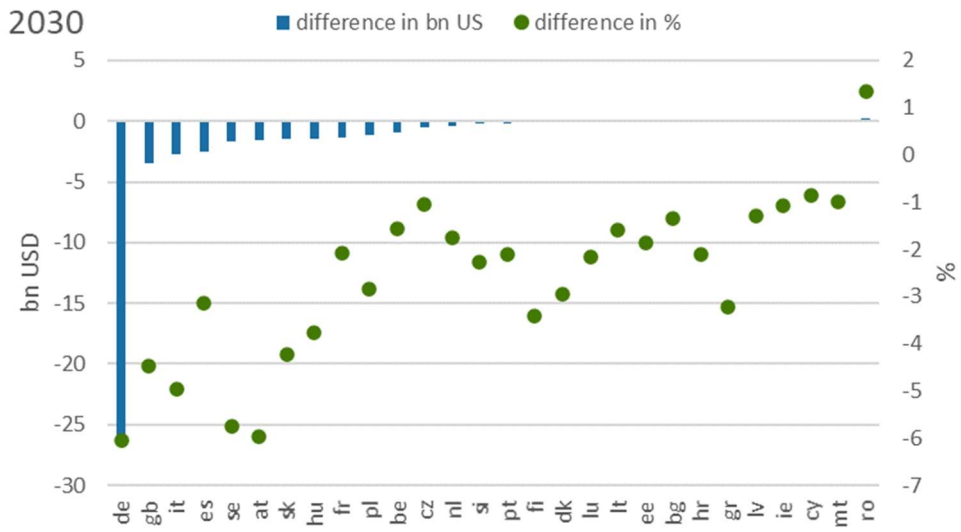
4.4 EFFECT ON TRADE VOLUME

The imposed tariff will impact export flows to the US. The volume effect was described earlier in chapter 3.3.2. Like the price effect, the degree to which exports react on tariffs depend on competition and market position. If a special tariff on EU cars is imposed by the US, export of cars from the EU-28 economies to the USA is likely to decline – depending on the price elasticity of trade. The higher the price elasticity the stronger the reaction on price changes. An increase in tariffs therefore lowers the demand for the product imposed by this tariff.

The effects on car exports by each of the EU-28 countries in the first year of the introduction of the special tariff is shown in Figure 13. The highest negative impact on car exports is

expected in Germany. Car export demand is likely to decline by 6 % or by 26 bn USD. Great Britain, Italy, Spain, and Sweden are the four economies with the next highest absolute negative impact on car exports. Except for Italy, all other economies do not host prominent car manufacturers – so called OEM manufacturer (Original Equipment Manufacturer). But many OEM manufacturers have factories in these countries.

Figure 13: Change in car exports of EU-28-countries due to US tariff on cars, 2030



Source: TINFORGE; own calculation

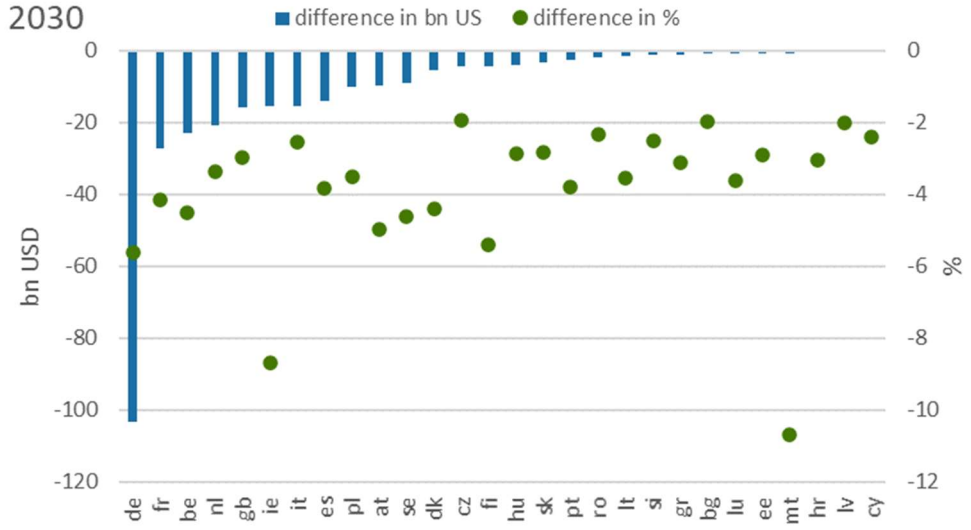
Shifting the view from car exports to total exports, the picture changes slightly. Germany remains the country with the largest impact. Two factors play together: Germany's economic performance depends largely on export dynamics and car exports represent the largest share in total export demand.

