Modelling the impacts of a surge in shipping costs

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Abstract:

The paper evaluates the impact of the increase of freight transport costs on the global economy. Using a detailed transport database, a set of detailed shocks by transportation mode, regions and commodities feed a multi-region, recursive dynamic general equilibrium model which analyses the sectorial (agri-food sectors, manufacturing) and macroeconomic (trade, wide-economic indicators) impacts of the recent surge in shipping costs.

Keywords: Global CGE model, transportation costs,

Introduction

During the third quarter of 2020, after the economic turndown caused by the COVID-19 pandemic crisis, the global economy showed a sharp increase mainly driven by the manufacturing sector due to the easing of the pandemic containment measures and the substantial policy support deployed by many governments. Following the collapse in global trade in the first half of 2020, global merchandise imports recovered, and by November 2020, they reached their pre-crisis level. The strong recover in global manufacturing activity caused a rise in international orders and resulted in supply bottlenecks. One of the signs of the supply bottlenecks was the rise of ocean freight shipping costs, especially for containerized goods. Since the second half of 2020, global freight shipping costs have been on a steady recovery path from the lows reached in the midst of the pandemic. The strong rise in demand for intermediate inputs to feed the strong manufacturing activity raised the demand for Chinese exports and for container shipments. At the same time, shortages of containers at Asian ports exacerbated supply bottlenecks and further increased shipping costs. The rise in shipping costs was further exacerbated by limited airfreight capacity as international flight volumes plunged due to travel restrictions and flight cancellations. The increase in shipping costs affected the economy globally and all traded sectors, from primary to manufacture, were affected. While there are indications that the stress on global transport logistics is eventually going to ease, developments are highly dependent on the evolution of the pandemic and on the solution of structural problems in maritime transport. While prices are thus expected to ease into 2022, they might remain higher than pre-pandemic levels.

The aim of this paper is to evaluate the impact of the increase of freight transport costs on the global economy. Using a detailed transport database, a set of detailed shocks by transportation mode, regions and commodities feed a multi-region, recursive dynamic general equilibrium model which analyses the sectorial (agri-food sectors, manufacturing) and macroeconomic (trade, wide-economic indicators) impacts of the recent surge in shipping costs

The present study employs a state-of-the-art multi-sector, multi-region recursive dynamic CGE model called MAGNET (Woltjer and Kuiper, 2014). MAGNET is based on the Global Trade Analysis Project (GTAP) model, which accounts for the behaviour of households, firms, and the government in the global economy and how they interact in markets (Corong et al., 2017). The model includes the food supply chain from farm, as represented by agricultural sectors - via food processing industries and food service sectors - to fork taking into account bilateral trade flows for major countries and regions in the world. Trade is modelled in a way that domestically produced goods can be sold on the domestic market or to other regions in the world. Similarly, domestic intermediate, private household and government demand for goods can be satisfied by domestic production or by imports from other regions in the world (i.e., the 'Armington assumption'). Sourcing of imports happens at the border, after which - on the basis of the resulting composite import price - the optimal mix of import and domestic goods is derived. Demand for and supply of commodities and endowments meet in markets, which are perfectly competitive and clear via price adjustments.

This study employs the GTAP database Version 10, contains a complete record of all economic activity (i.e., production, trade, primary factor usage, final and input demands, taxes, trade tariffs, and transport margins) for 65 activities and 141 regions for 2014. The MAGNET model includes an additional provision of disaggregated sectors compared to the original GTAP database. The sectorial disaggregation includes 14 primary agriculture commodities, 10 Food and beverages and 16 other sectors. The regional disaggregation comprises 20 regions including the EU, Australia, Canada, Japan, Mercosur, Mexico, New Zealand, and United States.

The improvement brought by this work consists of the integration into MAGNET of the detailed international transport costs published by UNCTAD (United Nations Conference on Trade and Development). The data include detailed figures for freight costs by transport mode (sea, air, road and rail), at country origin-destination level and for WCO HS6 commodity level. The available indicators include total transport costs, transport costs to FOB value, transport costs per unit, transport costs per 10 000 km, with year 2016 as a baseline. The structure of the UNCTAD data allows the aggregation of the indicators into the regions and commodity groups used by MAGNET. It also permits the parameterization of the transport cost variables used by the model and –as a result- the exploration of various scenarios.

A first set of exploratory analysis provides an evaluation of the overall impacts at regional and commodity level. Regions dependent on imports/ exports of low value to weight ratio products suffer the highest relative price increases. The same holds for regions that trade with long-distance partners, or do not have efficient freight transport infrastructure or services. Higher value goods may find alternatives in air or road transport, if possible. Goods transported by containers, especially reefers are more sensible to price increases, while the impact on goods transported in bulk was much more limited.

The paper contributes on two fronts: a) improving the link between the GTAP database and available data transport to improve the creation of scenarios looking at change on the transport market and b) providing a detailed analysis of the impact of the recent increase of transport price on selected sectoral and macroeconomic indicators at global and regional level.

The recent increase in transportation costs.

In 2020, lockdown measures and other impacts of COVID-19 suddenly cut the demand for containerized goods. In 2020, global container trade fell by 1.1% to 149 million twenty-foot equivalent units (TEU). The container volumes bounced back quickly as consumer demand increased, boosted by stimulus packages and measures to support incomes during COVID-19. In the second half of 2020, demand for container shipping started to pick up and absorb spare capacity. As demand picked up, carriers released more capacity but by that time, the supply was being constrained by other factors, notably port congestion and equipment shortages that kept vessels waiting, especially in West Coast North America. The result was exacerbated disruption and inefficiency at port. By the end of 2020, freight rates had surged to unexpected levels (UNCTAD, 2022).

Towards the end of 2020 and into 2021, container shortages and congestion at ports, along with other disruptions, led to record container freight rates, notably on the routes from China to Europe and the United States reflected in the Shanghai Containerized Freight Index (SCFI). In June 2020, SCFI spot rate on the Shanghai-Europe route was less than $1,000/TEU but by the end of 2020 had reached around $4,000/TEU and, by the end of July 2021, the SCFI has reached $7,395/TEU (UNCTAD, 2022).

Freight rates also escalated on the China-United States trade lane and also extended across developing regions, including South America and Africa (UNCTAD, 2022).

According to the Freightos Baltic Index (FBX), a global container freight index, the freight rates in August 2021 reached $10,174/FEU, an increase of 466% on the previous year and plateau at around $9,000/FEU during 2022.

An analysis of the U.S. case shows that containerized agricultural exports was 22 percent below the counterfactual from May 2021 to January 2022 and that this adverse trade effects translate into USD 10 billion in export losses (Carter et al., 2022).

The surge of freight cost might have an impact of domestic inflation rate. Although international shipping costs are generally not included in import price indices, importers can pass changes in shipping costs through to consumers in a manner that affects aggregate price growth. Empirical studies reveal that a one-standard-deviation increase in global shipping costs increases domestic headline inflation by about 0.15 percentage point, with the effect building up over the course of 12 months. Unlike many other pass-through that have been studied in the literature, this effect appears to have remained strong over time, perhaps reflecting the increased openness of countries to international trade (Carrière-Swallow et al., 2022). This implies that the increase in shipping costs observed in 2021 could increase inflation by about 1.5 percentage points in 2022 (Carrière-Swallow et al., 2022). The impact of the high freight charges will be greater in Small Island Developing States (SIDS), which could see import prices increase by 24% and consumer prices by 7.5%. In least developed countries (LDCs), consumer price levels could increase by 2.2% (UNCTAD, 2022). Within the EU, freight rates have a significant positive impact on the price of the sub-categories of Non-Energy Industrial Goods (NEIG). Following a shock in freight rates, the most hard-hit sectors appear to be garments and major household appliances, items that have traditionally been manufactured outside the euro area. The relationship between freight rates and inflation tends to become positive once the former rise above the $1,200-$1,500 levels (Michail et al., 2022). Empirical OECD estimates of these two relationships assess the implication for inflation of the average 50% rise in container prices observed in the first quarter of 2021. Assuming that shipping costs stabilise at their current level for the rest of 2021, in the short run, the rise of 50% in shipping costs observed in the first quarter of 2021 is estimated to raise quarter-on-quarter import price inflation by 2.5 percentage points. After one year, merchandise import price inflation is estimated to rise by 2 percentage points (OECD, 2021).

On the other hand, other analysis suggests that after one year, the pass-through of shipping prices into US Personal Consumption Expenditures (PCE) inflation is rather limited. Even a 50% annual increase in the Harpex – similar to that experienced leading up to January 2021 – could raise annual PCE inflation by up to 0.25 percentage points one year later. The size of this effect is also explained by the fact that international shipping costs make up only a relatively small share of the final cost of manufacturing output. Overall, given that supply challenges are largely driven by transportation rather than production constraints, the rise in transportation costs is expected to have only a modest impact on global economic activity (European Central Bank, 2021).

Additionally, the war in Ukraine will cause further disruptions to supply chains, which could keep global shipping costs—and their inflationary effects—higher for longer.

CGE Literature review

Transportation applications of CGE model are widespread. Despite some of the pitfalls associate to the use of CGE in transportation appraisal (Tavasszy et al., 2011), CGE models address several shortfalls of their predecessors (Shahrokhi Shahraki and Bachmann, 2018). CGEs can assess the economic impact of transport, including both direct and wider economic impacts, as they can determine the distribution of impacts among every market and agent in the economy by simulating the behaviour of households, firms and others from microeconomic first principles (Robson et al., 2018).

With regards to model applications, CGE have been applied to analyse infrastructure (road, rail) construction, transportation network changes (e.g., expansion, removal, and speed change), congestion costs, infrastructure investment/financing, land-use impacts, cross-border trade, transport cost change infrastructure interdependencies, trade facilitation and trade agreements. Robson et al., (2018) and Shahrokhi Shahraki and Bachmann, (2018) provide an extensive reviews of the academic literature relating to CGE modelling of transport.

CGE models have often been used to analyse the causality of transportation infrastructure investment on economic growth, assuming that infrastructure capital is regarded as an unpaid and intermediate input on the supply side and as a construction investment demand on the demand side (Kim et al., 2004). Most of the global studies dealing with the transportation sector relies on the GTAP database as their main economic data source. The GTAP model and all GTAP-based models, which represent transport cost using explicit approach, have been widely employed for analysis related to the transport sector. GTAP-E provided a quantitative evaluation of the economic impacts of a maritime carbon tax showing that imposing a maritime carbon tax on international container shipping is not expected to have a significant economic impact unless the amount of the carbon tax is very high (Lee et al., 2013). The GTAP model showed that investments in transportation infrastructure among 17 Belt and Road Initiative countries during 2014–2020 (Chen and Li, 2021) has an overall positive effect among the belt and road countries even if the impacts were found to vary substantially among different countries and regions.

The CGE model and database

The present study employs a state-of-the-art multi-sector, multi-region dynamic CGE model called MAGNET (Woltjer et al., 2014). MAGNET has been recently widely employed to simulate the impacts of agricultural policies (M'Barek et al., 2020), land issues (Sartori et al., 2019), sustainable development goals (SDGs) (Philippidis et al., 2020) and free trade agreements (Ferrari et al., 2021; Simola et al., 2021) on the global economy.

