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Propagation of Changes in Demand through International Trade: Case Study China*

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Abstract

China's economy, the second largest in the world, is undergoing a fundamental transition. Its transition from a strong focus on investment and exports towards a larger share of consumption could have important ramifications for China's trading partners. Using China as a case study, this paper deploys a sectoral input-output (IO) analysis to take into account higher-round spillovers from a reduction in import demand or a shift in the composition of the Chinese economy. This approach demonstrates strong indirect effects that exceed by far the initial shock from direct trade links, reflecting China's integration into a closely knit global value chain. The result suggests that the ongoing transition in China will have important effects on the global economy.

Keywords: Shock propagation · Trade channel · Input-Output · China

JEL Classification: F14 · C67 · F47

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1 Introduction

China has emerged as second largest economy in the world. The rise of the Chinese economy has boosted global growth, and its trade openness has created strong interlinkages with other economies. In recent years, however, China's economy has been undergoing radical change, with increasingly consumption replacing investment and exports as drivers of growth. This transition is likely to leave an imprint on global trading patterns and affects many economies around the globe.

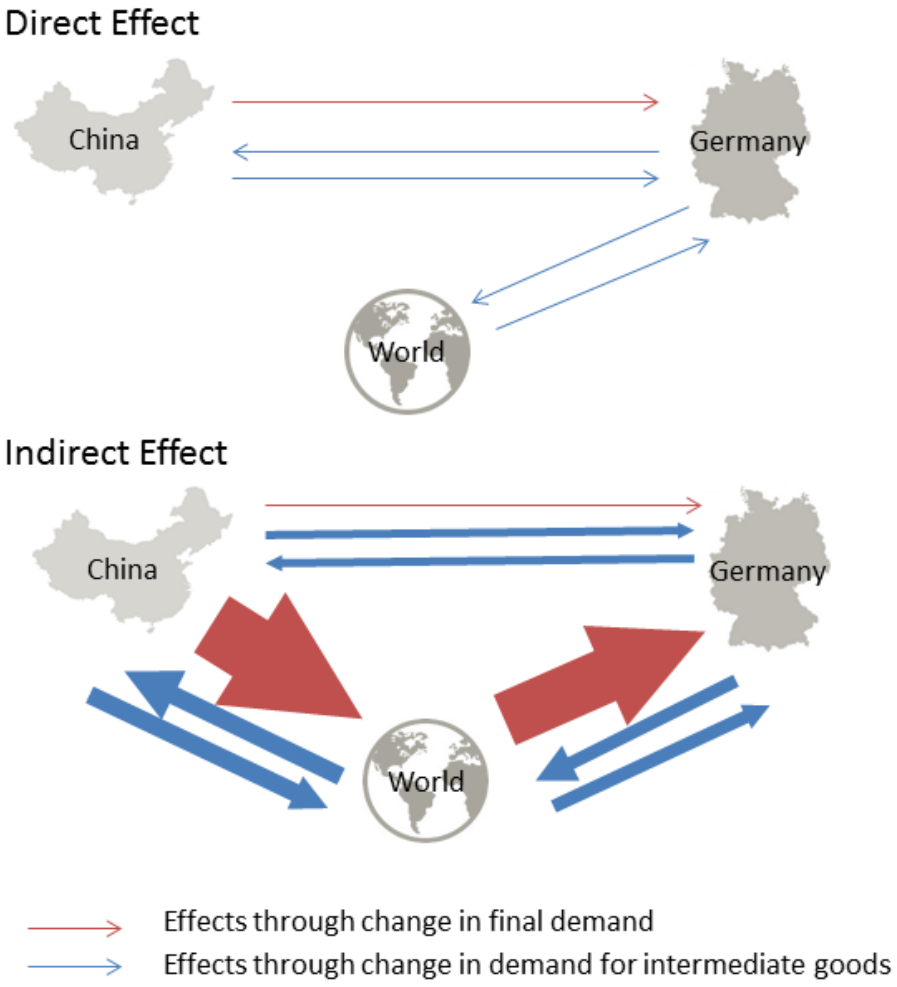
Trade is likely to be a key channel for spillovers from China's transition. Given the closely knit network of trade flows, trade is also a key channel for any effects to propagate through the global economy. An analysis of the propagation of a shock, such as from China's transition, must take into account changes in export and import volumes with China's trading partners as well as second-round effects from changes in the output of trading partners on their trading partners, and so on. This paper harnesses input-output (IO) analysis to quantify the effects of an economic change in one country and the diffusion to other countries via trade, and applies this to the current transition of China's economy.

As an example, let there be a reduction in output in country A. A first simple rule of thumb to calculate the effect of this reduction on country B would be to multiply the output change in country A with the share of exports from country B to country A, and the share of gross exports in GDP of country B. Yet, using exports disregards the fact that fewer exports also imply fewer imports related to the use of intermediate goods in production. Standard IO analysis on a sector level can capture this effect. An IO model takes all interdependencies between sectors into account and thus can calculate the effect including all intermediate effects via other sectors and countries.

Typical applications of the IO approach consider only direct effects, with final demand only shocked once and remaining exogenous afterwards. However, changes in trade induced by an initial demand shock also lead to changes in final demand of other countries. These higher-round effects are typically not considered. Given the close network of trade, the aim of this paper is to go beyond direct effects and calculate the total effect of a demand change in one country including the subsequent changes in exports, demand and output in other countries. We do so by extending the IO approach to include effects of changes in final demand due to final demand changes in other countries. We call these effects, as schematically depicted in Figure 1, indirect effects. Typically these indirect effects are much larger, as the direct export share to one single country is usually much smaller than to the rest of the world. Hence, in this model, the total effects on demand and output are propagated considerably through the network of worldwide trade.

Using the World Input-Output Database (WIOD), covering 40 countries with 35 production sectors each over a period from 1995 to 2011, allows us to model shocks to overall output and final demand as well as shifts in output between sectors. As China's transformation is likely to overhaul the structure of its output, our approach sheds light on the varying impact on other economies. Besides modeling the effects of lower overall economic growth in China, we analyse the implications of a shift in China's output from investment to consumption or a shift from primary and secondary to tertiary sectors for the global economy. Nevertheless, the results must be interpreted with caution. As the model only

Figure 1: Schematic representation of direct and indirect effects



Notes: Example illustration. Size of arrows represents relative size of economic effects.

takes the trade channel into account and is static in nature, the quantitative results do not take into account any compensating adjustments in demand and trade. While the results give an idea of the magnitude of indirect effects in trade networks, the overall effect should be interpreted with care and likely presents an upper ceiling.

The approach most closely related to ours is the import-export-model by Kireyev and Leonidov (2016, 2015). The authors estimate indirect effects of changes in imports and exports of an epicenter country on its trading partners through the international trade network. Our paper contributes to the literature by introducing a computable model based on input-output tables. This model takes into account indirect effects and exploits sector-level input-output tables

to also gauge the propagation of shocks from a change in the structure of final demand. We find that indirect effects are sizable, exceeding the direct impact on average by a factor of 10 to 15. This effect is larger than in comparative studies surveyed in Section 2.

Our methodology allows us to easily gauge the size of the direct and indirect effects, which are driven by the respective sectoral trade linkages on a value-added basis. It is therefore also possible to analyse a shift in the composition of final demand in an epicenter country. Our analysis shows that the direct and indirect effect of a shift – such as the one that is underway in China – could in particular affect Germany, in addition to the rest of Asia. For instance, a shift towards import substitution in transport equipment would hit Germany particularly hard, while indirect spillovers to third countries would be smaller.

We proceed as follows. In Section 2 we review related empirical and theoretical research. Section 3 introduces our augmented IO model, and Section 4 describes the data used. In Section 5, we first present estimated global results, followed by a case study of the impact of different transformations in Chinese final demand and an assessment of the results' robustness. Section 6 outlines our conclusions.

2 Literature

This paper is part of a growing literature on spillovers in international trade networks. The existing studies can be grouped into three main categories: i) empirical analyses, such as those based on global vector auto regression (GVAR) models, ii) model-based approaches like dynamic stochastic general equilibrium (DSGE) models or computable general equilibrium (CGE) models, and iii) input-output models. As a full review of all studies would exceed the scope of this paper, we focus on studies that include the effects of demand changes in China on the rest of the world, as does our case study in Section 5.2. Table 1 presents an overview of the reviewed papers.

