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RECOVERY FROM COVID-19 AND RUSSIA'S WAR OF AGGRESSION AGAINST UKRAINE

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Challenges to International Trade and the Global Economy: Recovery from COVID-19 and Russia's War of Aggression Against Ukraine

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Amidst the recovery from the impact of the COVID-19 pandemic, Russia's war of aggression against Ukraine has resulted in new challenges to the global economy and to international trade. This report relies on detailed trade data to assess the impact of these two overlapping shocks on international trade and supply chains. In February 2022, global trade was approaching pre-Covid levels in absolute terms, but with a different product and geographical composition resulting in a continued sense of tension in the trading system. Russia's war of aggression against Ukraine has added a new dimension of challenges as it has led to deliberate radical interruptions of trade linkages between Russia, Ukraine and many industrialised economies, with significant repercussions on prices of key commodities in the energy and agricultural sector.

Keywords: Oil, AMNE, ICIO analysis, General Equilibrium Model

JEL codes: F5, F17, F14, C67, C68, Q48

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

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Executive Summary

Amidst the recovery from the impact of the COVID-19 pandemic, The Russian Federation's (hereafter "Russia") war of aggression against Ukraine resulted in new challenges to international trade and the global economy. This report assesses these recent two big shocks to international trade. While the first part discusses the state of trade recovery before the war, the second is dedicated to the trade and supply chain impacts of the war. The main insights are:

Before Russia's war of aggression against Ukraine

- Global merchandise trade had largely recovered from the COVID-19 pandemic, while industrial production was still lagging behind.
- Trade in goods had recovered, but services trade was slow to catch up.
- Recovery was unequal across products and trade partners and the structure of trade was different compared to trade before the pandemic.
- The shift towards imports from the People's Republic of China (hereafter "China") observed in early stages of the pandemic was becoming less strong towards the end of 2021.
- Maritime transport disruptions were slackening.
- Semiconductors trade continued to grow.
- Commodity prices and energy were high and volatile.

Russia in the global economy

- Russia is a small player in international trade, specializing in exports of some agriculture commodities, energy and minerals, while importing more technologically advanced products.
- In the last two decades, Russia had been re-orienting its trade away from Europe and Central Asia towards East Asia Pacific, particularly as far as its imports are concerned.
- Foreign affiliates established in Russia accounted for 4.8% of gross output in 2016 (worldwide foreign affiliates account for an average of 11% of gross output). OECD countries that have implemented sanctions in the wake of Russia's invasion of Ukraine in 2022 were the main foreign investors in Russia, with companies from the United States, Germany and France most prominent.
- In a few product categories, Russia is a dominant supplier for global markets, such as asbestos, pig iron, uranium, nuclear reactors, sunflower seed and sunflower oil, mineral fertilisers and coal.
- However, there are many cases where Russia holds a dominant position in bilateral trade with specific countries for specific products.
- While countries in the east and north of Europe are among the most exposed to imports from Russia, for a large number of products substitution from other suppliers from within the OECD membership might be possible. In the top 10 most exposed countries with the exception of Türkiye, the joint share of products that can be considered 'somewhat replaceable' or 'replaceable' typically exceeds 55%.
- Products where substitution within the OECD membership may be more problematic are imported from Russia include some specific fuels, most notably natural gas, but also several kinds of metals, including pig iron and numerous steel-related products, as well as aluminium and platinum.

Possible effects of Russia's war of aggression and resulting sanctions

- Departure of foreign-owned firms from Russia is expected to lead to very substantial percentage drops in output in the motor vehicles industry in Russia, followed by publishing, audiovisual and broadcasting activities and chemicals. In absolute terms, however, wholesale & retail trade is the most exposed sector, followed by finance and insurance, and mining.
- According to our modelling results, the short run cost of sharply reducing oil imports by G7 countries and other European countries from Russia are estimated to be high and unevenly distributed across OECD countries with real income losses ranging between 0.4% and 2.9% across European countries. In the short term (when other suppliers do not step up production), the income loss would be three or more times higher than in the medium term (when global oil markets will have adjusted to the drop of supplies from Russia), emphasising the importance of easing the adjustment where possible.
- The cost differences range from 2.9% of household income loss in the short-term to 0.8% in the medium-term for Germany, and from 2.1% to 0.5% for Italy. In relative terms, Russia is impacted the most negatively in medium term. Countries that are most directly depending on Russian oil urgently need to plug short-term shortfalls and find energy alternatives for the most acutely affected countries and industries. Close international co-operation is key to addressing this challenge.
- Reducing bilateral trade with Russia more broadly by 40% on all goods and services is estimated to have a larger negative effect on Russia than an oil embargo. In this case, household real income losses in Russia is roughly double the loss under the oil embargo (-2.6% and -1.2% respectively), suggesting that measures related to energy trade are important, but they are not the only lever that can be used.
- Restrictions on exports of goods and services to Russia adds at least as much economic pressure as oil sanctions. Reducing exports of technologically advanced products throttles the capacity of the Russian economy.