The countries with the next highest vulnerability are – with respect to total exports – France, Belgium, the Netherlands, and Great Britain. This is surprising as these economies – except for Great Britain – do neither hold a higher share in car exports to the US (compare Figure 11) nor are US exports important for overall export demand (compare Figure 14). However, this impact makes sense when second round effects are considered: Although Germany has been often criticized by its large foreign trade surplus, Germany's export surplus also benefits other economies because of the relative high import content of exports. According to OECD calculations, the import content of exports for Germany was 20.3 % in 2016 – meaning that one fifth of total exports are imports.[13] Any change in Germany's export development therefore triggers down to its trading partners. For France (16 % of all exports are destined to Germany), Belgium (17 %) and the Netherlands (23 %), Germany is the main trading partner.[14]

[13] https://data.oecd.org/trade/import-content-of-exports.htm#indicator-chart

[14] Data for 2016 from OECD STAN Bilateral Trade

Figure 14: Change in total exports by EU-28-countries due to US tariff on cars, 2030

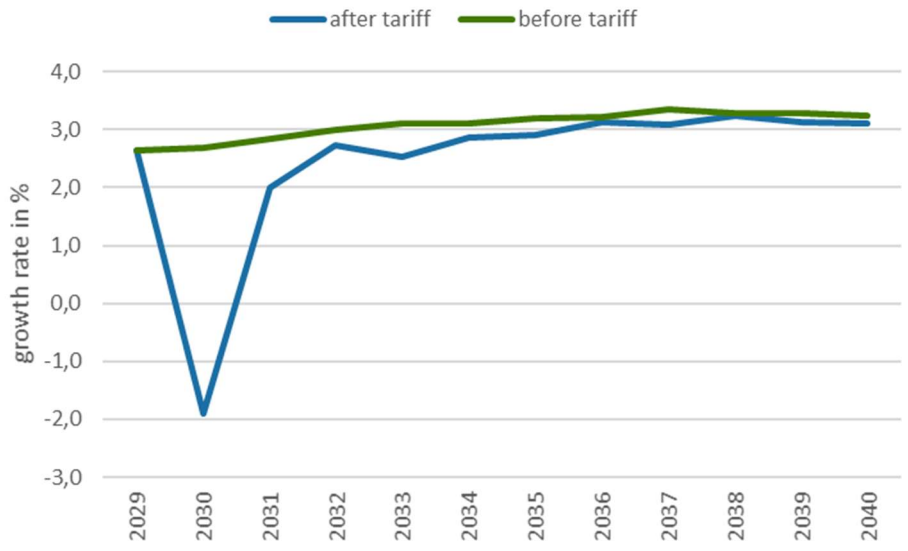


Source: TINFORGE; own calculation

4.5 EFFECT ON GERMANY'S ECONOMY

The degree to which Germany's exports are hit by the tariff is shown for the projection horizon in Figure 15. The introduction of the tariffs lowers real growth rates of Germany's total exports by 4.6 percentage points in the first year. In the long run, this effect decreases to a percentage change of 0.1 % compared to a world without additional tariffs on European cars. Looking on German car exports alone, the difference in growth rates in percentage points is much higher: In 2030, German car exports to the United States decline by 19 percentage points. The impact of US import tariffs on cars for Germany's export channel is therefore very high.

Figure 15: German exports, price adjusted



Source: TINFORGE; own calculation

The effect on exports does not only have impact on Germany's trading partners, it transmits to the entire economy. Induced by lower export demand, production is reduced within the car industry and its suppliers, jobs are cut, unemployment increases, less income is generated. The production slow-down effects private consumption that declines and which spills over to other sectors of the economy. The impacts are summarized in Table 9.

The development also shows that the German economy can adjust. In the long run, the negative impact flattens out. The economy moves back to its original growth path. However, the adjustment process will take around five years minimum. By 2035, the original growth path has been nearly reached again.

Table 9: Difference in real average growth rate in percentage points, Germany

	2030	2035	2040
Gross domestic product	-1,6	-0,1	-0,1
Private consumption	-1,5	-0,0	-0,0
State consumption	-1,2	-0,1	-0,0
Investments	0,0	-0,1	-0,0
Exports	-4,6	-0,3	-0,1
Imports	-3,9	-0,3	-0,1

Source: TINFORGE; own calculation

4.6 EVALUATION OF THE RESULTS

At first sight, the effects make sense. The transmission mechanism as described earlier is working. The effects react in the correct direction. However, it remains unclear without comparing the results with the results of other parties, whether the effect is justifiable with respect to its magnitude.