2.1 Empirical Models

Econometric models, and in particular multi-regional or global vector auto regression (GVAR) models, analyse (linear) dependencies between macroeconomic time series. The beauty of this approach lies in its structural parsimony, as the data is allowed to speak while capturing endogeneities. At the same time, this is also a drawback, as estimates may suggest spurious relationships, and empirical links may prove misleading in light of structural breaks in the data.

Duval et al. (2014) and Ahuja and Nabar (2012) are two studies employing panel regressions to estimate the effect of a change in Chinese demand for 63 countries from 1995Q1 to 2012Q4 and 64 countries from 2002 to 2011. Duval et al. (2014) confirm that growth spillovers from China are larger in economies that are generally more dependent on China and that they are twice as large for value added exported for final demand purposes. The results are very close to what Ahuja and Nabar (2012) find, showing that a decline in investment decreases GDP in regional supply-chain economies, such as Taiwan, Korea, and Malaysia, to a greater extent than in other economies, such as Germany. Commodity exporters with less diversified economies are also found to be affected

more severely.

The larger group of econometric studies is based on vector auto regression (VAR) models. In the IMF's World Economic Outlook, Blagrave and Vesperoni (2016) estimate a panel VAR studying the effect of a decline in China's final demand growth on export growth rates. A wide range of authors use extended VAR models, like factor augmented vector autoregression (FAVAR) models, e.g. Ahuja and Myrvoda (2012), or global vector autoregressive (GVAR) models, e.g. Dizioli et al. (2016), Dreger and Zhang (2013), Hong et al. (2016), Cesa-Bianchi et al. (2011), Cashin et al. (2016), or Inoue et al. (2015) (see Table 1). Most of these models include variables such as real GDP growth, inflation, real exchange rates, and short- and long-term interest rates. Additionally, some authors such as Cesa-Bianchi et al. (2011), Dreger and Zhang (2013) and Dizioli et al. (2016) include equity prices. Dizioli et al. (2016) and Cashin et al. (2016) include financial variables, such as a financial stress index, along with the oil price. The estimated effects for a demand shock of -1% of GDP in China vary between -0.05% and -0.12% of GDP for the EU, although the effects might not be exactly comparable. Furthermore, effects are stronger for countries more integrated into the regional supply chain (Dizioli et al., 2016; Hong et al., 2016), commodity exporters, and export-dependent countries (Inoue et al., 2015). Effects are also stronger when global financial volatility is higher (Dizioli et al., 2016; Cashin et al., 2016). Cesa-Bianchi et al. (2011) find that due to the stronger integration of China into the world economy, the long-term impact of a GDP shock in China has tripled since 1990.

Generally, effects found in panel regressions are larger than the effects observed with VAR models. The latter include various transmission channels through other countries and thus also incorporate their reaction to changes in Chinese demand. However, those models only analyse the macroeconomic variables at hand. Model-based approaches allow for the incorporation of additional microeconomic reactions, as discussed in the following.

2.2 Model-based Approaches

Dynamic stochastic general equilibrium (DSGE) models build on structural models of economies with multiple sectors or countries and can incorporate dynamic adjustments in response to shocks towards a new equilibrium. The advantage is that the structure of DSGE models considers microeconomic offsetting reactions, which can explain the smaller effects of shocks found in DSGE models compared to GVAR models. However, DSGE models tend to be complex and difficult to estimate. Resulting relationships hinge crucially on model assumptions.

The IMF uses different models for international spillover analysis, such as the Global Economic Model (GEM) by Laxton and Pesenti (2003) and the Global Integrated Monetary and Fiscal Model (GIMF) by Kumhof and Laxton (2007) and Kumhof et al. (2010). The complexities of these models limit the number of countries or regions for which they can be estimated. Andrle et al. (2015) provides a Flexible System of Global Models (FSGM), a group of multi-region, forward-looking semi-structural global models consisting of 24 regions. Some key elements, such as private consumption and investment, are modeled based on micro-foundations, while others elements, such as trade, labor supply, and inflation, have reduced-form representations. Estimations based on

Table 1: Summary of studies analysing international effect of demand shocks

Study	Method	Countries	Time	Shock in China	Results
Duval et al. (2014)	Panel	63	1995Q1-2012Q4	-1 pp GDP growth	GDP growth: -0.3 pp Asia, -0.15 pp Non-Asia
Ahuja and Nabar (2012)	Panel	64	2002-2011	-1 pp inv. growth	GDP growth: -0.1 pp World, -0.08 pp Germany
Blagrave and Vesperoni (2016)	VAR	46	2003Q1-2015Q3	-1 pp. GDP growth	Export Growth: -0.1 to -0.2 pp World, -0.9 pp Asia
Ahuja and Myrvoda (2012)	FAVAR	G20	2000M1-2011M9	-1% real estate inv.	GDP: -0.06% World, -0.03% EU, -0.12% Germany
Dizioli et al. (2016)	GVAR	26	1981Q1-2013Q1	-1% GDP	GDP: -0.10% to -0.35% Asia, -0.07% US, -0.12% EA
Dreger and Zhang (2013)	GVAR		1979Q1-2009Q4	+3% GDP (fiscal)	GDP growth: +0.4 pp, US, +0.6 pp Japan, +0.3 pp EA
Hong et al. (2016)	GVAR	62	1995-2011	-1% in investment	GDP growth: -0.08 pp US, -0.12 pp Germany
Cesa-Bianchi et al. (2011)	GVAR	33	1979Q2-2009Q4	+1% GDP	GDP: +0.05% EU, +0.035% US
Cashin et al. (2016)	GVAR	26	1981Q1-2013Q1	-1% GDP	GDP growth: -0.23 pp World, -0.12 pp EU
Inoue et al. (2015)	GVAR	33	1979Q1-2014Q3	-1% GDP growth	GDP: -0.07% US, -0.05 EA
Anderson et al. (2015)	FSGM	-	-	-12% GDP (4 yrs)	GDP (4 yrs): -1.6% World, -0.2% Advanced
Dizioli et al. (2016)	FSGM	-	-	-1% GDP	GDP growth: -0.1 pp World, -0.4 pp Malaysia
Zhai and Morgan (2016)	LINKAGE	-	-	-3% Inv. (4 yrs)	GDP growth: -0.19 pp EU, -0.42 pp World
Dreger and Zhang (2013)	NiGEM	44	2009/10	+3% GDP (fiscal)	GDP growth: +0.2 pp, US, +0.9 pp Japan, +0.3 pp EA
Dreger and Zhang (2013)	OEF	15	2009/10	+3% GDP (fiscal)	GDP growth: 0.0 pp, US, 0.0 pp Japan, 0.0 pp EA
Simola (2015)	IO	40	2011	-8% GDP growth	GDP: -5% EU
Kireyev and Leonidov (2016)	IO	170	1993-2020	-10% imports (4yrs)	GDP: -5.3% World, -4.8% Germany, -1.3% US

FSGM can be found in Anderson et al. (2015) or Dizioli et al. (2016), among others. As expected, the size of the effects in the two papers is very similar, although Anderson et al. (2015) focus on Sub-Saharan Africa and Dizioli et al. (2016) on ASEAN countries. Anderson et al. (2015) suggest that the impact on Sub-Saharan African economies varies depending on whether or not they are commodity exporters or importers on the one hand, and on their monetary policy regime on the other hand. Dizioli et al. (2016) find that net commodity exporters and countries with closer trade linkages with China are more affected by a shock originating in China than others.

Some DSGE models are commercially available, like NiGEM (National Institute for Economic and Social Research Global Econometric Model) or OEF (Oxford Economic Forecasting). Dreger and Zhang (2013), among others, use these models to check robustness. On average, the estimated effects of a demand shock in China on the rest of the world seem to be much smaller in DSGE or CGE models than with econometric models. Computable general equilibrium (CGE) models, sometimes also referred to as applied general equilibrium (AGE) models, are closely related to DSGE models but focus mostly on long-run relationships. Various authors use CGE models to estimate the effects of trade on production and other sectors. For instance, Zhai and Morgan (2016) deploy the LINKAGE model of the World Bank, again yielding quite moderate effects.

