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DYNAMISING TRADE IN A DOMESTIC INPUT-OUTPUT MODEL

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TINFORGE

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1 Introduction

Although Germany has a relatively moderate degree of openness (47%) compared to other European economies, its growth dependence on the trade channel is high: the growth impact of exports exceeds in general those of other GDP components and the export share of nominal GDP amounts to over 50%. Major industrial sectors like the car industry, the machinery and equipment industry or the chemical industry depend highly on foreign demand and, at the same time, are important employers and growth vehicles for the Germany economy. Although Germany is highly integrated in the European economy, the European crisis has shifted the export flow constantly towards other world regions. Especially China has turned into an important and vital trading partner.

In such an environment, changing trade patterns and its impact on the domestic economy are important features for scientific-based policy analysis. World models that capture first and second round trade affects have been developed and applied. Nowadays, these models also include sophisticate country models that often incorporate input-output relations and price models. The advantages of these models are clear. Nevertheless, they demand time, data and work capacity.

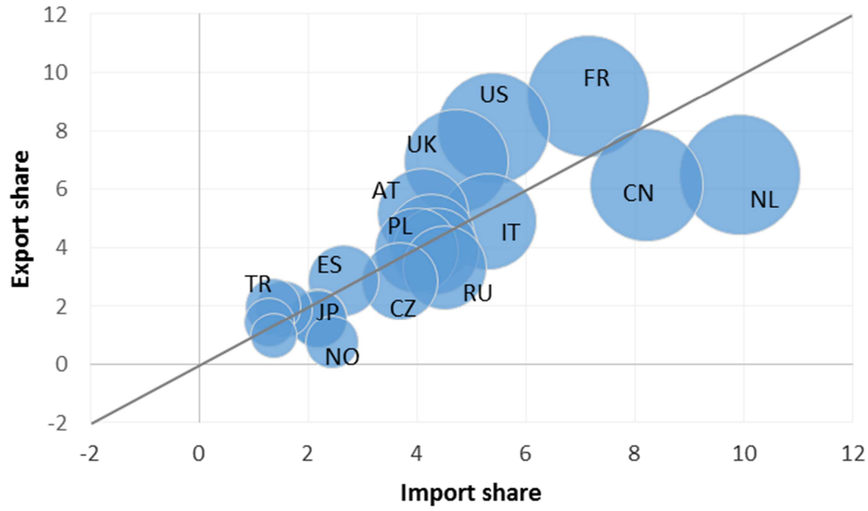
World trade in general is an exogenous given variable in national models such as INFORGE (Interindustry Forecasting Germany). In earlier versions, world trade was derived from the INFORUM model system (http://www.inforum.umd.edu), later, world trade was taken from the world model GINFORS. Currently, the trade module of INFORGE rests on third party projections that are integrated in a bilateral trade system. Each previous approach has proven to be less suitable for the purpose at hand: the INFORUM and GINFORS approach relied both on a complex world trade systems that lagged behind in their updating procedure. Current developments were not possible to integrate quickly. The current version, then again, does not encounter first and second round effects of world trade. The goal was to replace the import projection of third party institutions by a dynamic world trade model (TINFORGE) that could be easily updated and integrated into the national input-output model INFORGE.

2 Germany's trade relations

The growth impact of exports in Germany was mostly positive and dominating to the other determinants of GDP in the past. But in 2009, the vulnerability of the German economy due to its strong exposure to foreign trade became more than evident with a decline in real GDP of 5.1%. The negative growth impact of exports reached the level of -6.3%. Within one year, the recovery process, initiated by worldwide stimulus packages of estimated 2,000 billion USD, let to a strong economic upswing. Again, the export channel was the major driving force to this development.

At the same time, German foreign trade is strongly concentrated on certain regions and single economies. In Figure 1, the 20 largest trading partners of Germany are shown with respect to their total trade volume, export share and import share. The diagonal line indicates which countries are more relevant for imports and which one are more relevant in terms of exports. Those countries with a high import share, are mostly those economies that export raw materials to Germany. The most relevant economy for Germany are France, China and the United States as well as the Netherlands.