Some literature exists that discusses the effect of the implementation of a special tariff on EU car imports (Felbermayr et al. 2019, CAR 2018, Kolev 2019, Gunella & Quaglietti 2019). However, they all differ in their scenario specification, applied methodology and in their published indicators. In this respect, the comparison is only valid at parts and it only helps a bit to classify one's own results.

The following table summarizes the results. The bold rows are the scenarios that are the closest to compare with. Differences occur in magnitude but also in direction – which is very striking. Felbermayr & Steinigner (2019) are the only contribution that expect a positive impact on US GDP after the introduction of import tariffs. All other publications – including this paper – in all kind of scenarios also expect a negative downswing for the US.

Compared to Kolev (2019), the results from this paper can be categorized as large. However, in our paper we do not assume retaliation measures of the EU to counterstrike US tariffs. This may be a reason for the difference in magnitude. Additionally, no assumptions are made for government programmes to off-balance the negative impacts.

Table 10: Summary of tariffs effects; difference against baseline scenario

Source	Scenario	DE total exports	DE real GDP	US real GDP
Felbermayr & Steininger 2019[15]	**Additional US import tariffs of 25% on auto trade[16]**	**-11.6 bn EUR**	**-5 bn EUR**	**+5 bn EUR**
Kolev 2019[17]	US import tariff of 25% against half of CN imports	-0.4%	-0.1%	-0.6%
	US import tariff of 25% against all CN imports	-0.7%	-0.2%	-0.9%
	US import tariff of 10% against EU imports and imports of 5 other countries	-3.7%	-1.2%	-1.8%
	US import tariff of 25% against EU imports and imports of 5 other countries	-10.2%	-3.8%	-4.1%
	US import tariffs of 25% on cars imported from the EU; EU retaliates with import tariffs of 22%	**-0.9%**	**-0.3%**	**-0.2%**
CAR 2018	US import tariffs of 25% on cars against all countries	-	-	-59.2 bn USD
	US import tariffs of 25% on cars against all countries except CA, MX	**-**	**-**	**-15.3 bn USD**
	US import tariffs of 10% on cars against all countries	-	-	-25.5 bn USD
	US import tariffs of 10% on cars against all countries except CA, MX	-	-	-6.4 bn USD
This paper	**US import tariffs of 25% on car imports from EU-28 (data for 2030)**	**-4.5%** **-85 bn EUR**	**-1.6%** **-56 bn EUR**	**-0.6%** **-129 bn USD**

[15] Results are long run effects when adjustement process is completed; 5-10 years

[16] It is not clear form the publication whether the additional tariff of 25% is imposed against all countries or only against EU countries.

[17] Percentage deviation from baseline 5 years of after introduction of the tariff.

5 SUMMARY AND CONCLUSIONS

This paper gave a detailed description of modelling tariffs in the world trade model TINFORGE (chapter 3). It has been supplemented with general information on international trade framework and on the logic of tariffs and trade in theory (chapter 2). The modelling concept was tested on an empirical example (chapter 4) that simulated an increase of US import tariffs on EU motor vehicles.

The modelling concept of tariffs follows the widely used methodology of gravity models that determine trade flows via demand and trade tariffs. The effects are both seen on prices and on trade volume. The methodology at works has shown that tariffs are not welfare enhancing neither for the tariff charging country nor for its trading partners.

The example of car tariffs demonstrate that the car industry is highly interrelated in Europe and that the second-round effects are not to be underestimated. The results are comparatively high to other literature on that subject, which may have different causes. The usage of different types of trade models, different assumptions and data may be one reason. Another reason may be also that the TINFORGE model is limited in picture redirection of trade flows. The higher tariff for e.g. European cars leads to a decline in car demand in the US and not to a shift in demand towards e.g. Chinese cars. Instead, the falling demand in cars also impacts the export of Chinese cars, or Mexican cars etc. which again has effects on the overall car export in Germany.

This drawback in trade modelling in TINFORGE is subject for further research.