2.3 Input-Output Models

Spillover effects of economic shocks have also been estimated using input-output tables and models. IO matrices provide for direct trade links that are harnessed through simple algebra. The advantage is that neither structural assumptions nor econometric techniques are required, aside from establishing a relationship between the initial economic shock of interest and trade inputs-outputs. Causality can be directly captured from the data. Furthermore, IO models enable a much more detailed modeling of the structure of trade within and across sectors and economies. This allows for an analysis of sector-based higher-round effects from observed trade flows. The drawback is that the trade relationship is static on the basis of the provided data. No compensating reactions on the macro- or microeconomic level are modeled. Hence, IO models yield larger effects of a demand shock than econometric or model-based approaches.

Traditional IO analyses can be found in Simola (2015), Kuroiwa and Kuwamori (2010), and Bussière et al. (2013), among others. These papers are based on different sources of IO tables, such as the World IO database (WIOD; Simola, 2015), Asian international IO tables (Kuroiwa and Kuwamori, 2010), or OECD national IO tables (Bussière et al., 2013). Most IO studies find much larger effects than estimated by econometric or model-based approaches. Among other reasons, the larger effects are due to triangular trade, which involves importing intermediate goods from other countries to export final products to third countries (Kuroiwa and Kuwamori, 2010).

Traditional IO models assume the final demand vector(s) to be exogenous. In other words, the estimated effects do not take into account that demand in the countries other than the epicenter country might change due to the shock. Only few authors have examined the effects of international spillovers in the context of networks with higher-round effects resulting from a change in economies other than the epicenter. Contreras and Fagiolo (2014) use so-called avalanches to esti-

mate spillover effects using European Leontief IO matrices. They show that the spillover effects of economic shocks depend on the country size and the nature of the shock. Kireyev and Leonidov (2016) and Kireyev and Leonidov (2015), based on international import-export matrices, estimate the direct spillover effects of a country affected by a negative shock as well as spill-in and spill-back effects which occur due to the propagation of the shock through trading partners. To be able to quantify the higher-round effects, they estimate elasticities of import to export revenue. Their findings suggest that network effects are usually stronger for small open economies and that the effect depends on the network structure of the epicenter country. While the work of Kireyev and Leonidov (2016) and Kireyev and Leonidov (2015) are closest to our approach, their calculations are based on import-export tables. In contrast, we use input-output tables to capture more precisely the value-added component in the trade data.

3 Model

Our augmented IO model is based on a standard IO analysis. The following briefly introduces the main variables. There are n_c countries with n_s producing sectors. Each sector produces its output with various inputs from other sectors within the same country as well as (through imports from) other countries. Matrix Z with $n_c \cdot n_s$ rows and columns represents these inputs and outputs, respectively:

$$Z := \begin{bmatrix} z_{1,1,1,1} & \cdots & z_{1,1,1,n_s} & z_{1,1,2,1} & \cdots & z_{1,1,n_c,n_s} \\ \vdots & \ddots & \vdots & & & \\ & \cdots & z_{c_i,s_j,c_k,s_l} & \cdots & & \\ \vdots & & \vdots & \ddots & & \\ z_{n_c,n_s,1,1} & \cdots & & \cdots & & \end{bmatrix}$$

The entry z_{c_i,s_j,c_k,s_l} represents the input from sector s_j in country c_i to sector s_l in country c_k.

The final demand for each sector s_j in country c_i stemming from country c_k is represented by the elements of matrix D and the vector of sums over all countries for each sector s_j in country c_i is vector d, i.e. vector d represents the total final demand stemming from all countries together for sector s_j in country c_i. The total production of sector s_j in country c_i is denoted x_{c_i,s_j} in vector x (where $x_{c_i,s_j} = d_{c_i,s_j} + \sum_{m=1}^{n_c} \sum_{n=1}^{n_j} z_{c_i,s_j,c_m,s_n}$). Vector x denotes the total world output of sector s_j in country c_i.

$$x := \begin{bmatrix} \vdots \\ x_{c_i,s_j} \\ \vdots \end{bmatrix}, \qquad D := \begin{bmatrix} & \vdots & \\ \cdots & d_{c_i,s_j,c_k} & \cdots \\ & \vdots & \end{bmatrix} \qquad d := \begin{bmatrix} \vdots \\ \sum_{m=1}^{n_c} d_{c_i,s_j,c_m} \\ \vdots \end{bmatrix}$$

By introducing the technology matrix A and the Leontief inverse $(I - A)^{-1}$, the total output vector x can also be put in relation to the final demand vector d,

as follows:

$$x = (I - A)^{-1}d \qquad \text{with} \quad A = \frac{Z}{x} \tag{1}$$

The Leontief inverse (in this context as approximation of a geometric series) can also be used to calculate the change in total output in response to changes in the exogenous final demand.

$$\Delta x = (I - A)^{-1}\Delta d \tag{2}$$

Equation 2 is where the standard IO analysis usually ends. The results show how the total output of each sector in each country changes if the final demand in one or several (or even all) sectors in one or several countries changes, including changes in imports and exports for each sector and country. However, the analysis still treats the final demand vector as exogenous, i.e. final demand does not change following a change in total output.

Our augmented model introduces this link between a change in total output and final demand, and thus can also take into account spillover and feedback effects following an initial change in final demand. Similar to Kireyev and Leonidov (2015) or Contreras and Fagiolo (2014) we calculate those feedback and spillover effects in several steps τ to account for higher-round effects:

$$x_\tau = (I - A_{\tau-1})^{-1}d_\tau \tag{3}$$

where x_0, d_0, and A_0 are the initial total output vector, final demand vector and technology matrix, respectively, according to the data (as stated in Equation 1). An initial change in final demand changes d_0 to d_1 which can be used to calculate the first initial change in total output x_1 based on Equation 3, similar to standard input-output models (Equation 2). Beginning with the second step ($\tau \geq 2$) the final demand vector of the previous step is changed according to Equation 4, which takes the effects of a change of a country's total output on a country's and sector's final demand into account:

$$D_\tau = \begin{bmatrix} \vdots & & \\ \cdots & 1 + \gamma_{c_i,s_j,c_k} \frac{\Delta \sum_{n=1}^{n_s} x_{c_k,s_n,\tau-1}}{\sum_{m=1}^{n_s} x_{c_k,s_m,\tau-2}} & \cdots \\ \vdots & & \end{bmatrix} \odot D_{\tau-1} \qquad \text{for} \quad \tau \geq 2 \tag{4}$$

where $\odot$ represents an elementwise multiplication. The coefficient γ_{c_i,s_j,c_k} is the elasticity of the final demand in sector s_j of country c_i with respect to the change in total output of country c_k. The calculation of γ_{c_i,s_j,c_k} is described in Section 3.1 in more detail. Also, the technology matrix A_τ changes after each step as the matrix Z and output vector x change as well, i.e. $A_{\tau-1} = \frac{Z_{\tau-1}}{x_{\tau-1}}$.

The stepwise procedure continues according to Equation 3 until in step $\hat{\tau}$ the sum of squared total output changes is smaller than ϵ, i.e. $(\Delta x_{\hat{\tau}})'\Delta x_{\hat{\tau}} \leq \epsilon$. In our baseline estimations we use an ϵ of 0.00001 (which is equal to USD 1,000). A robustness check of our results with respect to this variable is described in Section 5.4.

When presenting our results, we will decompose the overall effect on the

output of a country $(x_{\bar{\tau}} - x_0)$ into a direct and an indirect component. The so-called direct effect $(x_1 - x_0)$ originates only from a change in the final demand in the epicenter country. The final demand of the remaining countries remains exogenous and fixed, as in traditional IO analyses. The indirect effect $(x_{\bar{\tau}} - x_1)$, or higher round effect, originates from changes in final demand in other countries and sectors.