Figure 1: The 20 largest trading partners of Germany by trade volume with their export and import share

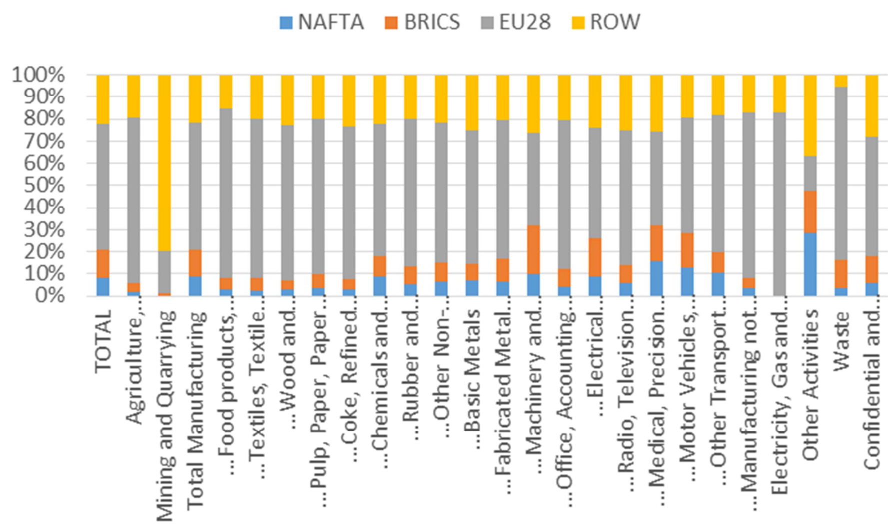


Source: Destatis 2014

On product level, Germany is net-exporter for most manufacturing products like cars, machineries and chemical products. Typically, Germany imports especially electronic products, textiles or raw materials.

By regions and product level, the EU-28 represent the most important export absorbing region for Germany. Most of the manufacturing products are sold to the European Union. The NAFTA or the BRICS region are comparable small. But looking into a more detailed product level, the BRICS region is becoming more important especially for the equipment and machinery industry.

Figure 2: Export share by region and products



Source: OECD 2014

3 Methodology

3.1 INFORGE

The IAB/INFORGE-model has been developed by the Institute of Economic Structures Research (GWS) and has been tested in numerous applications in the field of research and policy analysis (Ulrich et al. 2012, Barker et al. 2011, Lindenberger 2010). The model belongs to the INFORUM family of modeling (Almon 1991) that rests on two basic fundamentals: bottom-up construction and total integration. The former indicates that each industrial sector is modeled individually and that macroeconomic variables are calculated through explicit aggregation. This approach ensures that each individual sector is embedded within the economic context and that industrial interdependencies are explicitly incorporated and used to explain economic interaction. The latter describes a complex and simultaneous solution which takes into consideration inter-industrial dependence as well as the distribution of income, the redistribution effects of the state and the usage of income for goods. Thus, the input-output tables are fully implemented in the national accounts (Ahlert et al. 2009, Distelkamp et al. 2003). Both datasets are specified for improving the identification for gross fixed capital formation, private consumption, state consumption and foreign trade. Labour market specifics are consistently embedded in the macroeconomic context through output and unit costs. Macroeconomic indicators are determined by aggregation of 63 industries.

INFORGE solves simultaneously, is dynamic over time and is described with non-linear functions. Its basic dataset consists of input-output-tables and national accounts. The applied model in this paper follows the school of evolutionary economics (Nelson & Winter 1982) as features like technological change, imperfect competition and interdependencies, or partially sticky prices are standard characteristics. In INFORGE, parameters and their elasticity values are estimated econometrically with given time series for a large number of variables.

An integral element of input-output-modeling is the determination of intermediate demand between industries. Input coefficients represent the relation of intermediate demand to total production. In IAB/INFORGE technological change is identified by applying variable input coefficients. They are endogenously determined by relative prices and time trend. Using the Leontief-inverse $(I\text{-}A)^{-1}$ – with A as input coefficient matrix and I as identity matrix – and multiplying it with final demand (fd) gross production (y) by 59 industries is given. In the following equations the notations are as follows: lower case letters are vectors, upper case letters are either times series or matrices. The dimension of vectors and matrices are indicated with subscripts. The subscript t indicates time dependency.