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7 ANNEX

Tabelle 1: List of countries in TINFORGE

Serial #	ISO code	Country	Country groups
1	at	Austria	Europa/EU/EZ/OECD
2	be	Belgium	Europa/EU/EZ/OECD

3	cy	Cyprus	Europa/EU/EZ
4	ee	Estonia	Europa/EU/EZ/OECD
5	fi	Finland	Europa/EU/EZ/OECD
6	fr	France	Europa/EU/EZ/OECD
7	de	Germany	Europa/EU/EZ/OECD
8	gr	Greece	Europa/EU/EZ/OECD
9	ie	Ireland	Europa/EU/EZ/OECD
10	it	Italy	Europa/EU/EZ/OECD
11	lv	Latvia	Europa/EU/EZ
12	lt	Lithuania	Europa/EU/EZ
13	lu	Luxembourg	Europa/EU/EZ/OECD
14	mt	Malta	Europa/EU/EZ
15	nl	Netherlands	Europa/EU/EZ/OECD
16	pt	Portugal	Europa/EU/EZ/OECD
17	sk	Slovak Republic	Europa/EU/EZ/OECD
18	si	Slovenia	Europa/EU/EZ/OECD
19	es	Spain	Europa/EU/EZ/OECD
20	bg	Bulgaria	Europa/EU
21	hr	Croatia	Europa/EU
22	cz	Czech Republic	Europa/EU/OECD
23	dk	Denmark	Europa/EU/OECD
24	hu	Hungary	Europa/EU/OECD
25	pl	Poland	Europa/EU/OECD
26	ro	Romania	Europa/EU
27	se	Sweden	Europa/EU/OECD
28	gb	United Kingdom	Europa/EU/OECD
29	is	Iceland	Europa/OECD
30	no	Norway	Europa/OECD
31	ch	Switzerland	Europa/OECD
32	al	Albania	Südosteuropa/EU-Beitrittskandidaten
33	mk	Macedonia	Südosteuropa/EU-Beitrittskandidaten
34	me	Montenegro	Südosteuropa/EU-Beitrittskandidaten
35	cs	Serbia	Südosteuropa/EU-Beitrittskandidaten
36	tr	Turkey	Südosteuropa/Vorderasien/EU-Beitrittskandidaten/OECD
37	ba	Bosnia & Herzegovina	Südosteuropa
38	md	Moldova	Südosteuropa
39	bl	Belarus	Osteuropa
40	ua	Ukraine	Osteuropa

41	ca	Canada	Nordamerika/OECD
42	mx	Mexico	Nordamerika/OECD
43	us	United States	Nordamerika/OECD
44	ru	Russian (Federation of)	Asien/BRIICS
45	cn	China	Ostasien/BRIICS
46	tw	Chinese Taipei	Ostasien
47	hk	Hong Kong, China	Ostasien
48	jp	Japan	Ostasien/OECD
49	kr	Korea	Ostasien/OECD
50	mo	Macau	Ostasien
51	bn	Brunei	Südostasien
52	kh	Cambodia	Südostasien
53	id	Indonesia	Südostasien/BRIICS/OPEC
54	my	Malaysia	Südostasien
55	mm	Myanmar	Südostasien
56	mn	Mongolia	Südostasien
57	ph	Philippines	Südostasien
58	sg	Singapore	Südostasien
59	th	Thailand	Südostasien
60	vn	Viet Nam	Südostasien
61	bd	Bangladesh	Südasien
62	bt	Bhutan	Südasien
63	in	India	Südasien/BRIICS
64	mv	Maldives	Südasien
65	np	Nepal	Südasien
66	pk	Pakistan	Südasien
67	lk	Sri Lanka	Südasien
68	ge	Georgia	Zentralasien
69	ka	Kazakhstan	Zentralasien
70	kg	Kyrgyzstan	Zentralasien
71	bh	Bahrein	Mittlerer Osten
72	ir	Iran	Mittlerer Osten/OPEC
73	il	Israel	Mittlerer Osten/OECD
74	jo	Jordan	Mittlerer Osten
75	kw	Kuwait	Mittlerer Osten/OPEC
76	lb	Lebanon	Mittlerer Osten
77	om	Oman	Mittlerer Osten
78	qa	Qatar	Mittlerer Osten/OPEC
79	sa	Saudi Arabia	Mittlerer Osten/OPEC