3.1 Elasticity of Final Demand with Respect to Output Changes

To establish the link between a change in total output of a country c_k and the final demand for sector s_j in country c_i, we estimate the elasticity γ_{c_i,s_j,c_k} as follows:

$$\frac{d_{c_i,s_j,c_k,t} - d_{c_i,s_j,c_k,t-1}}{d_{c_i,s_j,c_k,t-1}} = \gamma_{c_i,s_j,c_k,t} \frac{\sum_{m=1}^{n_s} x_{c_k,s_m,t} - \sum_{m=1}^{n_s} x_{c_k,s_m,t-1}}{\sum_{m=1}^{n_s} x_{c_k,s_m,t-1}} + \varepsilon_t \quad (5)$$

Equation 5 is estimated for the final demand $d_{c_i,s_j,c_k,t}$ of each sector s_j in country c_i stemming from each country c_k over the time horizon $t = [1990, 2011]$ separately. ε_t is the idiosyncratic error term. We estimate Equation 5 with OLS. Coefficients are set equal to zero where no significance at the 1% level is found. The estimation assumptions are checked for robustness in Section 5.4.

3.2 Limitations

There are certain limitations to our approach. The standard IO analysis assumes constant returns to scale, no factor substitution, constant prices and exchange rates, as well as fixed sector-input shares (the Leontief production function). The technology (matrix A) is constant and time invariant. In addition to the limitations of the traditional IO analysis, we furthermore assume that there are no adjustments to counteract the final demand shock. Thus, there is no substitution between export demand of different countries. Another caveat to our approach is the estimation of the coefficients and their causal interpretation. Furthermore, our model only represents effects propagated through trade networks and does not take other channels into account, such as financial channels.

4 Data

The calculations in this paper are based on the WIOD, a database originating from a project funded by the EU Commission. Using the WIOD released in 2013, the data covers 40 countries worldwide and uses a model for the rest of the world stretching from 1995 to 2011. The database includes 35 production sectors, covering the main sectors of agriculture, industry and services such as mining and quarrying, chemicals, transport equipment, construction, transport and real estate activities, and five demand categories for each country. It includes final consumption expenditure by households, final consumption expenditure by non-profit organizations serving households (in the rest of the paper we combine the latter two into "household consumption"), final consumption expenditure by government ("government consumption"), gross fixed capital

formation ("investment") and changes in inventories and valuables ("inventories"). The tables have been constructed in a conceptual framework based on official input-output tables in combination with international trade statistics and national account data (Timmer et al., 2015).

In 2011, the 40 countries covered by the WIOD represented 83% of world GDP and 62% of world population. Table 2 presents summary statistics. While the model presented herein could be applied to a variety of countries and datasets, in this paper we concentrate on six countries or regions and base our calculations exclusively on the WIOD database. This also implies that our empirical results in Section 5 are based on data for the year 2011.

Table 2: Macroeconomic data based on the WIOD database for 2011

Country	Domestic demand	Imports	Exports	Net exports	GDP	Import intensity
United States	15.72	2.40	1.84	-0.56	15.16	13.5%
China	7.09	1.79	2.09	0.30	7.39	18.8%
Germany	3.19	1.30	1.60	0.30	3.49	26.7%
United Kingdom	2.35	0.72	0.70	-0.01	2.34	24.0%
EU	11.00	4.36	4.44	0.08	11.09	19.6%
Asia	10.07	2.29	2.40	0.11	10.18	15.0%

Notes: Summary statistics for selected countries and regions based on the world-input output database (WIOD). In trillion US dollars and for 2011. Asia includes Indonesia, India, Japan, Korea and Taiwan, excluding China. EU includes EU27 countries, excluding Germany and UK.

Our choice to rely exclusively on the WIOD is motivated by shortcomings of alternative data sources. For example, the OECD provides national IO tables covering all OECD countries and 27 non-member countries from 1995 to 2011. While offering a larger country coverage, it only includes IO tables with the domestic sectors and aggregated import and export values. Exports or imports are not split by trading partner. The same is true for the Global Trade Analysis Project (GTAP) database, a project of the Center for Global Trade Analysis of the Department of Agricultural Economics at Purdue University (Indiana, US). The GTAP database (version 9) covers 140 regions and 57 sectors from 1995 to 2013. Other data sources are more limited regionally. The Institute of Developing Economies Japan External Trade Organization (IDE-Jetro) offers an international output table for Asia and the BRICs for the year 2005. Eurostat offers IO tables for the EU only.

5 Results

This paper aims to gauge the effect of a decrease in final demand or a shift in its composition in one country on the rest of the world. The focus lies on the qualitative difference between different shocks to final demand and its composition, rather than the exact size of spillovers. We show that even a shift in the composition of final demand can have notable effects on trading partners and the world economy. Section 5.1 presents a comparison of the worldwide direct and indirect effects of a reduction in final demand depending on the epicenter country. To show the effects of more specific changes in final demand, Section 5.2 compares effects based on a case study for China.

5.1 Global Network Analysis

The global effects of a final demand shock depend on the size and structure of the economy of the epicenter country and the economic interdependencies with its trading partners. Figure 2 shows the direct and indirect effects of a decrease in final demand by 1% depending on the epicenter country. Corresponding values are presented in Table 5 in the Appendix.

As expected, the direct effect depends on bilateral import and export shares. After an initial -1% shock to final demand in the US, the direct effect in the US amounts to -1.8% in final demand. This effect is larger than the initial shock despite final demand in all other countries assumed to remain constant. The reason is that exports of other countries, which are affected by the initial shock, contain intermediate imports from the US. The initial effect is compounded by higher-round effects. These indirect effects are mainly determined by the size of the epicenter country and thus its importance for the world economy. The strongest indirect effects can be observed for the larger economic areas like the US and the EU. In total, indirect effects, which include the effect of changes in final demand in all other countries, add up to about 1.5 times the direct effect for the epicenter country, e.g. in the US -2.6%. In countries other than the epicenter country, the direct effect is usually much smaller than the indirect effect, as the export and intermediate goods share in one single country is small, yet even a small reduction in final demand across many trade partners compounds into a much more pronounced effect.

Interesting differences arise when comparing the direct and indirect effects of various regions. While a reduction in final demand in the US is associated with a large indirect effect on China, the indirect effect of a reduction in Chinese demand on the US is much smaller. The US is a major importer, hence a reduction in US demand has a stronger bearing on its trading partners. Final demand in China, in contrast, has a lower share of imports (Table 2). Furthermore, the relationship between direct and indirect effects also depends on the economic structure of a country's exports. German exports include a large share of imports, such that a reduction in final demand in Germany results in a smaller indirect effect through the world economy. In the UK on the other hand, the opposite is the case.

Compared to other studies using empirical or DSGE models (see Section 2), the effects found here are considerably larger. As discussed in Section 3.2, this difference is explained by the ceteris paribus assumption inherent in IO analyses, while other models may take into account offsetting reactions to the initial shock. Nevertheless, our results can shed light on some details other models might not be able to capture. For instance, the size of the direct effect on the epicenter country itself varies from -1.78% (for the US) to -1.45% (for Germany), depending on the share and composition of imports contained in the exports to the epicenter country throughout the trade network. The indirect effect on the world and other trading partners also depends on the integration of the country into the world economy. For the indirect effect, the import and export content of production in the various countries is important, a link typically not discernable in empirical or DSGE models.

For an easier comparison of the structure of the shocks and the effect on the world economy, Figure 3 (left side) presents the effects of a normalized reduction in final demand by 1% of German final demand (USD 32 billion) in each country

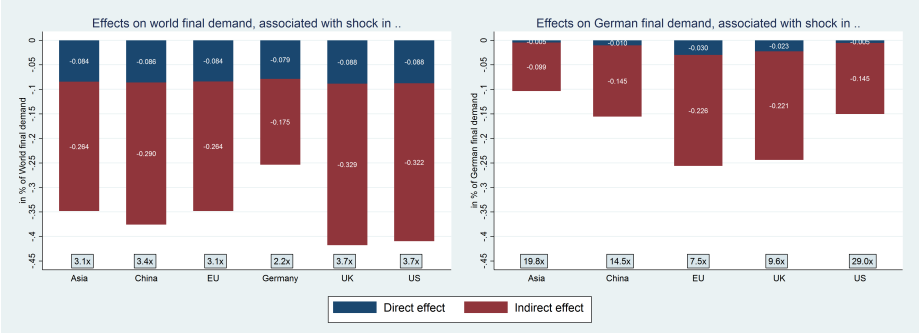
Figure 2: Effects of a reduction in final demand by 1%, by epicenter region/country

Notes: Size of the shock equals 1% of total final demand of the respective epicenter region/ country (mentioned in title of respective graph). Effects are presented in % of final demand of the respective region/ country. Asia includes Indonesia, India, Japan, Korea and Taiwan, excluding China. EU includes EU27 countries, excluding Germany and UK.

or region. The largest effects on the world economy stemming from such a shock of similar size are associated with reductions in final demand in the UK and the US. Both countries have large trade deficits and thus have the largest effects on the overall world economy. A reduction in Germany, in contrast, is only associated with an effect two-thirds the size of the US effect, as most of the shock would hit the domestic economy. Therefore the composition of the effect differs. In the case of the UK and the US, the indirect effect is about 3.7 times the direct effect, while in the case of Germany, the indirect effect amounts to only 2.2 times the direct effect.