The model is developed at Wageningen Economic Research and is applied and further extended at Wageningen Economic Research, the Thünen Institute and by the European Commission's JRC. It is a core model of the integrated Modelling Platform for Agro-economic Commodity and Policy Analysis (iMAP) (M'barek et al., 2012; M'barek and Delince, 2015). Detailed information on the MAGNET tool and its use can be accessed on the European Commission's Modelling Inventory Database and Access Services (MIDAS).

MAGNET is based on the Global Trade Analysis Project (GTAP) model, which accounts for the behaviour of households, firms, and the government in the global economy and how they interact in markets (Corong et al., 2017). The model includes the food supply chain from farm, as represented by agricultural sectors - via food processing industries and food service sectors - to fork taking into account bilateral trade flows for major countries and regions in the world.

Trade is modelled in a way that domestically produced goods can be sold on the domestic market or to other regions in the world. Similarly, domestic intermediate, private household and government demand for goods can be satisfied by domestic production or by imports from other regions in the world (i.e., the 'Armington assumption'). Sourcing of imports happens at the border, after which - based on the resulting composite import price - the optimal mix of import and domestic goods is derived. Demand for and supply of commodities and endowments meet in markets, which are perfectly competitive and clear via price adjustments.

Modes of international transport in the standard Global Trade Analysis Project (GTAP) model (Hertel, 1997) are handled by a global transport services industry that allocates a composite international transport good among exporting countries in direct proportion to their global export shares of a given product. The composite international transport good is a bundle of air, water (mostly vessel), and other (land, predominantly truck and rail) transportation services. The combination of the Free on Board (FOB) price at the country of origin with the composite international transport good generates a Cost, Insurance and Freight (CIF) price at the destination country. International margins are based on a bilateral dataset of modal transport shares that matches the country and product aggregation of the GTAP Data Base (Nuño-Ledesma and Villoria, 2019).

This study employs the GTAP database Version 10, contains a complete record of all economic activity (i.e., production, trade, primary factor usage, final and input demands, taxes, trade tariffs, and transport margins) for 65 activities and 141 regions for 2014 (Aguiar et al., 2019). The MAGNET model includes an additional provision of disaggregated sectors compared to the original GTAP database. The sectorial disaggregation includes 14 primary agriculture commodities, 10 Food and beverages and 16 other sectors. The regional disaggregation comprises 22 regions including the EU, Australia, Canada, Japan, Mercosur, Mexico, New Zealand, United States, China, Ukraine and Russia.

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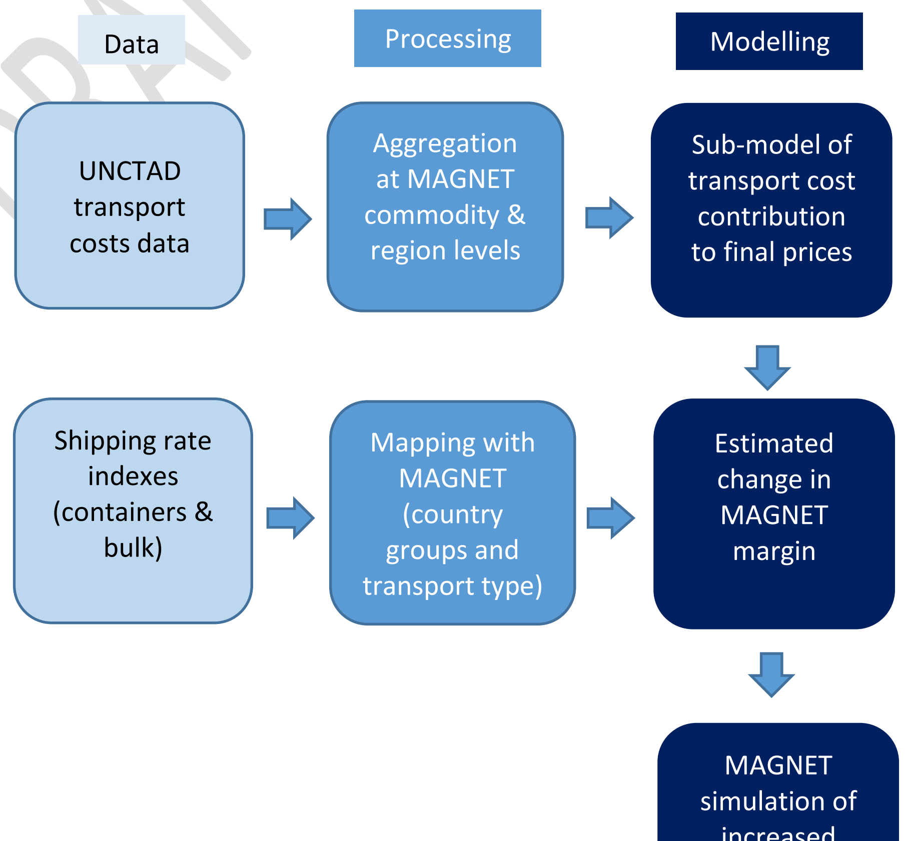
Scenario

The MAGNET baseline is calibrated to the EU Medium-Term Agricultural Outlook 2019-2030, published by the Directorate-General for Agriculture and Rural Development in December 2021 (European Commission, 2021). The macroeconomic developments (GDP, population growth rate, world crude oil price) are exogenously imposed to the model following the forecasts adopted in the EU Medium-Term Agricultural Outlook. In addition, the model is calibrated around trade statistics to replicate EU bilateral imports and exports for crucial agricultural sectors and trading partners for 2014 and 2020, using Comext trade statistics. The scenario is then performed as a comparative static exercise starting from 2020 data.

To simulate the impact of increased maritime transport costs on the global economy, we applied a methodology that combines the integration of new data sources on transport costs and the transformation of the detailed transport costs into a structure compatible with MAGNET. The improved coverage of transport costs allowed the development of a sub-model linking final prices to transport costs and the estimation of the repercussion of increased rates in maritime transport. We applied the resulting changes in margins –for all commodity, origin and destination combination in MAGNET to capture the potential impacts at sectoral and regional level (Figure 1).

Figure 1: Overview of modelling process



The main new data source used in this work is the UNCTAD Global Transport Costs Dataset for International Trade (UNCTAD, 2021). The dataset includes a set of six input and output tables, each distinguished by mode of transport. In the application presented here, we use the raw data (input) tables for international trade transported by sea. The reference year is 2016.

The dataset presents bilateral trade data as reported by countries in Comtrade Plus and as edited/imputed by United Nations Conference on Trade and Development (UNCTAD), World Bank and, Equitable Maritime Consulting based on a methodology specifically developed for the estimation of transport costs. The goal of the dataset is to provide a reference for maritime transport costs data, a key barrier to comprehensive impact assessments. However, the dataset, which provides mode-specific transport costs, can be equally harnessed to the benefit of analysis in all other major modes of transport.

The dataset aims to cover all modes of transport, all commodities and as many countries as possible (dependent on the bilateral trade data reported by the countries in Comtrade Plus). Based on the bilateral trade flows of commodities for which quantity, Cost, Insurance and Freight (CIF), and Free on Board (FOB) data exist, the dataset displays the related transport costs (incl. insurance costs) by the following dimensions on an annual basis.

1. By country pair (route)

2. By commodity (grouped based on the World Customs Organization Harmonized System six-digit code)

3. By mode of transport (mode by which the commodity reaches the border of the importing country): Sea, Air, Railway, Road, Other (non-specified or non-standard modes, e.g. pipelines, cables, etc. but also inland waterways).

The dataset currently covers 135 importing countries and 235 exporting countries (based on ComTrade Plus data) and includes nearly 25 million trade records. The dataset includes estimates of the transport costs related to bilateral trade. This is defined as the monetary price charged to transport a commodity from the exporting country to the importing country.

The methodology applied follows a two-stage process:

In a first step, comprehensive data have been compiled. For countries and commodities, Comtrade Plus data provides bilateral trade information—obtained from the customs declarations of international trade transactions—on:

- Cost, insurance and freight (CIF) value (in US$, nominal)
- Free on board (FOB) value (in US$, nominal)
- Quantity (in various units)

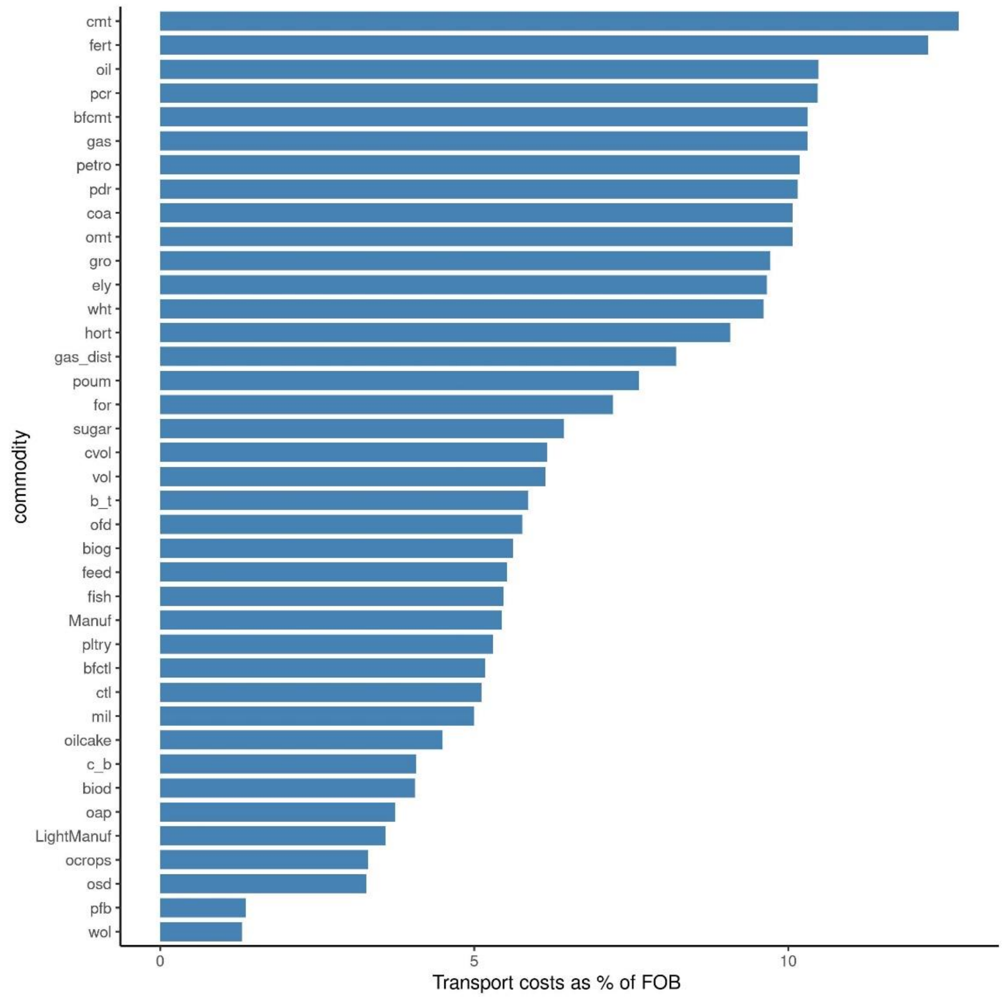
Additionally, a distance matrix has been added to obtain mode-specific information on transport distances between countries and to include another input variable:

- Distance (in km)

The database provides trade values at Harmonized Commodity Description and Coding System 6-digit (HS2012 HS6) commodity level that can be directly mapped to the commodities used in the MAGNET model. Based on these the difference between total CIF and total FOB trade values per MAGNET commodity, Figure 2 summarizes the ratio between transport costs (considered as the difference between CIF and FOB prices according to the UNCTAD definition) and FOB prices. The difference in values reflects a well-known effect in transport economics, an inverse relationship between the value-to-volume ratio and the transport costs per unit of value of the goods transported (Figure 2).