80	sy	Syria	Mittlerer Osten
81	ae	United Arab Emirates	Mittlerer Osten/OPEC
82	ye	Yemen	Mittlerer Osten
83	ar	Argentina	Südamerika
84	aw	Aruba	Südamerika
85	bo	Bolivia	Südamerika
86	br	Brazil	Südamerika/BRIICS
87	cl	Chile	Südamerika/OECD
88	co	Colombia	Südamerika
89	ec	Ecuador	Südamerika/OPEC
90	gy	Guyana	Südamerika
91	py	Paraguay	Südamerika
92	pe	Peru	Südamerika
93	sr	Suriname	Südamerika
94	uy	Uruguay	Südamerika
95	ve	Venezuela	Südamerika/OPEC
96	cr	Costa Rica	Zentralamerika
97	sv	El Salvador	Zentralamerika
98	gt	Guatemala	Zentralamerika
99	hn	Honduras	Zentralamerika
100	ni	Nicaragua	Zentralamerika
101	pa	Panama	Zentralamerika
102	dz	Algeria	Afrika/Nord/OPEC
103	eg	Egypt	Afrika/Nord
104	ma	Morocco	Afrika/Nord
105	sd	Sudan	Afrika/Nord
106	tn	Tunisia	Afrika/Nord
107	mr	Mauritania	Afrika/NordWest
108	bj	Benin	Afrika/West
109	bf	Burkina Faso	Afrika/West
110	cm	Cameroun	Afrika/West
111	cv	Cape Verde	Afrika/West
112	ci	Côte d'Ivoire	Afrika/West
113	gh	Ghana	Afrika/West
114	gn	Guinea	Afrika/West
115	ml	Mali	Afrika/West
116	ne	Niger	Afrika/West
117	ng	Nigeria	Afrika/West/OPEC
118	sn	Senegal	Afrika/West

119	gm	The Gambia	Afrika/West
120	tg	Togo	Afrika/West
121	bi	Burundi	Afrika/Zentral
122	cf	Central African Republic	Afrika/Zentral
123	ga	Gabon	Afrika/Zentral
124	cg	Republic of the Congo	Afrika/Zentral
125	et	Ethiopia	Afrika/Ost
126	ke	Kenia	Afrika/Ost
127	mg	Madagascar	Afrika/Ost
128	mu	Mauritius	Afrika/Ost
129	rw	Rwanda	Afrika/Ost
130	sc	Seychelles	Afrika/Ost
131	tz	Tanzania	Afrika/Ost
132	ug	Uganda	Afrika/Ost
133	mw	Malawi	Afrika/SüdOst
134	mz	Mozambique	Afrika/SüdOst
135	na	Namibia	Afrika/SüdWest
136	bw	Botswana	Afrika/Süd
137	za	South Africa	Afrika/Süd/BRIICS
138	zm	Zambia	Afrika/Süd
139	zw	Zimbabwe	Afrika/Süd
140	st	Sao Tome and Principe	Afrika
141	cu	Cuba	Karibik
142	do	Dominican Republic	Karibik
143	dm	Dominica	Karibik
144	jm	Jamaica	Karibik
145	ms	Montserrat	Karibik
146	vc	Saint Vincent and the Grenadines	Karibik
147	kn	Saint Kitts and Nevis	Karibik
148	tt	Trinidad and Tobago	Karibik
149	fj	Fiji	Pazifik
150	nc	New Caledonia	Pazifik
151	au	Australia	Ozeanien/OECD
152	nz	New Zealand	Ozeanien/OECD
153	pg	Papua New Guinea	Ozeanien
154	to	Tonga	Ozeanien
155	re	Rest of the world	
156	ww	Total World	

Tabelle 2: Industry activities in TINFORGE

ISIC Rev.4	Serial No.	Industry activities
DTOTAL	1	DTOTAL: TOTAL
D01	2	D01: Crop and animal production, hunting and related service activities
D02	3	D02: Forestry and logging
D03	4	D03: Fishing and aquaculture
D05	5	D05: Mining of coal and lignite
D06	6	D06: Extraction of crude petroleum and natural gas
D07	7	D07: Mining of metal ores
D08	8	D08: Other mining and quarrying
D10	9	D10: Food products
D11	10	D11: Beverages
D12	11	D12: Tobacco products
D13	12	D13: Textiles
D14	13	D14: Wearing apparel
D15	14	D15: Leather and related products
D16	15	D16: Wood and products of wood and cork, except furniture; articles of straw and plaiting materials
D17	16	D17: Paper and paper products
D18	17	D18: Printing and reproduction of recorded media
D19	18	D19: Coke and refined petroleum products
D20	19	D20: Chemicals and chemical products
D21	20	D21: Basic pharmaceutical products and pharmaceutical preparations
D22	21	D22: Rubber and plastics products
D23	22	D23: Other non-metallic mineral products
D24	23	D24: Basic metals
D25	24	D25: Fabricated metal products except machinery and equipment
D26	25	D26: Computer, electronic and optical products
D27	26	D27: Electrical equipment
D28	27	D28: Machinery and equipment n.e.c.
D29	28	D29: Motor vehicles, trailers and semi-trailers
D30	29	D30: Other transport equipment
D31T32	30	D31T32: Furniture; Other manufacturing
D35	31	D35: Electricity and gas
D36T99	32	D36T99: Other activities
DWASTE	33	DWASTE: Total Waste
UNALLO-CATED	34	UNALLOCATED: Unallocated