[1] $y_t = (I - A_t)^{-1} \cdot fd_t$

In INFORGE, exports are driven by world trade dynamics for German goods which are modelled in two dimensions: by goods and services and by export demanding countries (Maier et al. 2013). This allows accounting for diverging speeds in economic developments as well as for different demand structures by countries.

Starting point in INFORGE are the economic forecasts (gdpf) for 65 countries and one regions (Rest of World) taken from the International Monetary Fund[1], the European Commission[2] and the International Energy Agency[3]. The import share (impq) is calculated for each country. The ratio is assumed to remain constant over time. The development of imports (impf) is specified by the economic growth path of each trading partner.

[2] $impf_{cc,t} = impq_{cc,t} / 100 * gdpf_{cc,t}$ $\qquad cc \in [1,\ldots,65]$

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1 World Economic Outlook Database of the International Monetary Fund (IMF)

2 Ameco Database of the European Commission (EC)

3 World Energy Outlook of the International Energy Agency (IEA)

Bilateral trade matrices[4] (TRAD) for Germany are applied to determine the share of Germany in each country's import function (impqd). In the baseline scenario, these shares remain constant.

[3] $$impqd_{cc,t} = \sum_{g} \left(TRAD_{g,cc,t} \right) / 10000 / impf_{cc,t} \qquad cc \in [1,\ldots,65], g \in [1,\ldots,43]$$

Total export demand for German products can be derived by multiplying the import shares (impqd) with the projected import demand (impf) of each economy. The total export demand is distributed to 43 categories of goods by using the export shares on total export demand taken from the bilateral trade matrices (TRADQ). In the baseline scenario, these shares remain constant as well.

[4] $$TRAD_{g,cc,t} = TRADQ_{g,cc,t} / 100 * \left(impqd_{cc,t} * impf_{cc,t} * 10000 \right) \qquad cc \in [1,\ldots,65], g \in [1,\ldots,43]$$

The sum over all countries (exnsv) is then used to estimate German exports (x).

[5] $$exnsv_{g,t} = \sum_{cc} \left(TRAD_{g,cc,t} \right) / 1000000 \qquad cc \in [1,\ldots,65], g \in [1,\ldots,43]$$

[6] $$x_{j,t} = x_{j,t}\left(exnsv_{g,t} \right) \qquad cc \in [1,\ldots,65], g \in [1,\ldots,43]$$

3.2 TINFORGE

TINFORGE connects 70 countries and regions by trade. Each country is price taker for imports and offers export goods on the world market. The bilateral trade matrix from the OECD determines the trade shares between all countries. The model solves its regression functions until 2030 (Wolter et al. 2014). Trade shares are estimated with a time trend, allowing changing trade shares in time. As a result, TINFORGE produces estimated growth paths for 70 countries and regions.

In detail, each of the 70 countries receives export demand from the other countries and deliver, at the same time, export prices to which they are willing to sell their products. The distribution of the export volume to the trading partners is managed by the bilateral trade matrix BTM. The importing countries are shown in the columns (ic); the exporting countries are represented in the rows (ec). The export demand function for each exporting country ex_{ec} is as such:

[7] $ex_{ec}[t] = \Sigma SBTM_{ec,ic}[t] * im_{ic}[t]$ with $SBTM_{ec,ic}[t] = BTM_{ec,ic}[t]/im_{ic}[t]$