For cattle meat (cmt), transport costs represent an increase of 12.7% on the FOB price, while for fertilizers (fert) they represent 12.2%. In fact, the majority of commodities for which transport costs represent more than 6% of FOB price are low value to weight/volume products that are normally transported in bulk (crude oil, rice, gas, oil products, coal, cereals, etc.), or require special conditions for transport (meat, vegetables and fruits, live cattle, etc.). On the other extreme, higher valued commodities that are transported by sea such as wool or plant fibres have a rather low impact of transport costs (1.3-1.4%). The comparison between light manufacturing (3.6%) and manufacturing in general (5.4%) is also indicative of the influence of the product value. Above a certain level of value to weight/volume (or when additional speed constraints are present) maritime transport is not the preferred mode of transport and shippers prefer land or air transport. This would be the case – for example- for higher value pharmaceuticals, technological products or fresh flowers.

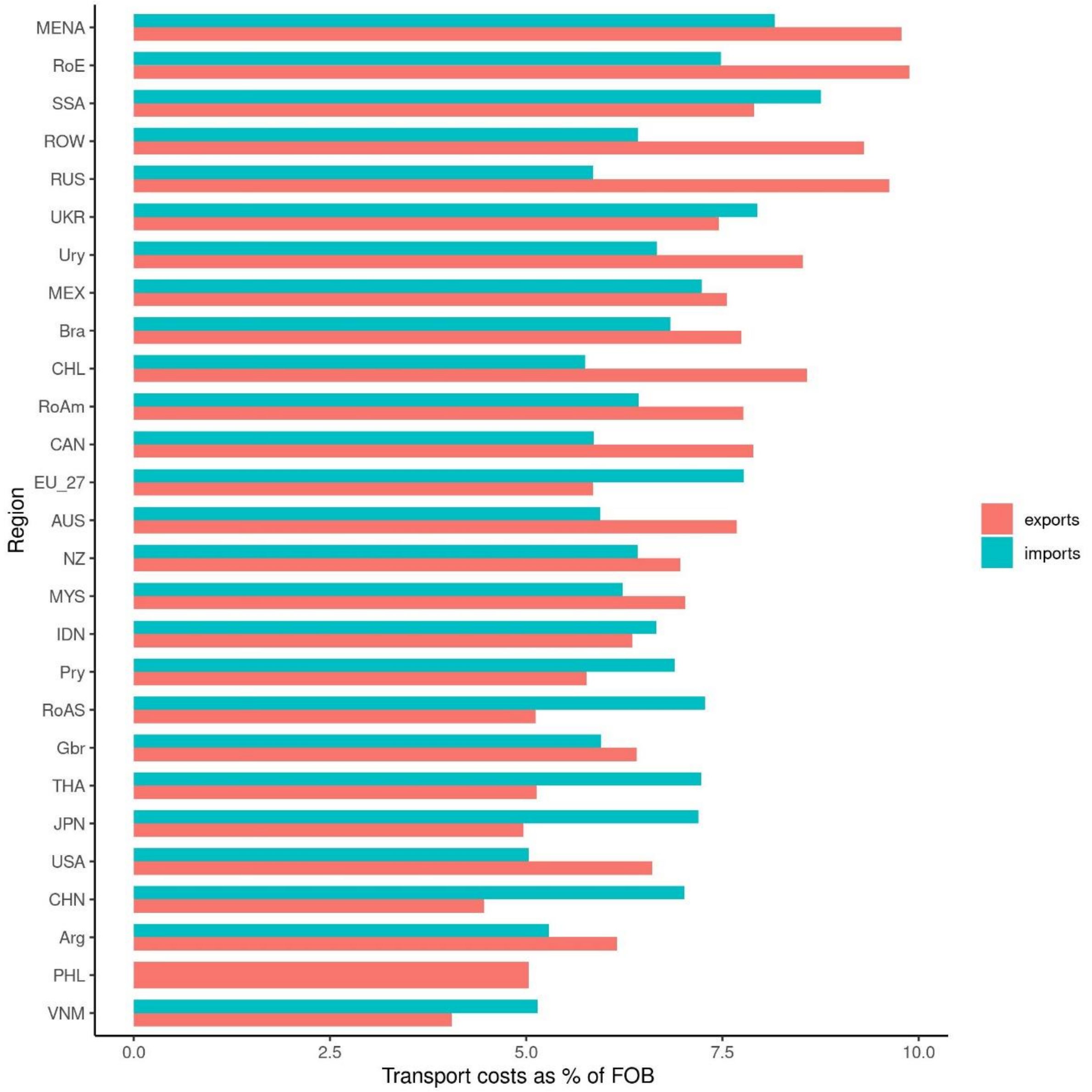
Figure 2: Weighted average of maritime transport costs to FOB price per MAGNET commodity



It is –nevertheless- obvious that the transport distances also have a role in determining the impact of transport costs. Commodities with a high concentration of either exporting or importing countries (e.g., sugar) may require a higher average transport distance than products with more uniform global trade patterns (e.g., other food products). Summarizing the data at MAGNET region level (Figure 3), the interplay of the product mix and geographical distribution is quite visible. Depending on the type of commodities, each region imports/exports, and the geographic distance from the trade partner regions, the average impact of transport costs on prices varies significantly by region, as well as between imports and exports for the same region. China is an example of the difference between imports and exports. Since China's international maritime trade mainly consists of importing raw material (usually in bulk) and exporting manufactured products (most frequently in containers), transport costs represent 7% of the total FOB value of imports and only 4.5% of the total FOB value of exports. A similar imbalance can be observed for EU27: 7.8% for imports, 5.9% for exports (the difference with China is due to the combination of different product mix and average distances). In contrast, USA and Australia show the opposite pattern: the repercussion of maritime transport costs are higher for exports than for imports, mainly because of the high share of raw materials (oil for the USA, coal and iron ore for Australia) in their total exports. The geographic distribution of their markets also influences, with Australia needing longer transport distances than the USA (or most other regions) on average.

The high variance of the impact of transport costs for each commodity or region implies that an increase in maritime transport costs, either uniform at global level or localised in specific regions or market segments may lead to diverse impacts for international trade.

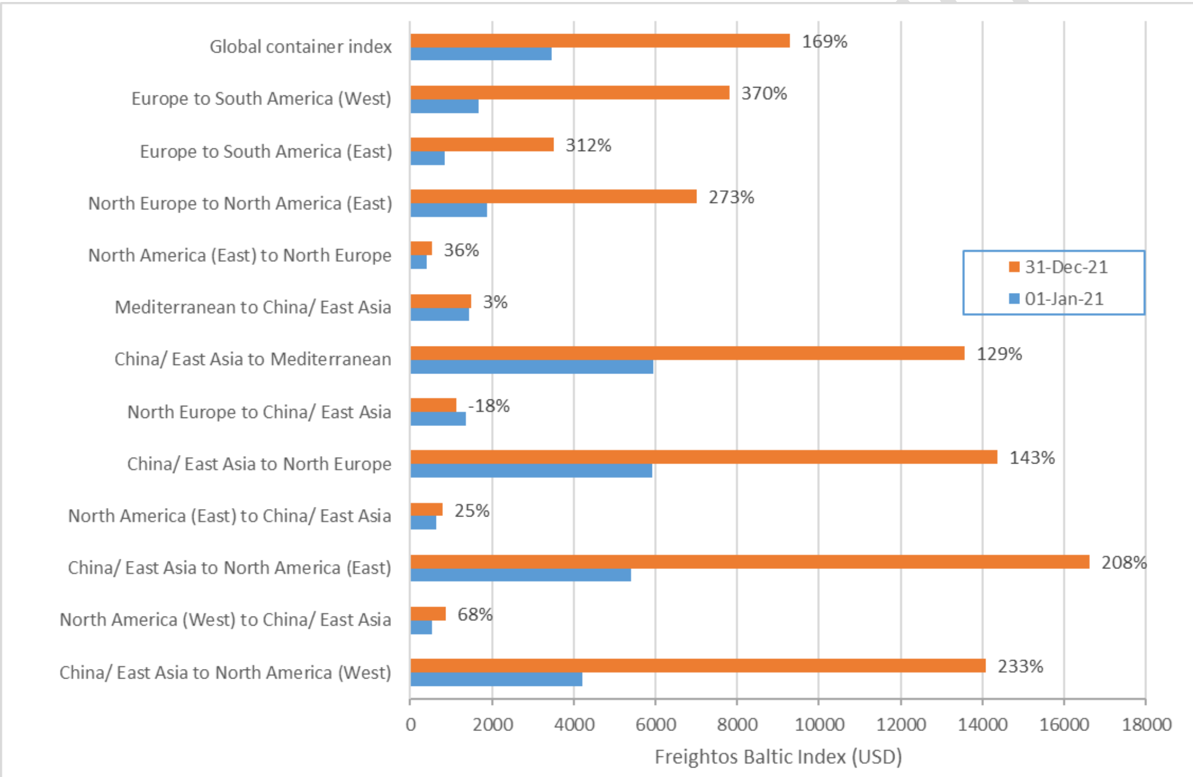
Figure 3: Weighted average of maritime transport costs to FOB price per MAGNET region



The other main source used in this work concerns the data on the changes in maritime transport rates using the Freightos Baltic Index (Freightos, 2022). The index tracks daily average market rates from container shippers and represents a benchmark for the evolution of prices across the international maritime container transport market. We extracted data for 13 different regional combinations as regards the change in their respective market index, between 1st January 2021 and 31st December 2021 (Figure 4). The indexes reflect the market imbalances that led to a steep increase in container rates, namely the increase in exports from China following the post-COVID-19 recovery of international trade, the congestion in Chinese and US West coast ports and the bottleneck created by the lack of empty containers. The global container market already depended on the demand and supply for containerized goods from China. The rates for containers from China were significantly higher than those to China, and this asymmetry was only accentuated when demand in the global container market increased. With Chinese exports as a driver, the rates from China increased by more than 100% for all its main export markets. Characteristically, the increase in rates in the opposite direction was much lower (even negative in the case of North Europe to China), since the ports on the side of China's partners did not face neither a congestion issue nor a lack of empty containers. Even though Chinese trade was the main driver, there were second order effects that led to prices increasing in unrelated markets, as for example in the Europe to South America market (probably because of capacity being moved to the China market).