1. Introduction

Throughout the year 2021 global trade was on the path to recovery from the impact of COVID-19. Trade flows had reached or exceeded pre-pandemic levels early in that year, while high demand, rising energy prices and commodity prices as well as localised lockdowns continued to result in some supply chain bottlenecks and added to inflationary pressures.

Amidst the recovery and closing of remaining trade gaps, Russia's war of aggression against Ukraine resulted in new challenges for international trade, particularly in agricultural commodity markets and in energy markets.

The recent two big shocks to international trade are assessed in this report. It builds on similar reports of this kind produced in 2021. While the first part of this report discusses the same set of issues as the earlier reports on the impact of the COVID-19 pandemic, the second part dedicates a separate section to the trade and supply chain impacts of the war. It presents early results relying on four sets of tools: detailed trade data at the product level; OECD Inter-Country Input-Output (ICIO) tables and the associated trade in value added indicators (TiVA); the OECD analytical database on activities of MNEs (AAMNE); and OECD's computable general equilibrium (CGE) model METRO. Country and product groupings and classifications vary somewhat between the different parts of the analysis because different data sources and methodologies are used. However, the different approaches allow for a more comprehensive and complementary assessment.

2. The pre-war state of trade recovery from the pandemic

Global trade has recovered, but industrial production is lagging behind

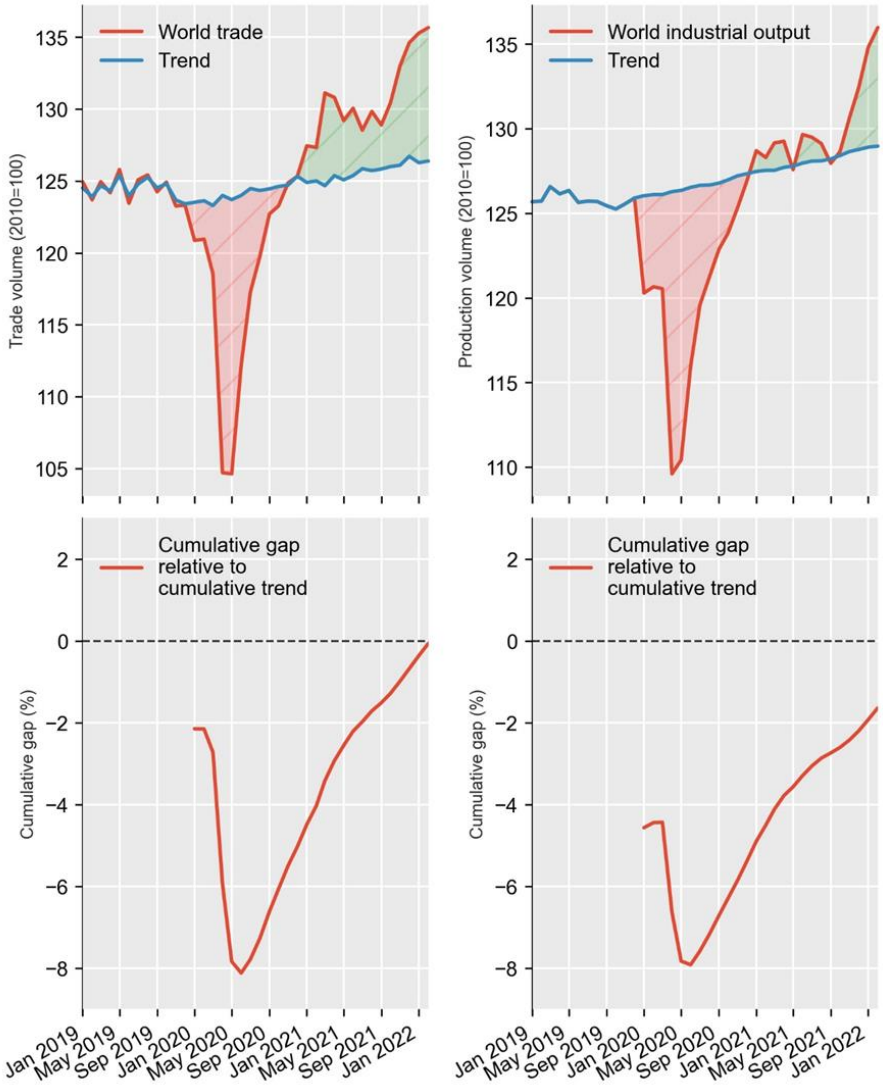
The steep drop of world merchandise trade in early 2020 and the quick recovery resulted in world trade volumes reaching their pre-pandemic levels by the end of 2020. However, the total accumulated loss in volumes relative to trend (Figure 2.1) was only slowly recovered, and this gap[1] closed only by February 2022. In contrast, the gap of world industrial production relative to trend was not closed in early 2022 and lags behind the trade recovery. Throughout 2021 a big part of the world economy was still hampered by lockdowns and disruptions in supply chains that slowed down industrial production more than trade. The only large economy that had closed its production gap by the second quarter of 2021 was China which also showed a consistently high export performance. Trade values, as opposed to volumes, show a sizeable increase in in the first quarter of 2022, mostly driven by high commodity prices (Box 2.1).[2]