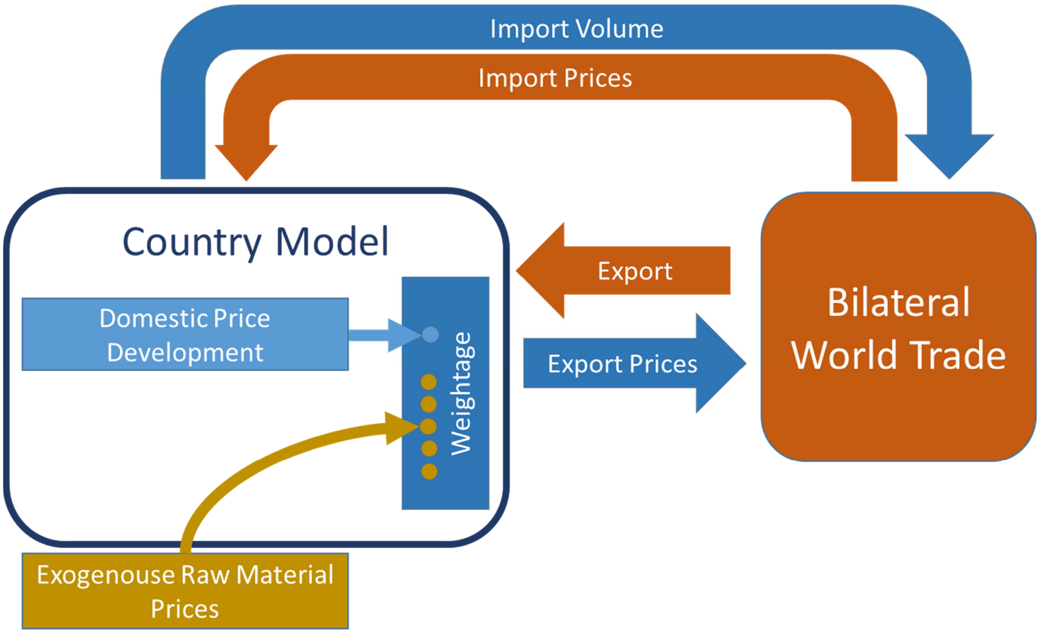
Import prices are similar explained: the import price of each country ipc_{ic} is the result of a weighted export prices epc_{ec} of those countries from where the products are bought.

[8] $ipc_{ic}[t] = \Sigma SBTM_{ec,ic}[t] * epc_{ec}[t]$

The average export price varies significantly in relation to the country's specific position on world market and competitiveness. Raw material exporting countries like Saudi-Arabia, that rely on one certain product mostly set their export prices on other determinants than domestic wage developments. Differently Germany, that exports mostly final and intermediate processed products. Their prices depend on domestic cost factors such as wage developments.

[4] Published by the Organization of Economic Cooperation and Development (OECD)