The situation in the bulk transport sector, both dry and liquid, was considerably different. The shipping market is much more uniform and local bottlenecks may be more easily absorbed by the global transport supply. The post-COVID-19 recovery stimulated higher transport demand for goods transported in bulk also, but the pressure for the transport rates was lower than for containers. As a result, rates for dry bulk transport increased on average by 40% and for tankers by 10%.

Figure 4: Change in container rate index, year 2021 (Freightos Baltic Index)



To simulate the impact of the increases in container shipping rates, we decomposed the transport cost data into elements that can account more accurately for the part that corresponds to the container cost. We formulated a function of transport cost per value of product that distinguished between a fixed part that depends on the loading/discharging port and a variable part that depends on transport distance.

Transport cost per value is the ratio between total transport costs according to the UNCTAD assumptions (CIF price- FOB price) and total FOB value, and represents the weighted average (by value) of all registered trades (at HS2012 HS6 level) of commodity c (in MAGNET commodity groups)

$$tcv_{ijc} = (\text{Total CIF}_{ijc} - \text{Total FOB}_{ijc}) / \text{Total FOB}_{ijc} \qquad \text{(Eq. 2)}$$

where i is the exporting region, j is the importing region and c the commodity (i, j and c all according to the MAGENT structure)

The fixed costs on the port side would include port charging (loading/ unloading, storage), insurance and tariffs/ charges applied to the cargo (as opposed to the ones applied to the ship, which would be included in the shipping rate). The transport cost per unit of value can thus be expressed as:

$$tcv_{ijc}=\left(\frac{\text{Fixed cost}}{FOB}\right)_{ic}+\left(\frac{\text{Fixed cost}}{FOB}\right)_{jc}+\left(\frac{\text{Variable cost}}{FOB}\right)_{ijc}\times \text{Transport distance}_{ij} \qquad \text{(Eq. 2)}$$

which allows the distinction between fixed port parts and a variable part that is proportional to the transport distance.

The processed dataset, using MAGNET commodities and sectors, contains 12808 observations. For each commodity c, we applied a regression model that aimed at estimating the variable transport component of total costs:

$$tcv_{c}=f(i,j,\text{Transport distance}) \qquad \text{(Eq. 3)}$$

The resulting coefficients of the 39 different commodity models correspond to the fixed and variable components of tcv_{c} and should have positive values. The results of the commodity level models were all significant (Annex X.1), with the majority of adjusted R2 values in the range 0.8-0.99 (the only exceptions, being wool -0.636- and processed food, which was 0.770).

The simulation in MAGNET

$$margin_{ijc}=margin_{ijc}^{0}\times\left(fcv_{ijc}+vcv_{ijc}\times rate_{ijc}/\left(rate_{ijc}^{0}\right)\right)/tcv_{ijc} \qquad \text{(Eq.4)}$$

where

$margin_{ijc}^{0}$ is the original margin used in MAGNET and $margin_{ijc}$ is the new margin after the shock,

$rate_{ijc}^{0}$ is the average shipping rate in 2020 and $rate_{ijc}$ the average shipping rate in 2021,

fcv_{ijc}, vcv_{ijc} and tcv_{ijc} are the fixed, variable and total costs per unit of value,

and i, j, c the origing, destination and commodity respectively.

The estimated change in the margin varies considerably across commodities and regions. Two interesting examples are and light manufacturing (LightManuf, Figure 5) and wheat (wht, Figure 6).

Transport costs represent less than 20% of the FOB price for all origin-destination pairs in international trade for light manufacturing, but apart from a few outliers, most pairs have a ratio close to the mean for the sector. Out of the three largest importers of light manufacturing (USA, EU-27, Japan), EU-27 shows more variance in that respect, with imports from certain (distant) destinations having a ratio of over 8%. On the other hand, the change in the estimated change in the MAGNET margin is more limited for the EU than for USA, as direct repercussion of the increase in transport costs from China, which were more pronounced in the case of USA. In contrast, Japanese imports of light manufacturing were affected less, since the distance to China is small (and thus not affected significantly by the increase in container rates) and the transport costs of imports from the USA or Europe did not rise extensively.

For wheat, which at sea is exclusively transported by dry bulk, the transport cost to FOB price ratio tends to concentrate at a higher level around 10% (wheat being- as discussed above- a low volume to weight product). The increase in container rates does not affect the increase in the margin assumed in MAGNET, since transport rates for dry bulk have only increased by 40% on average. The fact that the increase in dry bulk rates was similar across the world led to a much more limited variance in terms of the change in the MAGNET margin, between 17% and 23%, for the various origin-destination pairs. The three largest wheat importing MAGNET regions (EU-27, India and MENA) have a comparable estimated change in the MAGNET margin of about 20%.

The full set of correlations for all commodities can be found in Table A 3.

Figure 5: Correlation of increase in MAGNET margin and transport costs as share of FOB price, by origin-destination combination, light manufacturing

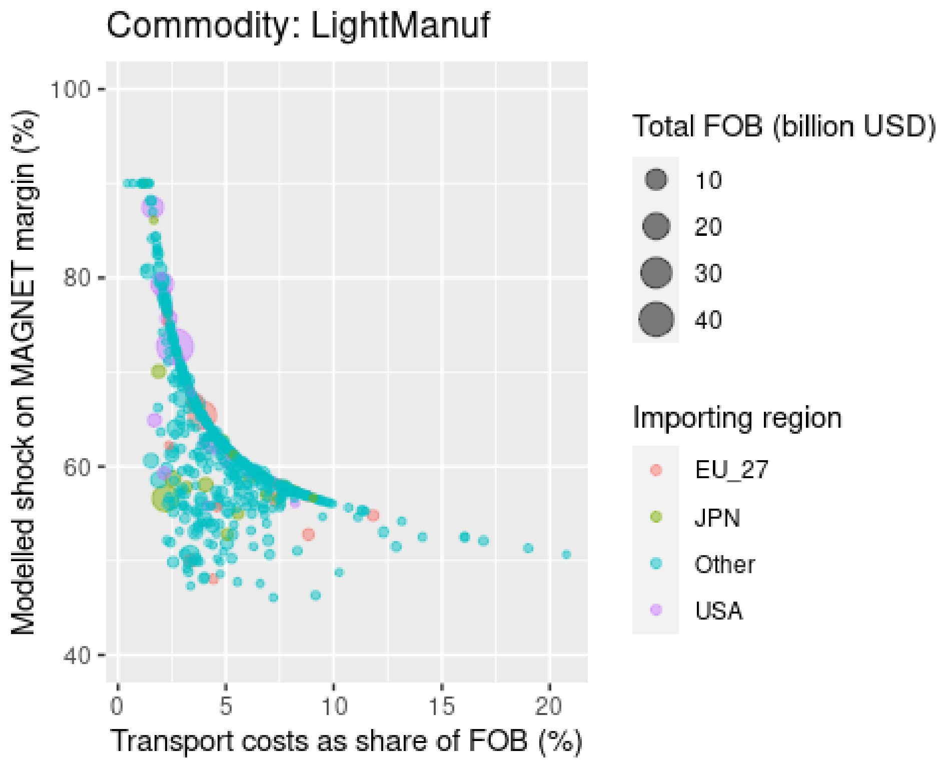
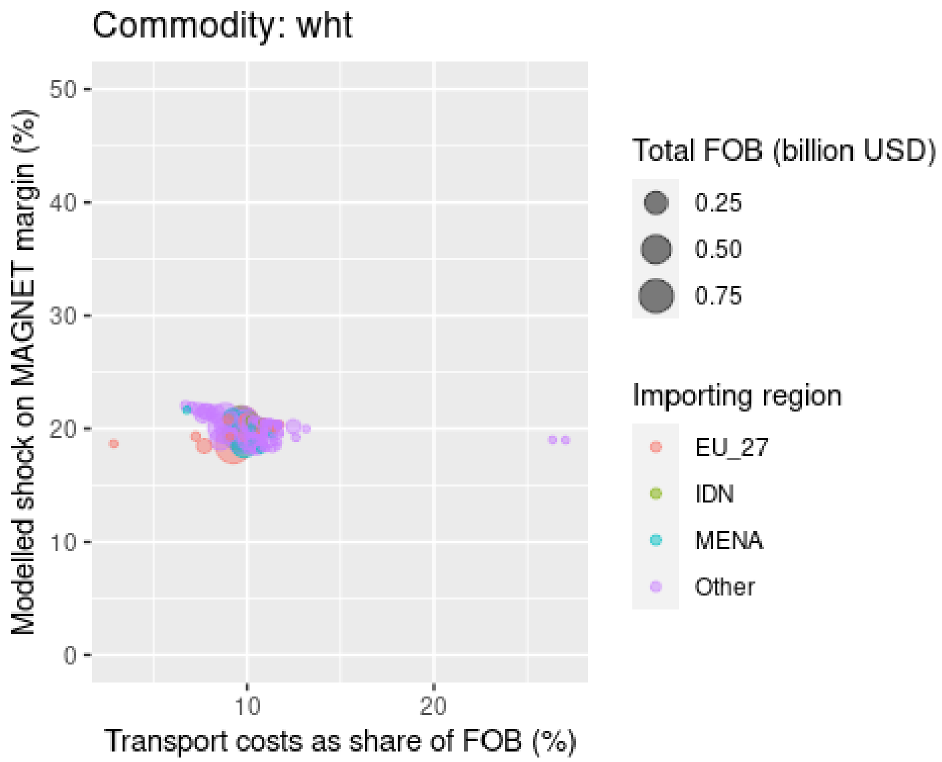


Figure 6: Correlation of increase in MAGNET margin and transport costs as share of FOB price, by origin-destination combination, wheat