Figure 3 (right side), in turn, shows the effect of same-sized shocks originating in different countries or regions on German GDP. As expected, the strongest effect on Germany can be observed following a reduction of final demand in the EU. Merely taking into account direct effects by comparing the trade shares of the US, China and the EU would not have captured sizable indirect effects that propagate the original shock. This is most pronounced for shocks originating in the US or China. While exports to Germany constitute only 7.5% and 7.7% of total exports from the US and China, respectively, exports to Germany make up for 43.9% of all EU exports. Hence, while the direct effect on Germany differs a lot depending on where the shock originates, taking into account the indirect effect reduces the difference. For instance, the total effect of a reduction in the

Figure 3: Effects of a reduction in final demand by USD 32 billion on the world and Germany, depending on epicenter country or region



Notes: Size of the shock equals 1% of German final demand. Asia includes Indonesia, India, Japan, Korea and Taiwan, excluding China. EU includes EU27 countries, excluding Germany and UK. Values in boxes indicate relative size of indirect to direct effect.

EU final demand on the German economy is only around twice as large as the effect of a reduction in Chinese or US final demand.

5.2 Case Study: China

A case study of China helps to analyse the effects of a reduction or a shift in final demand in more detail. Following the reforms initiated by Deng Xiaoping in 1978, China started to open up its economy. The average real growth rate of GDP per year exceeded ten percent over the last 25 years. Following the global financial crisis, growth in other advanced economies has remained mediocre and China became the key driver of global growth. Over the past ten years, China's contribution to worldwide GDP growth was three times larger than the contribution of the European Union and the United States combined (Figure 4, left side).

During its economic rise, China's economy went through important transitions. After China's accession to the World Trade Organization (WTO) in 2001, export growth leaped. In turn, trade catalyzed investment growth, which for a long time has been the largest contributor to GDP growth (Figure 4, right side). Given the high imports of intermediate and investment goods, the contribution of net exports to GDP growth has remained low.

However, China has also been confronted with a wide range of challenges (e.g. Shambaugh, 2016; Song et al., 2016). In recent years, China's economy has been in a process of rebalancing from investment towards consumption. Alongside this shift, China's tertiary sector has been expanding while the share of the primary and secondary sectors has been declining. Furthermore, China has striven to on-shore production and become less dependent on imports from the rest of the world. All of these transformations of the Chinese economy affect the rest of the world in considerable ways, given the Chinese economy's large size and its extensive trade links.

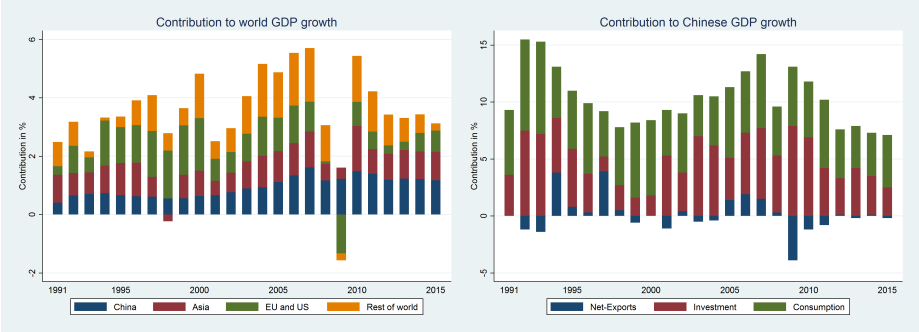
These transitions make it relevant to investigate different scenarios for the change in final demand in China and their effects on the rest of the world.

So far we have only considered a final demand shock in China that affects all final demand categories proportionally. In the following, we extend this by assuming shocks to only a specific category. Furthermore, we consider a shift of demand from one final demand category to another. Most likely, a combination of both changes is at work. We use China as the epicenter country where the initial shock takes place, and examine the direct and indirect effects in several scenarios.

5.2.1 Reduction of Final Demand

While growth rates of the Chinese economy have started to decline since 2008, China's contribution to world GDP growth remains high at around one third. Despite the government's attempts to maintain high growth rates through public investments, a further slowdown in growth could be possible. In particular, slower growth could result from a weakening of investments. We try to capture these developments in a first set of scenarios.

Figure 4: China's contribution to worldwide growth and growth composition, 1991-2015

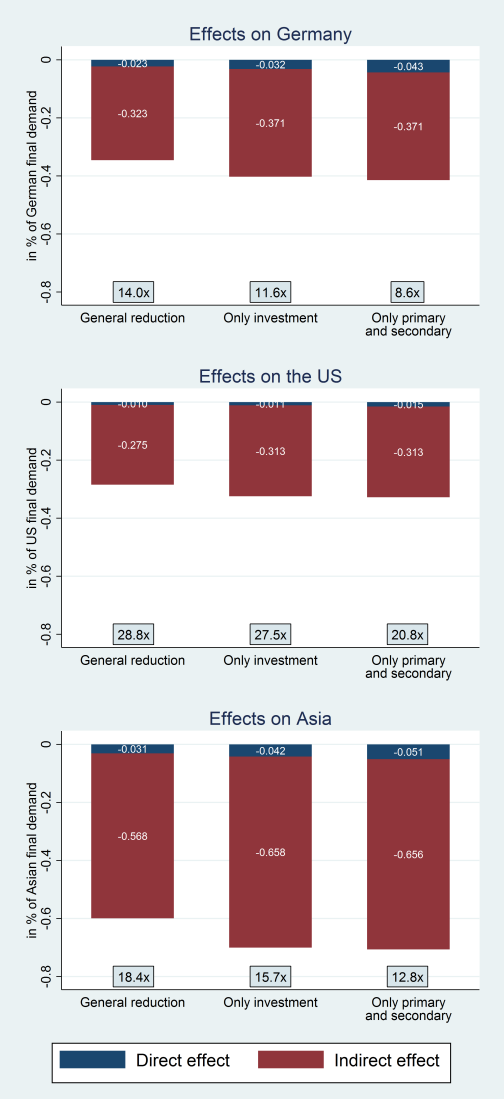


Notes: Asia excluding China. Source: World Bank

In the first scenario, we simulate a decline in Chinese economic growth and reduce China's total final demand by 1%. Given the model is linear, this decrease in final demand equals a lower-than-expected growth rate of final demand. The second scenario shows the effect of a reduction of 1% in total final demand only in investment, which could reflect a change in Chinese economic policy to reduce high investment rates. Household consumption, government consumption and inventories remain unchanged. Furthermore, in a third scenario we assume a reduction of 1% of total final demand only in the primary and secondary sectors, two sectors likely to suffer during China's economic rebalancing. Final demand for the service sectors remains unchanged.

A general reduction of Chinese final demand is associated with a direct reduction of German final demand by 0.02% (Figure 5, upper panel). This reflects the small share of China's imports from Germany in Chinese final demand. However, the indirect effect amounts to 0.32% of German final demand—14 times larger than the direct effect—as the shock to Chinese final demand reduces the final demand of German trading partners.

Figure 5: Scenarios of reduction of Chinese final demand



Notes: The scenarios are: General reduction of final demand (-1%); Reduction in investment (-1% total final demand); Reduction in demand for primary and secondary sectors (-1% total final demand). Asia includes Indonesia, India, Japan, Korea and Taiwan, excluding China. Values in boxes indicate relative size of indirect to direct effect.