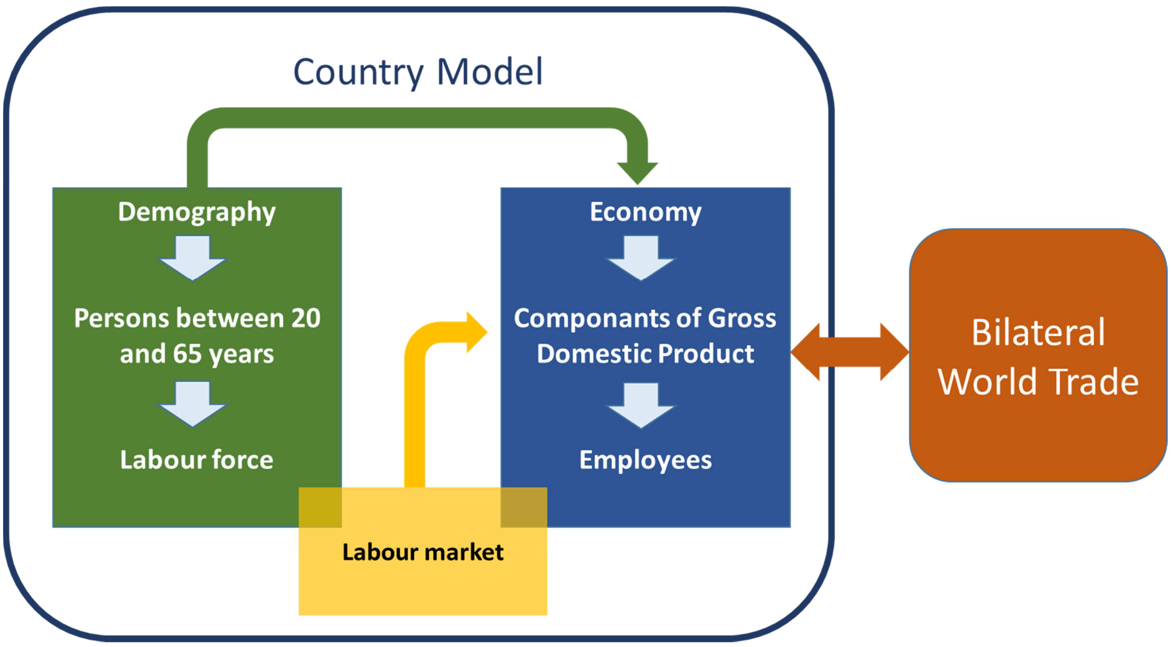
Figure 3: Overview TINFORGE structure



The bilateral trade matrix (BTM) shows the export volume of 70 trading partners. The export volume of exporting countries (ec) are influenced by the import demand of its trading partners (ic). In the past it was deductible, that trade shares are variable over time. That is why in TINFORGE the trade shares are flexible and are determined by a declining trend forecast. Different trends are tested. An automatic regression approach was chosen in order to manage the large number of regression options. If no trend is significant, the trade share remains constant. The approach assures that the sum over all trade shares is 100%.

[9] $SBTM_{ec,ic}[t] = f\{Trend\}$ side condition $100 = \Sigma_{ec} SBTM_{ec,ic}[t]$

Figure 4: Country models and world trade



4 Simulation

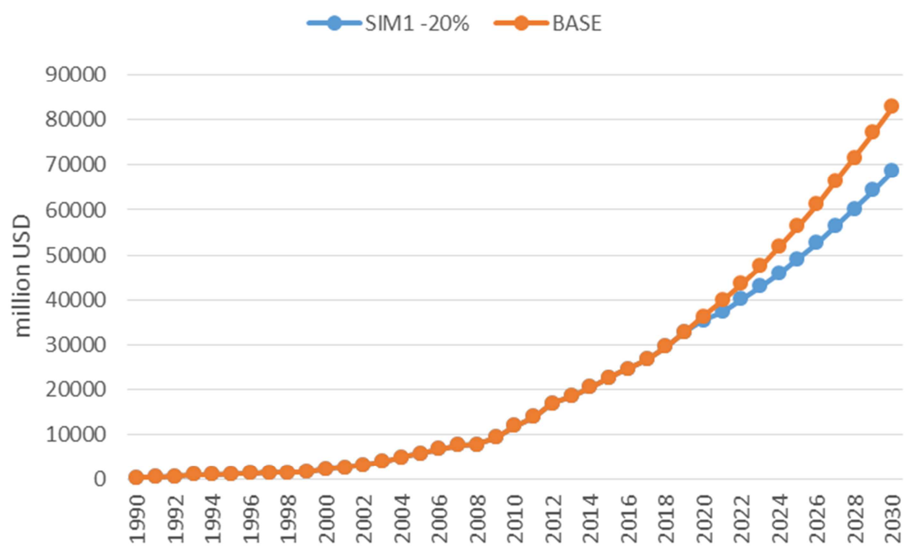
On the example of an economic downswing in China, the trade effects on Germany are demonstrated. TINFORGE is applied in order to demonstrate the additional effects of second and third round trade effects on national growth performances.

The world model TINFORGE is used as starting point: a recession assumption in China is implemented in TINFORGE. The GDP growth deviations between the TINFORGE-baseline scenario and TINFORGE-recession-scenario are integrated in INFORGE as exogenous factors. Whereas the first simulation in INFORGE only considers the single effects of China's GDP growth (SIM-1 solo), the second simulation also considers the GDP effect of all other trading partners as well (SIM-2 total).

The recession simulation for China assumes a decline in real private consumption of 20% for each year starting in 2020. The high impact has been randomly chosen as well as the starting year of the simulation.