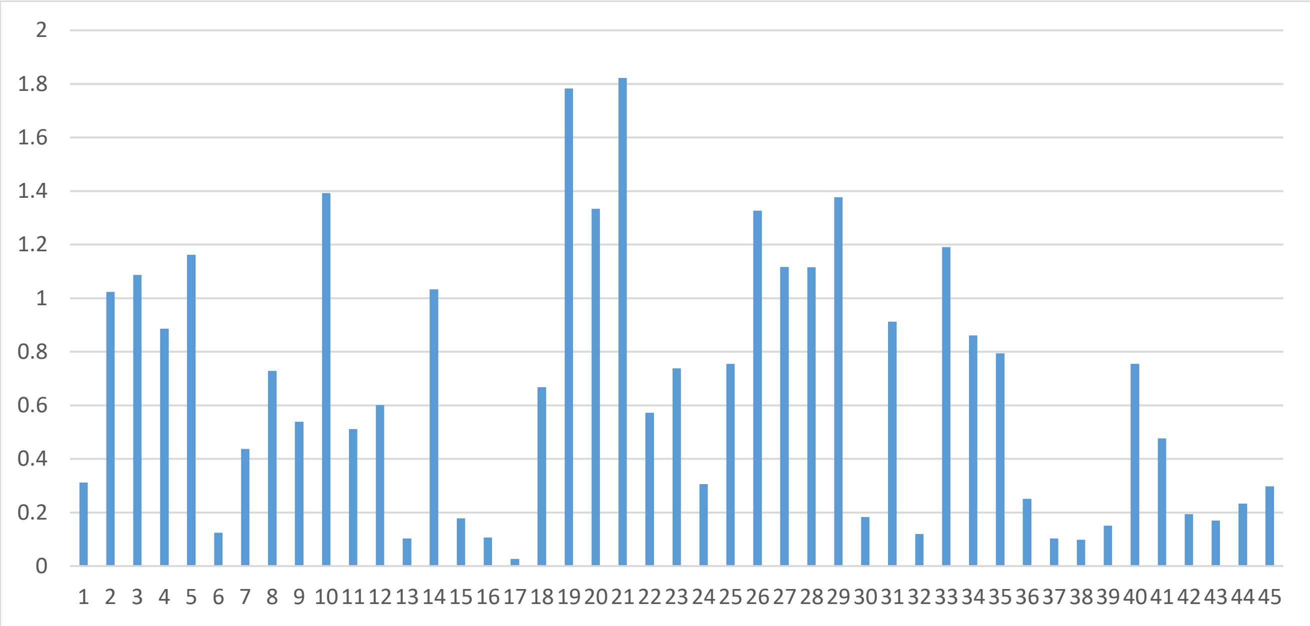


Preliminary simulation results

Global Trade impacts

The percentage change of the price index of imports, calculated as a weighted average of CIF prices imports of each commodities in all regions, show a generalised increase of prices (Figure 7). Global CIF prices shows a linear relationship with the shock applied to the model. Products whose transport margins increased the most are showing the highest CIF prices increase, among them: wool, dairy, other food. The other key variable behind the highest increase of price is the initial share of maritime transport costs. This explains the high impact on commodities such us processed rice, oils&meals.

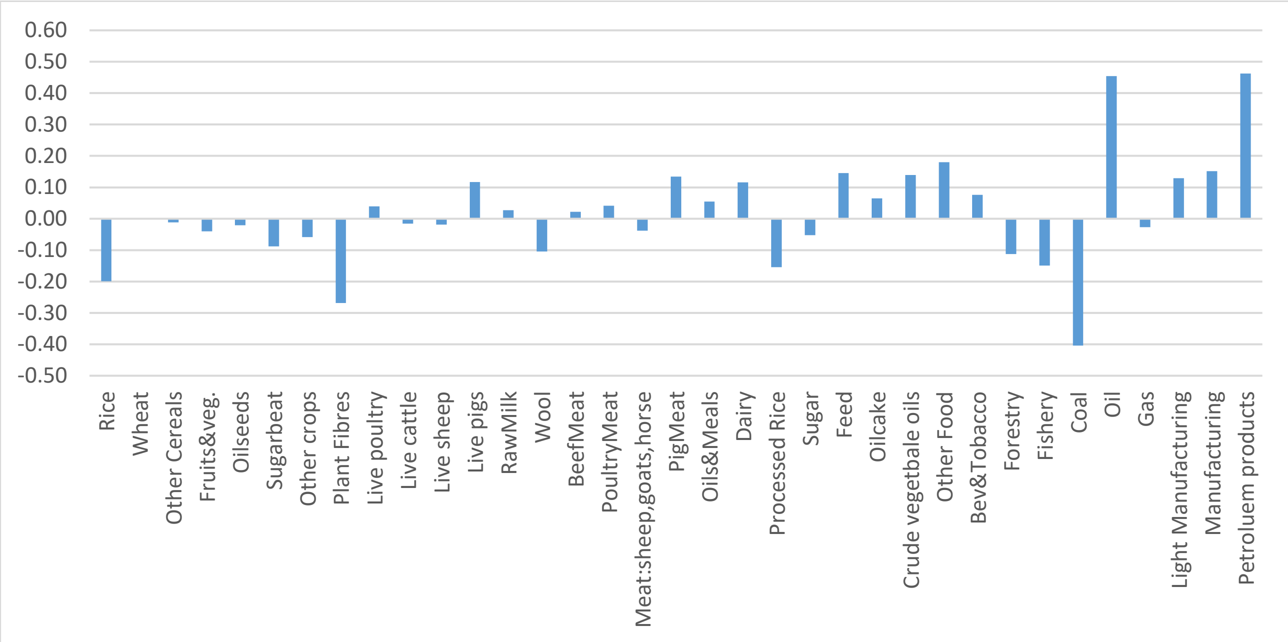
Figure 7: Change in CIF price index of imports of commodity (% change)



Source: authors' calculations based on MAGNET results.

The world price index, calculated using the FOB prices for each good supply, shows how the water transportation shock has mixed impacts on FOB index prices (Figure 8). In some cases the CIF and FOB prices move in parallel, as it the case for dairy products, other food, pig meat. In other cases as the example of wool whose margins is the one increasing the most, the effects on FOB prices have an opposite sign. The demand of imports of wool products due to the increased margins fall (global imports fall by more than 2%) and due to the specific sector elasticities and market structure, particularly where most of the domestic production is export-oriented, their FOB price need to fall to reach an equilibrium.

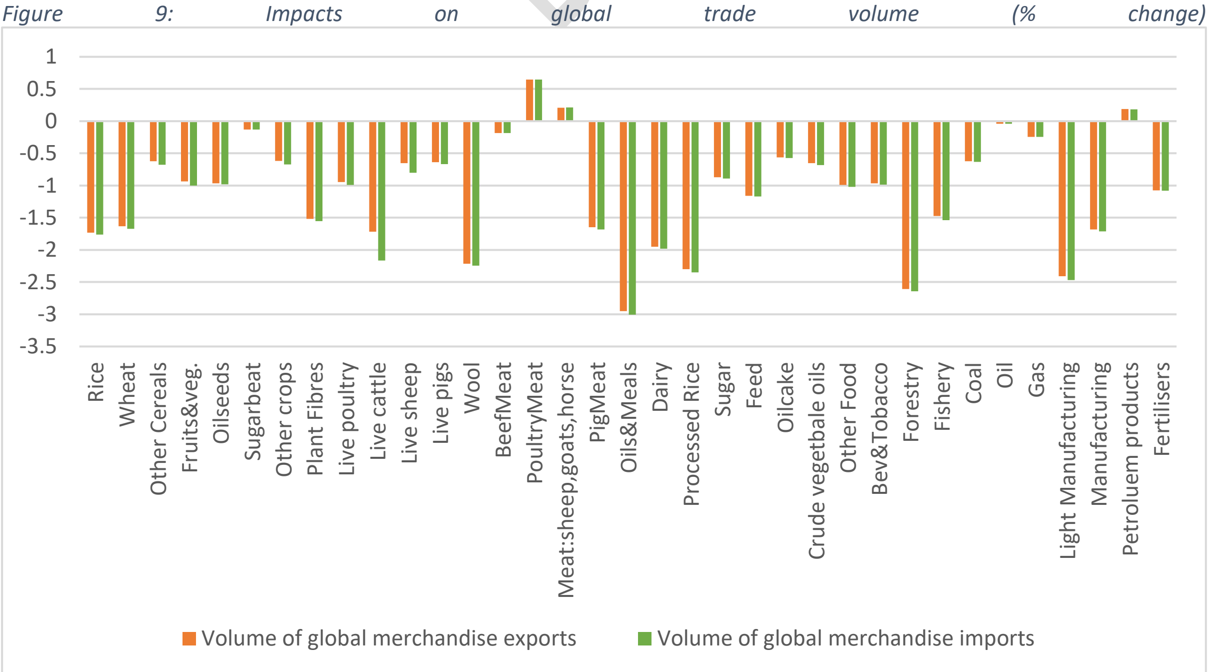
Figure 8: Impacts of global prices (% change)



Source: authors' calculations based on MAGNET results.

The volume of world trade would decrease by 0.42%, while the value of world trade would decrease by 0.23%. Looking at the volume of trade by commodities, excluding a few exceptions (poultry and other meat, petroleum products), results show a decrease of both imports and export globally (Figure 9). Commodities whose CIF prices increase the most also see a lowest reduction of trade volumes.

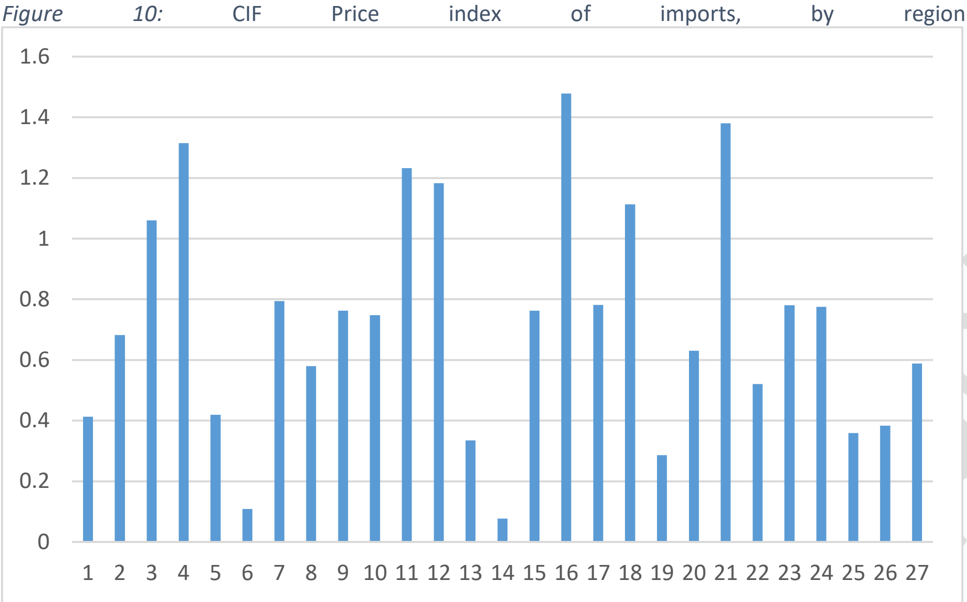
Figure 9: Impacts on global trade volume (% change)



Source: authors' calculations based on MAGNET results.

The CIF price index per country (Figure 10) reflects the impact of the shocks on analysed countries and regions and is largely driven by the increase in the margins for manufactured and light manufacture goods, which are the products with the highest margin increase and highly trade products.