If the negative demand shock only hits investments, the direct effect for Germany rises to 0.03% while the indirect effect at 0.37% is only moderately larger. The higher direct impact reflects the higher share of German exports in Chinese investment. A negative demand shock of 1% only to the primary and secondary sectors is associated with a decrease in German final demand by 0.41%, composed of a direct effect of 0.04% and an indirect effect of 0.37%. The direct effect from a shock to final demand in these sectors is double the size of a general shock on final demand, reflecting Germany's exposure to the Chinese goods sectors, particularly in industry, as opposed to the rather small relevance

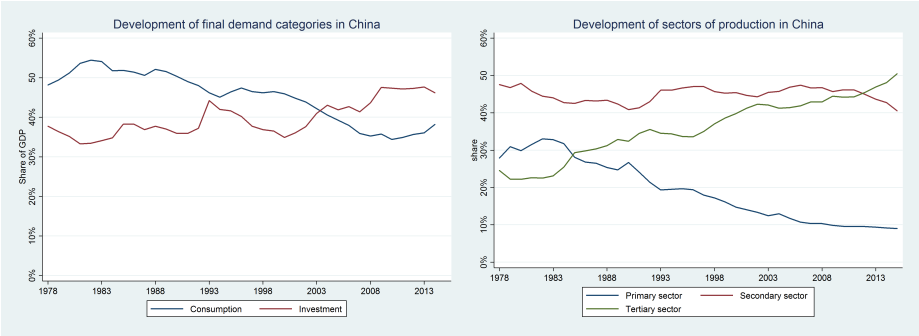
of Germany's service exports to China.

As presented in the middle and lower panels of Figure 5, the overall pattern of the results for the US and Asia (without China) is similar to those for Germany. The overall lower direct and indirect effects for the US are due to its lower share of exports to China and the world economy, in other words the fact that the US is a less open economy than Germany. The opposite holds for the rest of Asia, which features strong trade links with China and a high degree of openess.

5.2.2 Change in the Structure of Final Demand

China's long period of growth was characterized by strong investment and trade. China developed into a manufacturing hub as part of the global value chain, importing large volumes of intermediate goods for processing. This picture is slowly changing as the Chinese economy transitions from an investment- and export-oriented economy to a more consumption-led and service-based economy.

Figure 6: GDP shares in China, 1978-2014



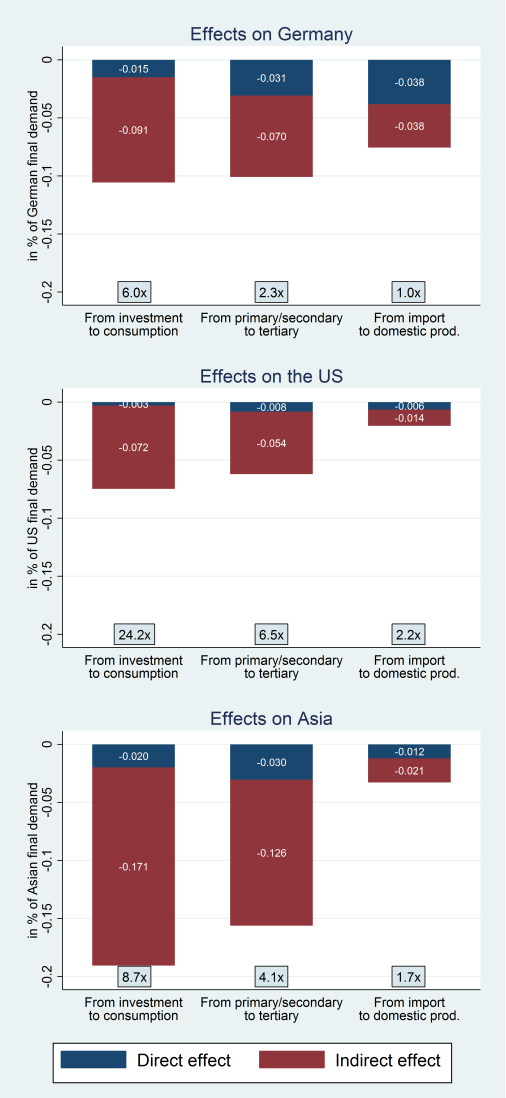
Source: World Bank

Figure 6 (left side) shows that the share of investment in GDP slightly increased to close to 50% in 2008. Since 2014, its share has decreased slightly, whereas the share of consumption has picked up gradually. A similar picture emerges for the secondary sector in China. The share of the industry and construction sectors was stable at around 45% until 2010, when it started to decline (Figure 6 right hand side). In 2012, the share of the tertiary service sector exceeded that of the secondary sector for the first time. These sectoral shifts are likely to have a bearing on Chinese import patterns.

In another set of scenarios, we model a shift of 1% of final demand in China's total final demand between different sectors, while leaving total final demand unchanged. First, we model a shift of 1% of total final demand from investment to household consumption. Government consumption and changes in inventories remain unchanged. Second, we model a shift of 1% of total final demand from final demand for the primary and secondary sectors to final demand for the service sector. Finally, we model a decrease in Chinese final demand for foreign transport equipment and an increase in final demand of the domestic transport equipment category. This can serve as an example for a government policy

to promote import substitution by imposing local content requirements in the automotive sector.

Figure 7: Shift in Chinese final demand



Notes: The scenarios are: From investment to consumption (1% total final demand), From primary and secondary to tertiary sectors (1% total final demand), Domestic production instead of imports (10% in "transport equipment"). Asia includes Indonesia, India, Japan, Korea and Taiwan, excluding China. Values in Boxes indicate relative size of indirect to direct effect.

Figure 7 shows that even if overall final demand in China remains unchanged, a shift in final demand between certain categories leads to a decrease of final demand in other regions. A shift from investment to consumption weighs most on final demand in Germany, the US and the rest of Asia as the import share of Chinese investment is much larger than the import share of Chinese consumption. Similarly, a transformation of the Chinese economy from industry to

services also reduces final demand in the other regions as services have a lower import content than industry. Overall, the results are obviously smaller than in the scenarios of Section 5.2.1 for a reduction in the overall level of final demand. Nevertheless, the magnitude of direct effects are nearly the same. This can be explained by the large exposure of particularly German exports to investment goods and goods of the primary and secondary sectors. Of the total Chinese final demand falling on German goods, investment goods account for 70% and, using an alternative classification, goods of the primary and secondary sectors account for 96%. In the scenario of a demand shift from imports to domestic production of transport equipment, the direct effects are relatively strong at 0.04% of German final demand, as this is the largest single export category in German-Chinese trade. The indirect effects on Germany are in all three scenarios by far smaller, as total final demand remains unchanged and most of Germany's trading partners are less affected. In particular, German exports in the transport equipment sector seem to involve other countries to a lesser extent than exports of this category from the US or the rest of Asia, therefore the shock is not amplified other shocks.

5.3 Within Country Effects

A more detailed analysis of the effect of the various scenarios of a shock in final demand in China on output of the various sectors is presented for Germany in Table 3. The hardest hit sectors in Germany would be Basic and Fabricated Metals; Machinery, Electrical and Optical Equipment; Transport Equipment and Renting of Machinery and Equipment. This general pattern recurs when only investment or only primary and secondary sectors are shocked. Furthermore, one can see that a shift in China towards consumption or tertiary industries would also be clearly visible in the service sectors in Germany. However, the effect is negative throughout the service sectors as the negative effect stemming from a reduction in demand for (intermediate) services from domestic industry sectors outweighs the small additional demand for services exports from China (Chinese import-intensity of services is very small). For example in the scenario of a shift from primary/secondary to tertiary industries, the sector Real Estate Activities is almost as strongly influenced as the Electrical and Optical Equipment sector. Furthermore, a shift towards domestic production in the Transport Equipment sector in China obviously hits the same sector in Germany hardest, but there are also sizable effects in the service sectors that provide intermediate goods and services to the Transport Equipment sector.

As the tertiary industries in most regions in our sample take up large shares of GDP, the composition of the total effect of the various scenarios hinges heavily on the effects on the tertiary industries. A decomposition of the total effect across industries and countries – which is unique to IO models – is presented in Table 4. The shown impact demonstrates the importance of trade-supporting industries, which often consist of services. Especially in the US and UK, the tertiary industry contributes around 80% to the total effect, while in Germany it contributes around two-thirds of the total effect. Only in China does the overall effect depend more strongly on secondary industries.