In TINFORGE, the decline in private consumption leads to a loss in real GDP. The effect is not that strong as for private consumption, because other effects outbalance the total growth impact: a decline in private consumption implies a decline in import demand which in turn has a positive effect via the trade balance on GDP. The effects on real import demand are shown in the following graph. They turn out to be lower compared to the baseline scenario as well. But differently to the effects on private consumption, they do not experience such a sudden decline in the year of the shock. Instead, the steadily loose pace compared to the baseline scenario. This effect is the result of the specific regression equation for China's real imports: they are not only determined by domestic demand but also by export demand. This is so because China functions as a world work bench and, hence, a lot of imported products are bound for exports.

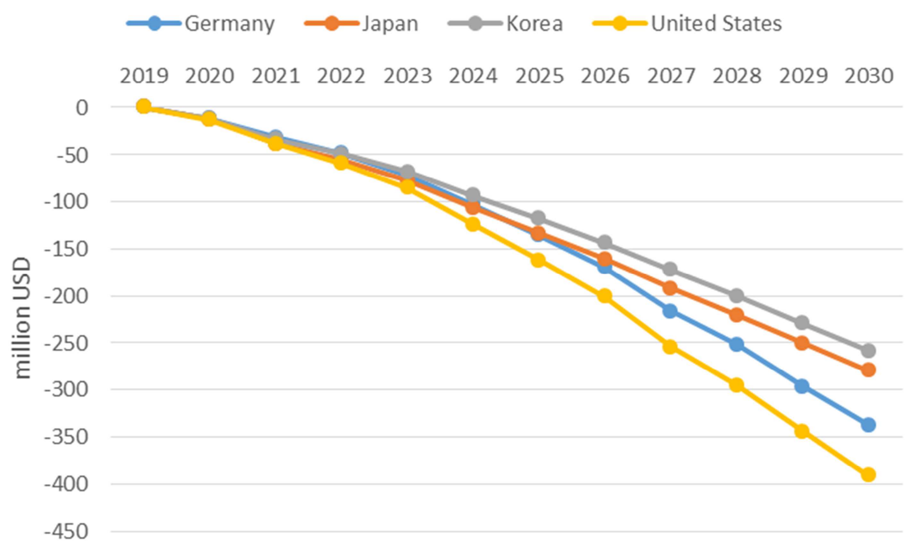
Figure 5: Simulation 1: declining real import demand in China



Source: TINFORGE

The overall declining growth path initiated by a decline in private consumption triggers down to all trading partners of China. A decline of China's import demand is – vice versa – a decline of export demand for other countries of the world that show trade relations with China. The strongest effects strike the United States, Germany, Japan and Korea.

Figure 6: Export demand – effect in absolute numbers to baseline scenario; 4 most effected trading partners