Figure 10: CIF Price index of imports, by region (% change)

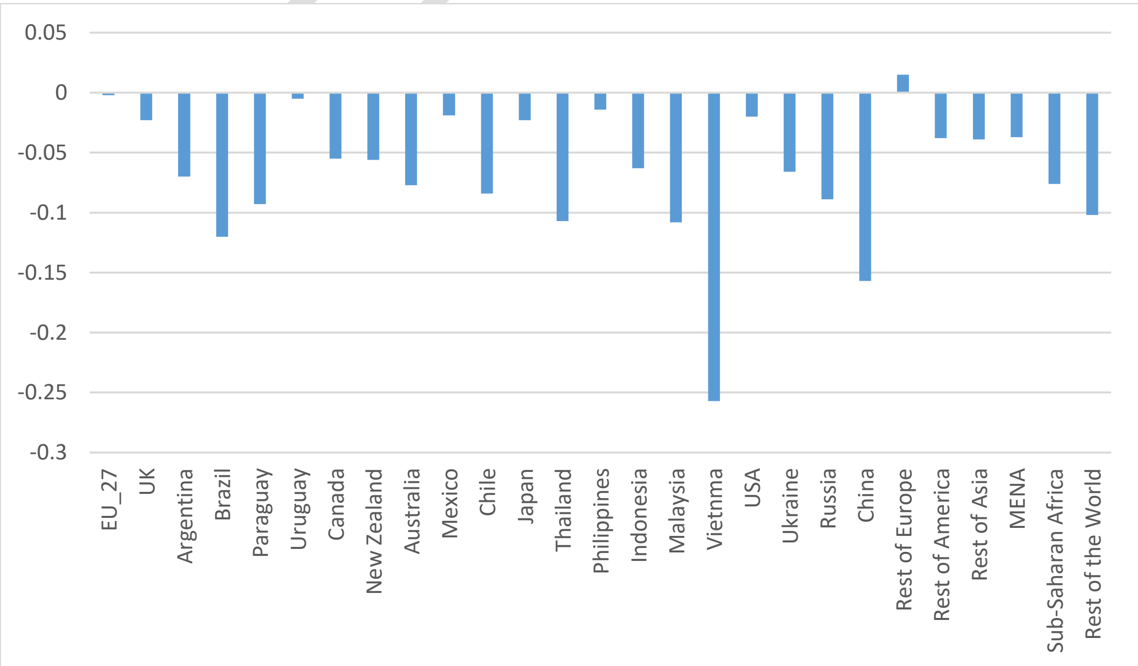


Source: authors' calculations based on MAGNET results.

Macroeconomic Impacts

The increase of transportation cost is detrimental to the gross domestic product (GDP) of all selected countries (Figure 11).

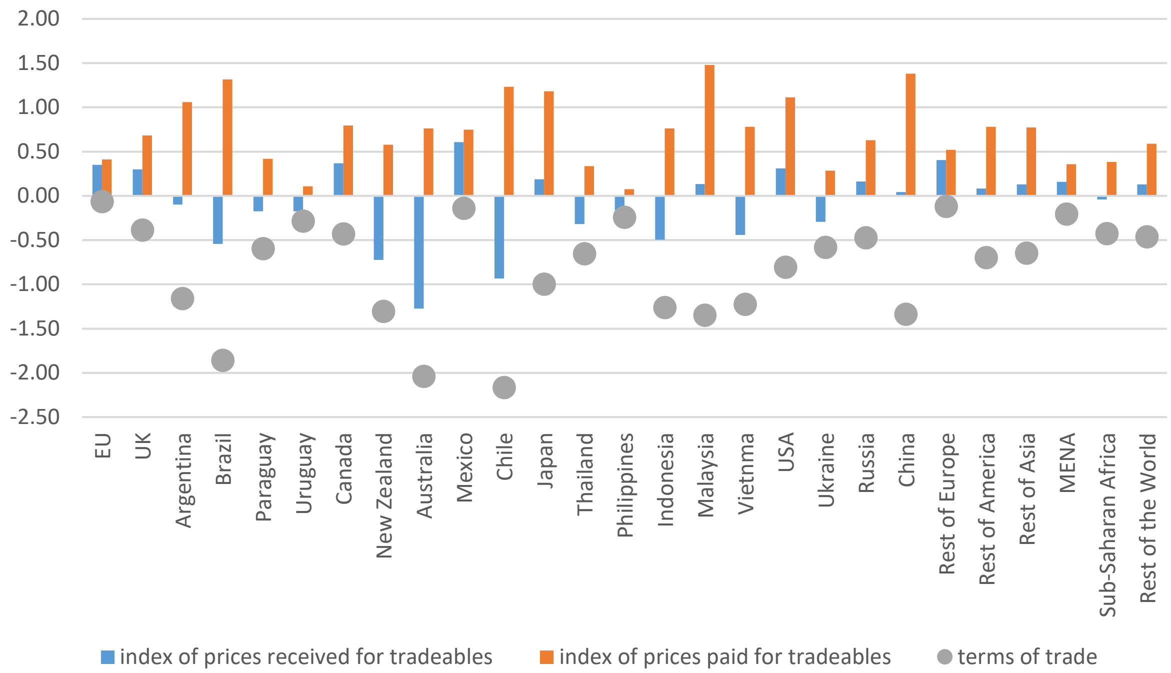
Figure 11: Impacts on real GDP (% change)



Source: authors' calculations based on MAGNET results.

The movement of the countries terms of reference, i.e., the difference between the index of prices received for tradables and the index of prices paid for tradables (Figure 12) largely explains the impact on the GDP. The rise of the imports bill is all cases superior to the rise in the index of price received for exports (which in some cases is already negative) causing a generalised fall in the terms of trade.

Figure 12: Terms of trade



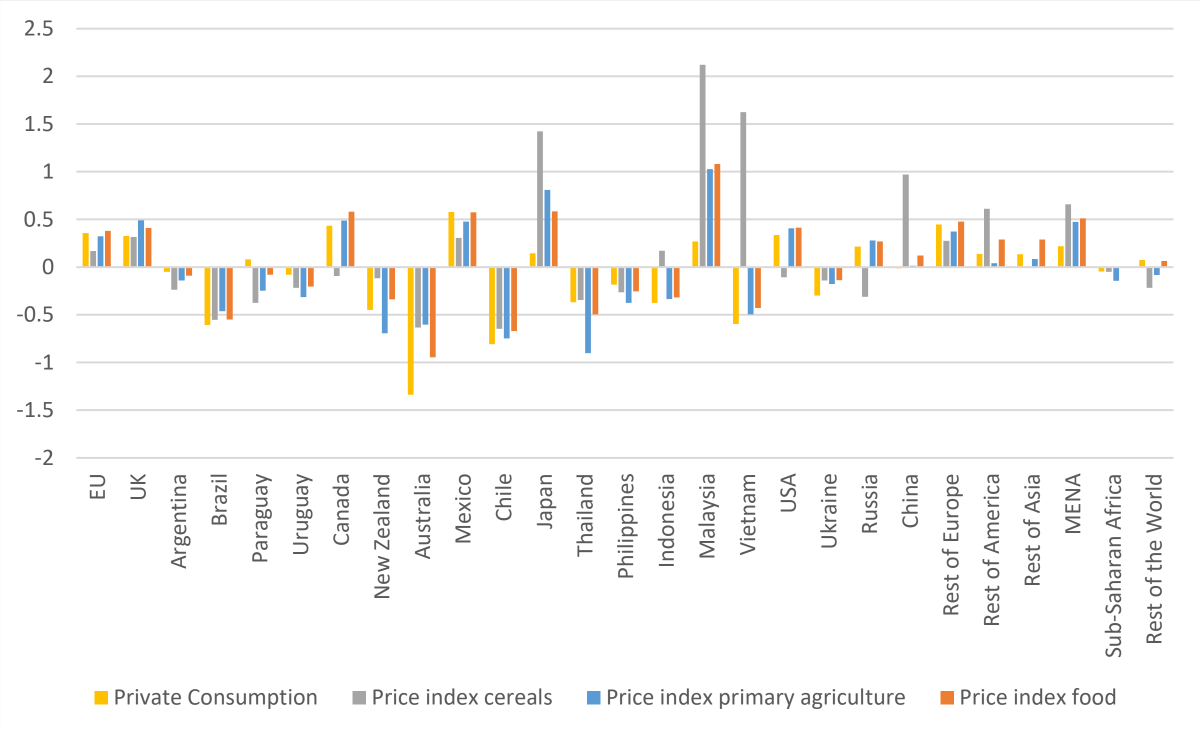
Source: authors' calculations based on MAGNET results.

To evaluate the effects of the shock on the price change in the selected countries, we present percentage change of the overall price index, cereals, primary agriculture and food commodities (including meat, dairy and processed food) (Figure 13).

Countries that are large importers of agri-food commodities, (e.g., Japan) see their agri-food related price indices increase. The cereal price index increases by around 1.5% in Japan while the manufactured food price index by around 0.5%. In agri-food exporters countries (e.g., Mercosur countries), the agri-food related price indices drop as their exports diminish and the increase availability of commodities for domestic consumption depress domestic prices.

The impact on the overall price index is limited including cases (Brazil, Australia and New Zealand) where the index shows relevant drop.

Figure 13: Price index for private consumption expenditure, cereals, primary agriculture and processed food (% change)

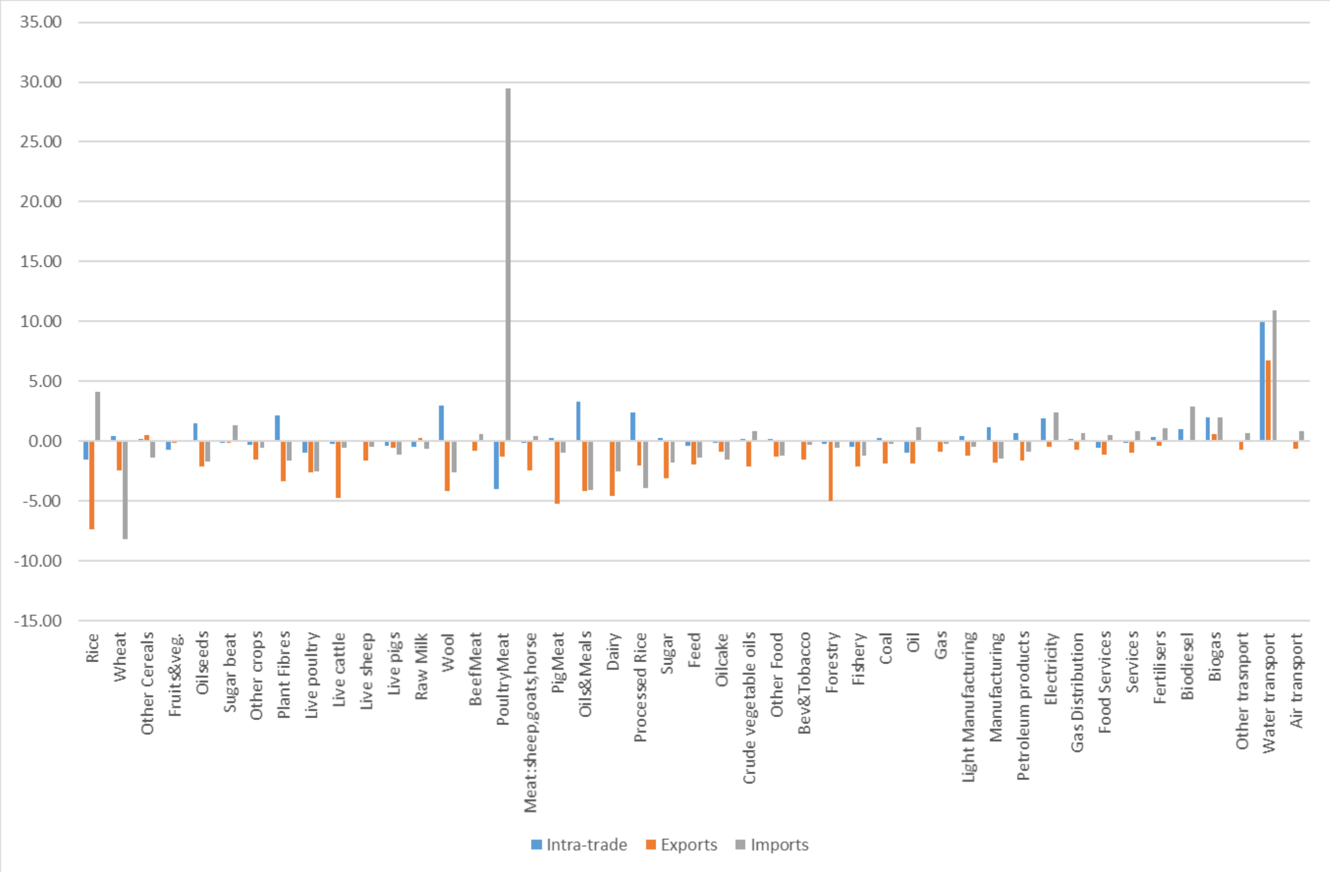


Source: authors' calculations based on MAGNET results.