Table 3: Reduction in output across German sectors depending on shock in final demand in China

	General reduction	Only investment	Only primary and secondary	From investment to consumption	From primary/ secondary to tertiary	From import to domestic prod.
Agriculture and Forestry[1]	-0.004%	-0.005%	-0.004%	-0.001%	-0.001%	0.000%
Mining and Quarrying	-0.001%	-0.001%	-0.001%	0.000%	0.000%	0.000%
Food, Beverages and Tobacco	-0.014%	-0.016%	-0.016%	-0.004%	-0.003%	-0.002%
Textiles and Textile Products	-0.002%	-0.002%	-0.002%	0.000%	0.000%	0.000%
Leather, Leather and Footwear	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Wood and Products of Wood and Cork	-0.002%	-0.002%	-0.002%	0.000%	-0.001%	0.000%
Pulp, Paper[2]	-0.008%	-0.010%	-0.009%	-0.002%	-0.002%	-0.001%
Coke, Refined Petroleum and Nuclear Fuel	-0.008%	-0.010%	-0.010%	-0.002%	-0.002%	-0.001%
Chemicals and Chemical Products	-0.019%	-0.021%	-0.021%	-0.004%	-0.004%	-0.001%
Rubber and Plastics	-0.008%	-0.009%	-0.009%	-0.002%	-0.002%	-0.001%
Other Non-Metallic Mineral	-0.004%	-0.005%	-0.005%	-0.001%	-0.001%	-0.001%
Basic Metals and Fabricated Metal	-0.033%	-0.039%	-0.039%	-0.009%	-0.011%	-0.005%
Machinery, Nec	-0.034%	-0.043%	-0.042%	-0.013%	-0.015%	-0.002%
Electrical and Optical Equipment	-0.030%	-0.035%	-0.035%	-0.008%	-0.011%	-0.001%
Transport Equipment	-0.036%	-0.047%	-0.041%	-0.018%	-0.010%	-0.036%
Manufacturing, Nec; Recycling	-0.003%	-0.004%	-0.004%	-0.001%	-0.001%	0.000%
Electricity, Gas and Water Supply	-0.014%	-0.016%	-0.016%	-0.004%	-0.004%	-0.003%
Construction	-0.020%	-0.024%	-0.024%	-0.006%	-0.006%	-0.004%
Sale and Maintenance of Motor Vehicles[3]	-0.005%	-0.006%	-0.006%	-0.001%	-0.002%	-0.001%
Wholesale Trade and Commission Trade[4]	-0.018%	-0.021%	-0.021%	-0.005%	-0.005%	-0.004%
Retail Trade[5]	-0.013%	-0.016%	-0.015%	-0.004%	-0.004%	-0.003%
Hotels and Restaurants	-0.006%	-0.007%	-0.007%	-0.002%	-0.002%	-0.001%
Inland Transport	-0.008%	-0.009%	-0.009%	-0.002%	-0.002%	-0.001%
Water Transport	-0.004%	-0.004%	-0.005%	-0.001%	-0.001%	0.000%
Air Transport	-0.004%	-0.004%	-0.004%	-0.001%	-0.001%	0.000%
Other Transport Activities[6]	-0.011%	-0.013%	-0.013%	-0.003%	-0.003%	-0.002%
Post and Telecommunications	-0.008%	-0.009%	-0.009%	-0.002%	-0.002%	-0.001%
Financial Intermediation	-0.012%	-0.014%	-0.013%	-0.003%	-0.003%	-0.002%
Real Estate Activities	-0.029%	-0.034%	-0.033%	-0.008%	-0.009%	-0.006%
Renting of M&Eq[7]	-0.049%	-0.057%	-0.056%	-0.012%	-0.014%	-0.008%
Public Admin and Defence[8]	-0.016%	-0.019%	-0.018%	-0.005%	-0.005%	-0.003%
Education	-0.011%	-0.014%	-0.013%	-0.003%	-0.003%	-0.002%
Health and Social Work	-0.021%	-0.026%	-0.025%	-0.006%	-0.007%	-0.005%
Other Community, Social and Personal Services	-0.014%	-0.017%	-0.016%	-0.004%	-0.004%	-0.003%
Private Households with Empl. Persons	-0.001%	-0.001%	-0.001%	0.000%	0.000%	0.000%

Notes: Values represent output changes (total effect) per sector following shocks in China described in scenarios in headline as percentage of initial output. The scenarios of final demand changes in China are: General reduction of final demand (-1%), Reduction in investment (-1% total final demand), Reduction in demand for primary and secondary sectors (-1% total final demand), Shift from investment to consumption (1% total final demand), Shift from primary and secondary to tertiary sectors (1% total final demand), Domestic production instead of imports (10% in "transport equipment"). [1] Agriculture, Hunting, Forestry and Fishing; [2] Pulp, Paper, Printing and Publishing; [3] Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel; [4] Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles; [5] Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods; [6] Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies; [7] Renting of M&Eq and Other Business Activities; [8] Public Admin and Defence; Compulsory Social Security

Table 4: Reduction in output across industries and countries depending on shock in final demand in China

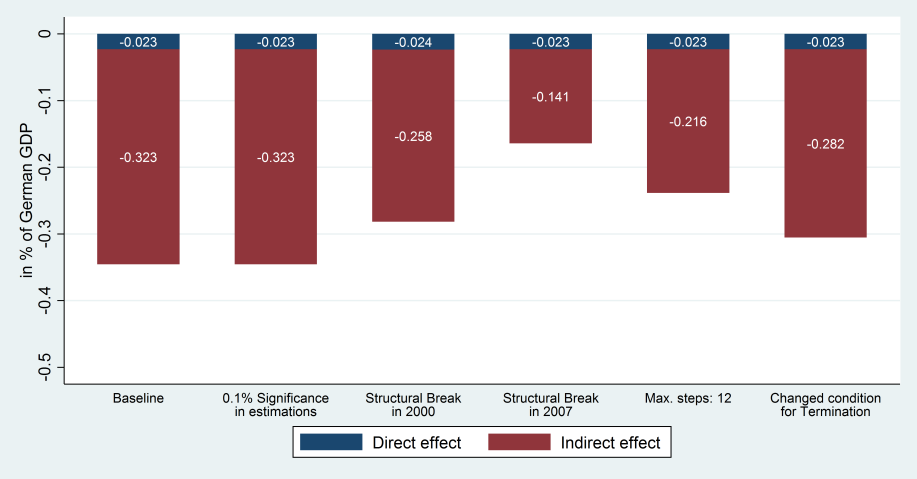
	General reduction	Only investment	Only primary and secondary	From investment to consumption	From primary/ secondary to tertiary	From import to domestic prod.
US						
Primary	-0.01%	-0.02%	-0.02%	0.00%	0.00%	0.00%
Secondary (plus Construction)	-0.06%	-0.07%	-0.07%	-0.02%	-0.01%	0.00%
Tertiary	-0.21%	-0.23%	-0.24%	-0.05%	-0.04%	-0.01%
China						
Primary	-0.18%	-0.15%	-0.30%	0.08%	-0.18%	0.01%
Secondary (plus Construction)	-2.31%	-2.82%	-2.59%	-0.95%	-0.42%	0.11%
Tertiary	-1.57%	-1.43%	-1.24%	0.16%	0.52%	0.08%
Germany						
Primary	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Secondary (plus Construction)	-0.13%	-0.15%	-0.15%	-0.04%	-0.04%	-0.03%
Tertiary	-0.22%	-0.25%	-0.26%	-0.07%	-0.06%	-0.05%
UK						
Primary	0.00%	-0.01%	-0.01%	0.00%	0.00%	0.00%
Secondary (plus Construction)	-0.10%	-0.12%	-0.12%	-0.03%	-0.02%	-0.01%
Tertiary	-0.39%	-0.44%	-0.45%	-0.09%	-0.08%	-0.04%
EU						
Primary	-0.01%	-0.01%	-0.01%	0.00%	0.00%	0.00%
Secondary (plus Construction)	-0.11%	-0.12%	-0.12%	-0.03%	-0.02%	-0.01%
Tertiary	-0.23%	-0.26%	-0.27%	-0.06%	-0.05%	-0.02%
Asia						
Primary	-0.02%	-0.02%	-0.02%	0.00%	0.00%	0.00%
Secondary (plus Construction)	-0.22%	-0.26%	-0.26%	-0.07%	-0.06%	-0.01%
Tertiary	-0.36%	-0.42%	-0.43%	-0.12%	-0.10%	-0.02%

Notes: Values represent composition of output changes (total effect) per industry and country following shocks in China described in scenarios in headline as percentage of total output. The scenarios of final demand changes in China are: General reduction of final demand (-1%), Reduction in investment (-1% total final demand), Reduction in demand for primary and secondary sectors (-1% total final demand), Shift from investment to consumption (1% total final demand), Shift from primary and secondary to tertiary sectors (1% total final demand), Domestic production instead of imports (10% in Transport Equipment). Asia includes Indonesia, India, Japan, Korea and Taiwan, excluding China. EU includes EU27 countries, excluding Germany and UK.