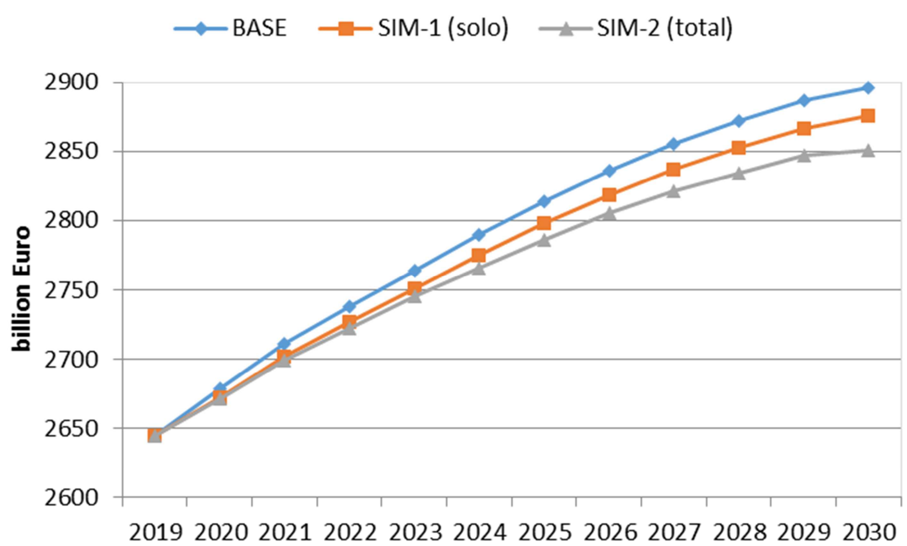


Source: TINFORGE

5 Results

Implementing the results for China alone (SIM-1 solo) and for all other trading partners of Germany (SIM-2 total) in the national model INFORGE indicates, that the error of disregarding second and third round effects on trade simulations in national models are considerable large. In Figure 7, real GDP in the baseline scenario (BASE), in simulation 1 and 2 is shown. In the short term, the differences between both simulations are not large, but in the long run the differences grow intensively. By 2030, real GDP is twice as low in SIM-2 then in SIM-1.

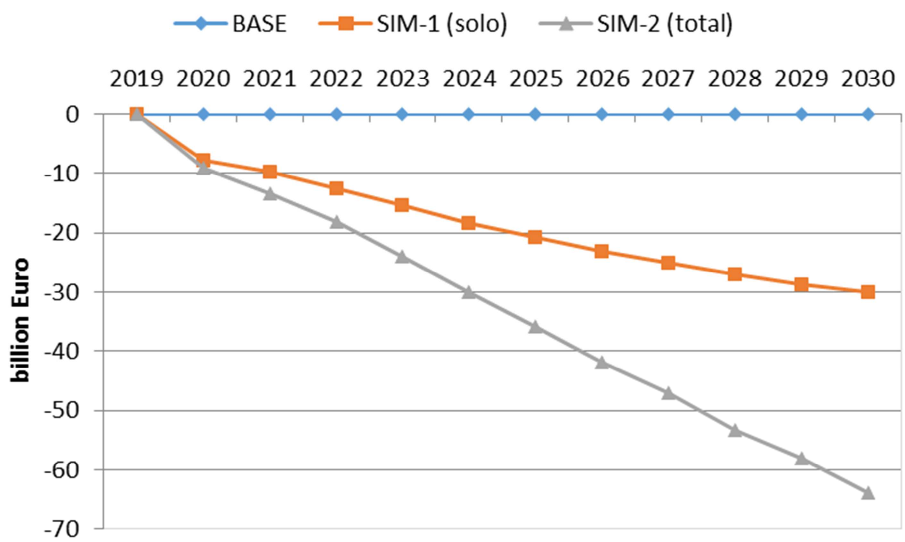
Figure 7: Real GDP of Germany



Source: INFORGE

In Figure 8, the absolute difference of real exports is given for both simulations. Again, the decline in real export demand for Germany is much stronger when all effects of China's recession is considered. The impact of China's reduced import demand on the United States, for instance, also affects Germany indirectly. The lower growth performance of the US, due to China's downturn, also leads to a declining import demand of the US and therefore, also the US demands fewer products from Germany. Not only are the exports towards China affected but also to Nord America.