EU Trade impacts

Focusing on the specific case of the European Union (EU) (Figure 14), results show how the EU imports and export are negatively affected for most of the commodities. On the other hand, the intra-trade is able to compensate for some of loss imports coming from extra-EU countries.

Figure 14: EU intra-trade, imports and exports vs the rest of the world (% change)



Source: authors' calculations based on MAGNET results.

Production

The results on production show how countries and region would react to the increase of shipping cost according to their net trade position (Table 1). Regions which are net importer would try to substitute missing imports increasing domestic production while, on the opposite, net exporters will react to missing export possibilities due to increase in costs reducing domestic production.

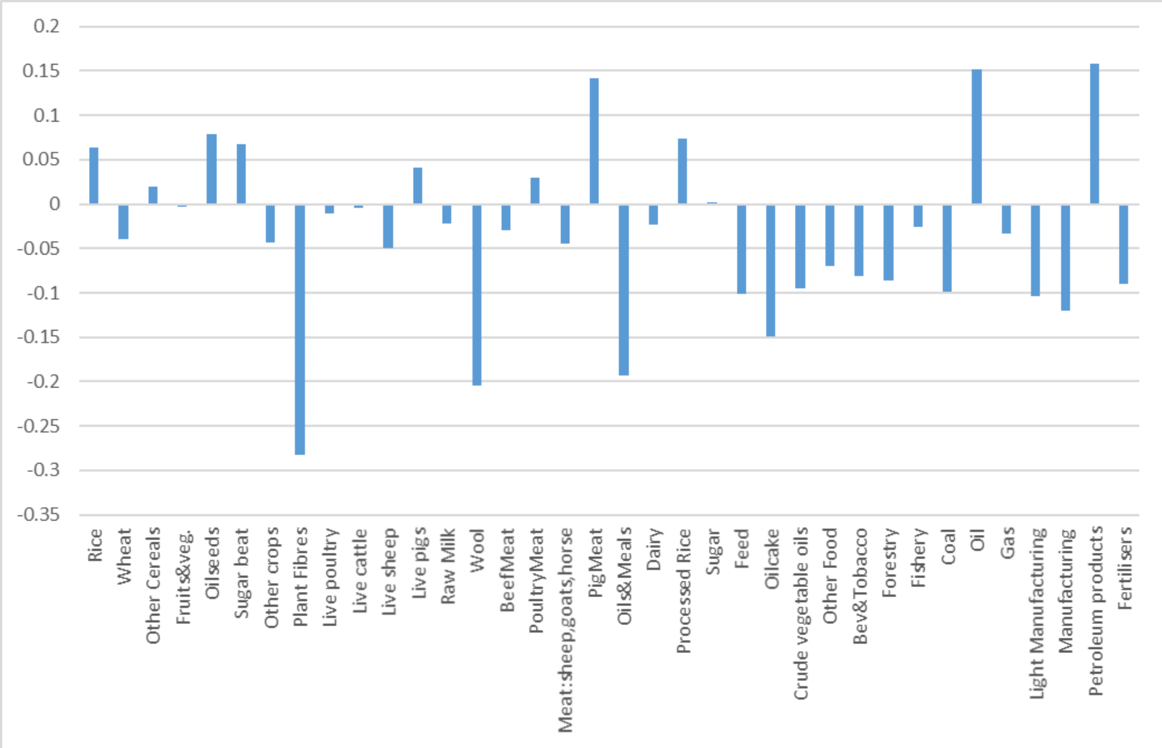
Table 1: Change in domestic production by region and activity (% change)

	EU	UK	Mercosur	Canada	New Zealand	Australia	Japan	USA	Russia	China	Rest of Europe	Rest of America	Rest of Asia	MENA	SSA	RoW
Rice	0.57	-0.03	0.16	0.58	1.09	1.17	0.35	-0.52	0.05	0.07	-0.24	0.20	-0.08	0.55	0.46	0.71
Wheat	-0.50	0.23	1.21	-2.10	2.41	-0.59	1.41	-1.73	-0.79	0.31	-0.14	0.19	-0.21	0.95	2.26	-0.56
Other Cereals	0.01	-0.17	-0.59	0.00	0.74	1.46	0.97	-0.32	0.45	0.13	0.06	0.15	0.11	0.40	0.00	0.17
Fruits&veg.	-0.18	-0.23	0.07	0.86	-0.04	0.51	0.43	0.44	0.45	0.02	0.05	-0.22	-0.04	-0.17	-0.08	0.04
Oilseeds	0.42	0.31	-0.55	-1.38	0.60	-0.22	1.65	-1.09	-0.97	0.57	0.18	0.52	0.61	0.57	0.14	0.99
Sugar beat	-0.20	-0.10	0.11	0.21	0.78	1.10	0.46	-0.67	0.10	0.26	-0.18	-0.32	0.07	-0.17	0.10	0.35
Other crops	-0.29	-0.19	0.65	0.82	1.51	0.07	0.51	0.06	0.12	-0.06	-0.16	-0.27	0.09	-0.17	-0.24	0.11
Plant Fibres	-1.11	-0.47	-0.28	0.11	0.33	0.66	-1.20	-0.95	-0.78	-0.08	-0.44	-0.05	-0.36	0.08	-0.77	-0.18
Live poultry	-0.81	-0.49	1.65	-0.47	0.58	0.88	0.39	-0.40	0.02	0.08	0.07	0.08	0.01	-0.25	0.24	0.05
Live cattle	-0.25	-0.46	0.18	-0.35	-0.20	1.11	0.39	-0.27	0.10	0.17	-0.17	-0.17	0.07	0.82	0.10	0.02
Live sheep	-0.47	-0.75	0.14	-0.75	0.93	2.39	-0.25	-0.35	0.02	-0.05	-0.42	-0.09	-0.05	-0.15	-0.07	0.00
Live pigs	-0.48	-1.25	0.85	-1.55	0.84	0.52	1.22	-1.53	0.06	0.38	-0.03	0.42	0.33	0.39	0.34	0.19
Raw Milk	-0.40	-0.36	0.03	0.23	-1.40	0.56	0.10	-0.08	0.02	0.60	-0.07	0.25	0.02	0.27	0.42	0.13
Wool	0.50	-2.14	-1.15	2.53	-0.46	-0.55	-1.16	0.12	-0.52	-0.20	0.41	-0.99	0.22	0.08	-1.81	-0.27
Beef Meat	-0.06	0.01	0.29	-0.35	1.31	2.42	0.25	-0.23	0.01	-0.11	-0.21	-0.05	-0.15	-0.40	-0.09	0.04
Poultry Meat	-1.39	-0.54	3.24	0.11	0.01	0.81	0.13	-0.04	-0.07	-0.31	-0.03	0.05	0.26	-0.95	0.05	0.57
Meat:sheep,goats,horse	-0.16	-1.62	0.23	-0.93	0.91	3.18	-0.22	-0.34	-0.04	-0.23	-0.53	-0.12	-0.39	-0.72	-0.03	-0.40
Pig Meat	-0.62	-2.70	1.95	-4.30	2.82	6.73	1.91	-2.47	0.74	0.95	0.09	0.83	1.14	1.14	1.29	1.72
Oils&Meals	0.15	-0.24	-2.16	-3.21	-13.45	-0.82	0.87	-3.65	-3.90	0.22	-7.83	1.46	0.43	1.61	2.14	4.85
Dairy	-0.60	-0.83	0.03	0.23	-1.57	0.67	0.35	-0.13	0.17	0.80	-0.13	0.28	0.26	0.34	0.85	0.16
Processed Rice	1.35	1.00	0.17	0.65	6.65	1.55	0.35	-1.05	0.95	0.08	1.13	0.22	-0.20	1.41	2.78	2.12
Sugar	-0.21	-0.17	0.08	0.17	0.98	1.36	0.53	-0.71	0.06	0.39	0.14	-0.43	0.10	-0.31	0.19	1.74