5.4 Robustness Checks

To check the robustness of our results, we calculate results for several modifications of the baseline case (Column 1 in Figure 8). All variants present the effect of a reduction in Chinese final demand by 1% on Germany. First we assess the robustness with respect to the estimated elasticities of final demand to output (see Section 3.1). In the baseline scenario Equation 5 in Section 3.1, estimated by OLS, we set all coefficients to zero that are not significant at the 1% level. Column 2 in Figure 8 re-estimates the baseline case allowing only for a 0.1% significance level, which does not alter results.

Figure 8: Effects of a general reduction of Chinese final demand by 1% on Germany: Robustness checks



Notes: Column 1 - Baseline case, Column 2 - Significance level 0.1% of coefficients in Equation 5, Column 3 - Structural break in 2000 in estimation of Equation 5, Column 4 - Structural break in 2007 in estimation of Equation 5, Column 5 - Maximum number of steps equal to 12 in procedure described in Section 3, Column 6 - Condition for termination of stepwise procedure changed to a sum of squared output changes (ϵ) of less than 0.01%

To account for structural breaks, Columns 3 and 4 in Figure 8 estimate Equation (5) including a dummy variable for specific time periods. In Column 3, we set the dummy for the years 2000 to 2011, assuming that in 2000 the Internet and modern communication methods started to simplify trade and changed the way trade reacts to output changes. In Column 4, we use a dummy for the years 2008 to 2011 to capture the global financial crisis. In both cases, the results do not change qualitatively, but the effects are slightly smaller.

Our baseline calculates indirect effects step-wise by iterating Equation 3 until the sum of the squared output changes is smaller than ϵ (see Section 3). Column 5 in Figure 8 shows the results of our calculations when the procedure is stopped after 12 steps, and Column 6 when ϵ is set to 0.01% instead of 0.001%.

In sum, we see that the baseline case marks the lower floor of our robustness checks. While the magnitude of indirect effects differs between the columns, the key result of sizable indirect effects remains.

6 Conclusions

Given its size and intimate trade links, China has become pivotal for the global economy. With Chinese growth slowing and important transitions of its domestic economy underway, trading partners are likely to feel more than just a pinch. However, traditional ways of analysing trade links may miss the important effects that even a change in the composition of an economy such as China's can have for trading partners. Furthermore, other analyses, while having other advantages, may not be able to reflect the amplifying effect from global value chains.

By deploying input-output analysis complemented by higher-round effects, this paper tries to capture these indirect effects. Using granular input-output matrices from 2011, the analysis allows the incorporation of the value-added component on a sector and country level, enabling the analysis of a shock not only to overall final demand, but also a shock to its composition. Hence, this model extension is well-suited for an application to the impact of China's economic transformation on trading partners.

Our results suggest that an overall decline in final demand by 1% of final demand in China has a smaller effect on the global economy than a similar shock originating in the US or the EU, reflecting the size of the respective economic areas and the share of imports in final demand. Standardizing the initial shock across countries suggests that a shock to final demand in Germany has a lower bearing on world final demand than on other regions considered. This reflects the large share of Germany's trade surplus, compared to trade deficits in the US or the UK, for example. In each case, the original shock is amplified through indirect, higher-round effects. Assuming a lower elasticity of final demand with respect to output changes would yield a less intense indirect effect.

Looking at shocks to final demand originating in China, the impact on Germany is generally larger than on the US, but smaller than on the rest of Asia, which can be explained by the extent of trade links. Moreover, a demand shock specifically to investment or primary and secondary sectors, in other words import-intense sectors of China, have stronger effects than a broad-based final demand shock. China's transition, which is poised to change the composition of final demand, would therefore still have an impact on trade partners. In a scenario that leaves aggregate demand unaffected, a shift in its composition from investment to consumption would impact trade partners more than a shift from production towards services. A shift towards import substitution in transport equipment would particularly hit Germany's strong automotive exports while indirect effects are relatively weak, suggesting this key sector of the German economy is more independent than other sectors.

While the approach of this paper cannot take into account offsetting effects like a general equilibrium model, which is most relevant in the long run, the results suggest stronger spillovers from demand shocks than if looking at direct trade links. The sectoral analysis, furthermore, shows that even shifts in the composition of the epicenter economy matter. Certainly, the mechanics of the trade impact must be interpreted with great caution.

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Appendix

Table 5: Effects of a 1% final demand shock in respective epicenter country

	Germany	China	US	UK	EU	Asia	World
Shock in China							
Direct effect	-0.02	-1.70	-0.01	-0.01	-0.01	-0.03	-0.19
Indirect effect	-0.32	-2.36	-0.27	-0.49	-0.33	-0.57	-0.64
Total effect	-0.35	-4.06	-0.28	-0.50	-0.34	-0.60	-0.84
Shock in US							
Direct effect	-0.03	-0.05	-1.78	-0.03	-0.02	-0.03	-0.43
Indirect effect	0.71	-2.39	-2.62	-1.20	-0.74	-1.05	-1.59
Total effect	-0.74	-2.44	-4.41	-1.23	-0.77	-1.08	-2.02
Shock in UK							
Direct effect	-0.02	-0.01	-0.01	-1.69	-0.02	-0.01	-0.07
Indirect effect	-0.16	-0.28	-0.11	-2.29	-0.20	-0.14	-0.24
Total effect	-0.18	-0.29	-0.11	-3.98	-0.21	-0.14	-0.31
Shock in Germany							
Direct effect	-1.45	-0.01	-0.00	-0.02	-0.03	-0.01	-0.08
Indirect effect	-0.53	-0.26	-0.08	-0.25	-0.19	-0.13	-0.18
Total effect	-1.98	-0.27	-0.08	-0.27	-0.22	-0.14	-0.25
Shock in EU							
Direct effect	-0.10	-0.03	-0.01	-0.07	-1.65	-0.02	-0.29
Indirect effect	-0.78	-1.14	-0.37	-1.10	-1.90	-0.58	-0.91
Total effect	-0.88	-1.17	-0.39	-1.17	-3.55	-0.60	-1.20
Shock Asia							
Direct effect	-0.01	-0.04	-0.01	-0.01	-0.01	-1.71	-0.27
Indirect effect	-0.31	-1.03	-0.31	-0.50	-0.33	-2.59	-0.83
Total effect	-0.33	-1.07	-0.32	-0.52	-0.34	-4.30	-1.10

Notes: Shock equals 1% of respective epicenter country final demand. Size of the effect in % of respective country final demand. Asia includes Indonesia, India, Japan, Korea and Taiwan, excluding China. EU includes EU27 countries, excluding Germany and UK.

Table 6: Effects on world/Germany of a 1% final demand shock in respective epicenter country (normalized to 1% German total final demand)

	China	US	UK	EU	Asia	Germany
Effects on World						
Direct effect	-0.19	-0.43	-0.07	-0.29	-0.27	-0.08
Indirect effect	-0.64	-1.59	-0.24	-0.91	-0.83	-0.18
Total effect	-0.84	-2.02	-0.31	-1.20	-1.10	-0.25
Effects on Germany						
Direct effect	-0.01	-0.01	-0.02	-0.03	-0.01	-1.45
Indirect effect	-0.15	-0.14	-0.22	-0.23	-0.10	-0.53
Total effect	-0.16	-0.15	-0.24	-0.26	-0.10	-1.98

Notes: Shock equals 1% of German final demand. Size of the effect in % of respective country final demand. Asia includes Indonesia, India, Japan, Korea and Taiwan, excluding China. EU includes EU27 countries, excluding Germany and UK.