Figure 8: Real exports of Germany, difference to BASE

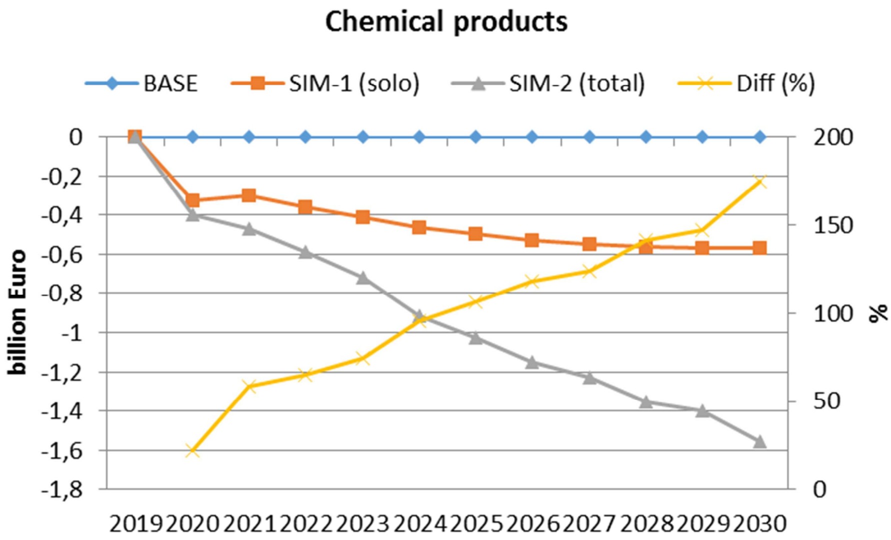


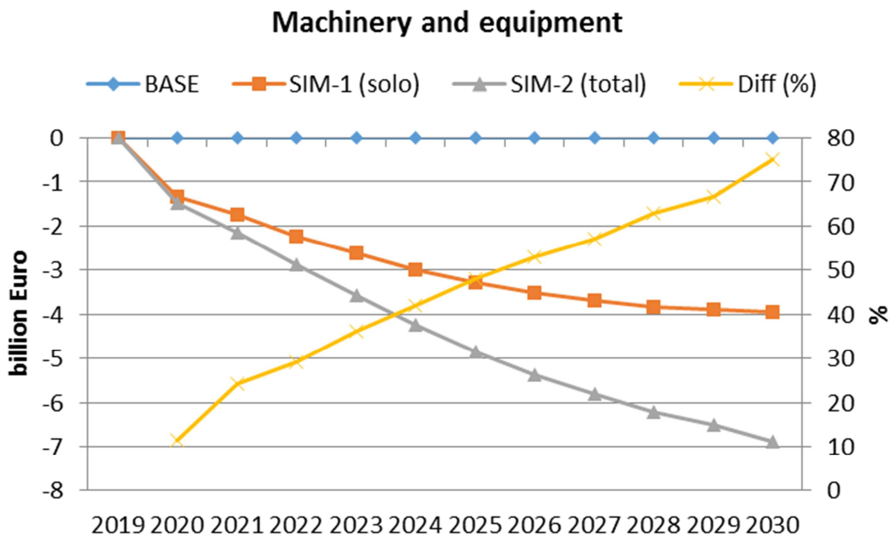
Source: INFORGE

This observation has also its leverage on structural level. Especially the case of chemical products and machinery and equipment are prominent examples for the differences it makes. As shown in Figure 2, different to machinery and equipment, chemical products are not much exported to the BRICS region. Chemical and chemical products hold a share of 7% on all German exports dedicated to China, whereby the share of chemicals bounded for the US is 14%. Instead, machinery and equipment have a share of 28% of all exports to China, but only 17% of all exports to the US. Accordingly, the non-consideration of second and third round trading effects must not effect the chemical industry as much as the machinery and equipment industry. But the additional effect coming from those indirect effects must be much strong for the case of the chemical industry than for the machinery and equipment industry.

The total effect is stronger for machinery and equipment. But this is due to the fact, that the export volume of machinery and equipment is much higher than the export volume of chemical products per se. The observation holds for both products types, that SIM-2 has a stronger effect on real production. When comparing SIM-1 with SIM-2 in relative terms, the effects are much larger for chemical products then for machinery and equipment. Whereas the percentage difference between SIM-1 and SIM-2 for chemical products rising to 175% in 2030, it is only 75% for the case of machinery and equipment.

Figure 9: Real production – difference in billion Euro towards BASE; percentage change between SIM-1 and SIM-2 for chemical products and machinery and equipment.





Source: INFORGE

6 Conclusion

The results show, that a consideration of not only direct but also of indirect trade effects are important and can alter the output within in national models significantly. It is not only that the effects on macro level are much larger, but also structural effects differ extremely. Effects on the labour market – which has not been subject of the analysis of this paper – are likely to look different. Albeit the qualitative results do not differ to whether third or second trade effects are considered or not, the quantitative effects are significantly different.

The analysis has shown that a national model may improve its quantitative analysis significantly when it adapts inputs from world models. The combination of TINFORGE and INFORGE – as demonstrated in this paper – allows implementing in a very detailed national input-output model second and third round trade effects without having to use a whole fledged world model.

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