Feed	-0.92	-0.94	0.33	-1.21	-0.84	2.15	0.86	-0.97	-0.16	0.43	-0.63	0.26	0.10	0.17	0.37	0.19
Oilcake	-0.55	-0.60	-0.32	-1.20	-0.76	0.98	0.92	-0.84	-3.53	0.08	-0.93	0.39	0.55	-0.78	2.05	2.99
Crude vegetable oils	-0.16	-0.15	-0.13	0.66	-0.48	0.34	0.13	0.04	0.06	0.00	-0.37	-0.07	-0.18	-0.08	-0.01	0.00
Other Food	-0.35	-0.27	0.07	0.34	0.04	0.58	0.17	-0.02	0.12	0.04	-0.71	0.01	-0.17	0.01	-0.11	-0.15
Bev&Tobacco	-0.16	-0.10	0.36	-0.28	-1.88	0.27	1.18	-0.14	-0.29	0.38	-0.15	-0.24	-0.10	0.04	-0.64	0.73
Forestry	-0.13	-0.97	0.12	0.35	-0.35	0.57	0.25	0.16	0.20	0.05	-1.09	0.03	-0.09	-0.02	-0.03	0.55
Fishery	-0.03	0.13	0.36	-0.77	-0.16	0.26	-0.03	-0.41	-0.35	0.03	-0.21	0.21	-0.22	0.18	-0.40	-0.34
Coal	0.26	0.21	0.22	0.15	0.31	0.69	0.29	0.12	0.17	0.26	1.02	0.12	0.33	0.09	0.21	0.21
Oil	-0.09	-0.16	0.17	-0.06	0.08	0.54	0.04	-0.04	-0.05	0.02	-0.34	0.00	0.13	-0.05	0.05	0.00
Gas	-0.04	0.04	0.77	0.63	-1.57	1.34	0.85	0.67	-0.39	-0.54	-0.93	0.52	-0.56	-0.19	-0.06	-1.27
Light Manufacturing	-0.27	-0.32	0.07	0.42	0.51	-0.59	-0.45	0.24	-0.10	-0.01	-0.19	0.03	-0.29	-0.46	-0.26	-0.34
Manufacturing	0.66	0.40	0.03	0.43	0.31	0.40	0.44	-0.10	0.29	-0.02	1.27	0.38	-0.33	0.78	0.37	0.31
Petroleum products	-0.09	-0.03	-0.02	0.06	-0.07	-0.14	-0.11	0.04	-0.06	-0.16	-0.23	-0.07	-0.29	-0.21	-0.11	-0.11
Electricity	-0.38	-0.06	-0.14	0.08	-0.34	0.43	-0.12	-0.10	-0.05	-0.40	-0.65	0.06	-0.18	-0.10	0.43	0.15
Gas Distribution	-0.09	-0.08	-0.13	-0.06	-0.03	0.04	-0.09	-0.04	-0.11	-0.15	-0.22	-0.13	-0.20	-0.11	-0.12	-0.20
Food Services	0.00	-0.03	-0.14	-0.18	-0.07	-0.03	-0.12	-0.09	-0.08	-0.11	-0.05	-0.06	0.02	0.01	-0.02	-0.05
Services	-1.16	0.12	0.06	-0.96	1.43	2.07	0.56	-0.74	-0.27	0.11	-1.51	-0.24	0.32	-0.80	0.47	-0.30
Fertilisers	0.51	0.45	2.08	1.62	-0.08	1.08	-0.76	0.94	1.42	0.31	0.90	0.17	-0.15	-0.16	0.24	0.19
Biodiesel	0.13	-0.29	0.42	0.42	0.79	1.25	0.05	-0.04	0.41	0.27	0.33	0.43	0.18	0.28	0.41	0.36
Biogas	-0.16	0.03	-0.06	-0.03	0.21	0.21	-0.09	-0.08	-0.11	-0.09	0.13	-0.10	0.12	-0.12	-0.08	-0.11
Other transport	19.30	18.44	6.72	12.15	14.80	3.75	25.20	4.29	4.78	11.73	18.23	8.31	16.75	15.56	5.03	12.24
Water transport	-0.80	-0.31	0.14	-0.30	0.42	1.97	-0.29	-0.28	-0.14	-0.11	-0.48	-0.15	-0.09	-0.11	0.12	-0.21
Air transport	0.45	-0.17	-0.88	-0.37	-0.63	-1.22	-0.55	-0.34	0.02	-0.49	0.25	-0.25	-0.46	0.23	0.07	-0.12

Overall, global production react in a diverse way to the shipping cost increase (Figure 15). The combination of different shock magnitude, substitution possibilities between traded and domestically produced commodities and rigidities in the demand of the different commodities, create a very heterogonous pattern where global production can vary between -0.3%(plant fibres) and 0.15% (oil and petroleum products).

Figure 15: Quantity index of world supply of goods (% change)



Sensitivity analysis

To compare the results of the model, an additional set of simulation is performed applying a uniform increase in the water transport unitary cost equal to 35%.

Conclusions and policy indications

The model is sensitive to the variance of transport costs within each commodity group, and applying specific origin-destination dependent margins (as opposed to a uniform increase of the margin per commodity) appears to improve the realism of the results. The non-uniform increase in transport costs allows demand to shift towards the markets with the lowest resulting CIF price and creates a within-sector substitution effect. For commodities with very elastic demand and for which the transport costs represent a high share of the CIF price, an increase in transport costs may lead to only combinations with lower FOB prices to be traded, resulting in lower volumes at lower prices.

The second order effects on trade across all commodity groups are also considerable. Even commodities that are not directly affected by costs in transport (no change in the margin) present fluctuations in their prices and volumes, reflecting the changing conditions in their input sectors.

Annexes

Table A 1: Commodities included in MAGNET database

Number	GTAP code	Description
1	Paddy rice	Rice, husked and unhusked
2	Wheat	Wheat and meslin
3	Other grains	Maize (corn), barley, rye, oats, other cereals
4	Vegetables and Fruit	Vegetables, fruits, nuts, potatoes, cassava, truffles,
5	Oilseeds	Oil seeds and oleaginous fruit; soy beans, copra
6	Cane and beet:	Sugar cane and sugar beet
7	Fibres crops	Fibres crops
8	Wool	Wool, silk, and other raw animal materials used in textile
9	Other Crops	Live plants; cut flowers and flower buds; flower seeds and fruit seeds; vegetable seeds, beverage and spice crops, unmanufactured tobacco, cereal straw and husks, unprepared, whether or not chopped, ground, pressed or in the form of pellets; swedes, mangolds, fodder roots, hay, lucerne (alfalfa), clover, sainfoin, forage kale, lupines, vetches and similar forage products, whether or not in the form of pellets, plants and parts of plants used primarily in perfumery, in pharmacy, or for insecticidal, fungicidal or similar purposes, sugar beet seed and seeds of forage plants, other raw vegetable materials
10	Cattle	Cattle
11	Sheep: Approximation for sheep live animals	Sheep, goats, horses, asses, mules, and hinnies; and semen thereof
12	Poultry live animals	Poultry
13	Other Animal Products: approximation for pig live animals	Swine and other live animals; eggs, in shell (fresh or cooked), natural honey, snails (fresh or preserved) except sea snails; frogs' legs, edible products of animal origin n.e.c., hides, skins and furskins, raw , insect waxes and spermaceti, whether or not refined or coloured
14	Raw milk	Raw milk
15	Beef	Fresh or chilled meat and edible offal of cattle.
16	Sheep meat: approximation for sheep meat	Fresh or chilled meat and edible offal of sheep, goats, horses, asses, mules, and hinnies. raw fats or grease from any animal or bird.
17	Poultry meat: approximation for poultry	Preserves and preparations of meat, meat offal or blood, flours, meals and pellets of meat or inedible meat offal; greaves
18	Pork	Pig meat and offal.
19	Oils and measl	Crude and refined oils of soya-bean, maize (corn),olive, sesame, ground-nut, olive, sunflower-seed, safflower, cotton-seed, rape, colza and canola, mustard, coconut palm, palm kernel, castor, tung jojoba, babassu and linseed, perhaps partly or wholly hydrogenated, inter-esterified, re-esterified or elaidinised. Also margarine and similar preparations, animal or vegetable waxes, fats and oils and their fractions, cotton linters, oil-cake and other solid residues resulting from the extraction of vegetable fats or oils; flours and meals of oil seeds or oleaginous fruits, except those of mustard; degras and other residues resulting from the treatment of fatty substances or animal or vegetable waxes.
20	Dairy	Milk: dairy products
21	Rice	Rice, semi- or wholly milled
22	Sugar	Sugar
23	Other Food	Prepared and preserved vegetables, pulses and potatoes; prepared and preserved fruits and nuts; wheat and meslin flour; other cereal flours; groats, meal and pellets of wheat and other cereals; other cereal grain products (including corn flakes); other vegetable flours and meals; mixes and doughs for the preparation of bakers' wares; starches and starch products; sugars and sugar syrups n.e.c.; preparations used in animal feeding; lucerne (alfalfa) meal and pellets; bakery products; cocoa, chocolate and sugar confectionery; macaroni, noodles, couscous and similar farinaceous products; food products n.e.c.
24	Beverages and tobacco	Beverages and tobacco products

Table A 2: Countries and regions included in MAGNET database

Number	GTAP code	Name	Description
1	EU	EU	Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, the Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden
2	AUS	Australia	Australia
3	CAN	Canada	Canada
4	IDN	Indonesia	Indonesia
5	JPN	Japan	Japan
6	MERC	Mercosur	Argentina, Brazil, Paraguay, Uruguay
7	MEX	Mexico	Mexico
8	NZL	New Zealand	New Zealand
9	PHL	Philippines	Philippines
10	THA	Thailand	Thailand
11	CHL	Chile	Chile
12	MYS	Malaysia	Malaysia
13	VNM	Vietnam	Vietnam
14	USA	United States of America	United States
15	RUS	Russia Federation	Russia Federation
16	CHN	China	China
17	UKR	Ukraine	
18	GBR	United Kingdom	
19	RoE	Rest of Europe	Switzerland, Norway, rest of the European Free Trade Association, Albania, Belarus, rest of eastern Europe, rest of Europe
20	RoAm	Rest of Americas	Rest of North America, Bolivia, Colombia, Ecuador, Venezuela, Peru, rest of South America, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, El Salvador, rest of Central America, Dominican Republic, Jamaica, Puerto Rico, Trinidad and Tobago, Caribbean
21	RoAs	Rest of Asia	Hong Kong, South Korea, Mongolia, Taiwan, rest of East Asia, Brunei, Cambodia, Laos, Singapore, Rest of South-East Asia, Bangladesh, India, Nepal, Pakistan, Sri Lanka, rest of South Asia
22	MENA	Middle East and North Africa	Bahrain, Iran, Israel, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, Turkey, United Arab Emirates, rest of western Asia, Egypt, Morocco, Tunisia, rest of North Africa
23	SSA	Sub-Saharan Africa	Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Guinea, Nigeria, Senegal, Togo, rest of western Africa, rest of Central Africa, rest of South Central Africa, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Tanzania, Uganda, Zambia, Zimbabwe, rest of eastern Africa, Botswana, Namibia, South Africa, rest of South African Customs Union
24	RoW	Rest of the world	Rest of Oceania, Kazakhstan, Kyrgyzstan, Tajikistan, rest of former Soviet Union, Armenia, Azerbaijan, Georgia, rest of the world

*Table A 3: **Summary of regression models by commodity***

commodity	adjusted R^2	p value
b_t	0.955	5.98E-254
bfcmt	0.945	8.34E-68
bfctl	0.999	8.20E-06
biod	0.946	4.99E-20
biog	0.979	2.09E-80
c_b	0.994	6.08E-09
cmt	0.943	7.16E-25
coa	0.921	7.72E-70
ctl	0.976	2.51E-67
cvol	0.983	1.64E-233
ely	0.999	0.00065956
feed	0.930	2.31E-157
fert	0.877	4.58E-122
fish	0.979	3.43E-295
for	0.916	1.93E-116
gas	0.997	1.03E-54
gro	0.962	1.15E-146
hort	0.880	1.52E-158
LightManuf	0.906	1.40E-187
Manuf	0.842	6.36E-142
mil	0.900	2.37E-106
oap	0.859	5.26E-123
ocrops	0.942	1.86E-223
ofd	0.770	2.66E-115
oil	0.997	7.50E-120
oilcake	0.967	3.02E-118
omt	0.948	3.64E-65
osd	0.909	1.69E-136
pcr	0.975	2.82E-117
pdr	0.999	1.95E-29
petro	0.986	3.72E-283
pfb	0.866	4.65E-66
pltry	0.988	2.07E-18
poum	0.946	6.04E-62
sugar	0.959	1.12E-127
vol	0.934	9.87E-182
wht	0.995	1.03E-109
wol	0.636	2.13E-36

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