[1] The gap measures the accumulated monthly shortfall (the red part of Figure 2.1) and excess (the green part of Figure 2.1) of trade volumes relative to pre-2020 trend. For more detail on the estimations, see Annex A.

[2] For a documentation of trade value outcomes for G20 economies during the first quarter of 2022, see International trade statistics: trends in first quarter 2022 - OECD.

Figure 2.1. The accumulated COVID-19 trade shortfall was recovered by February 2022, but industrial output lags behind

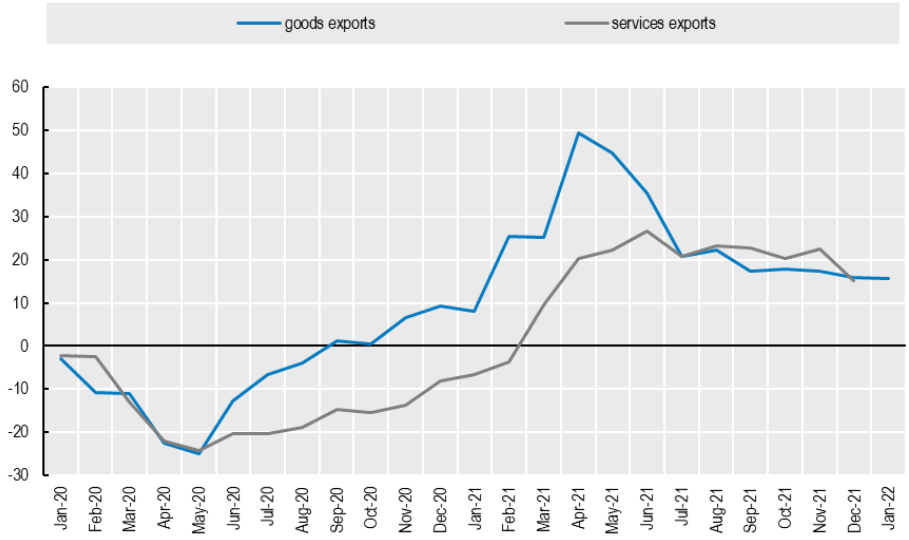
World trade and world industrial output volumes and cumulative gaps (seasonally adjusted)



Note: The trend is estimated with data for 2010-01 to 2019-12 using the Theta method.
Source: CPB World Trade Monitor, OECD calculations.

Figure 2.2. Services trade grew throughout 2021 albeit more slowly than goods trade

Exports of goods and services, total trade of G7 countries and China, Year-on-year growth rates



Source: OECD calculations using WTO data.

Trade in goods has recovered …

Trade in goods has been on a path to recovery to pre-pandemic levels since May 2021, but the road is less bumpy for some products than for others. While Pharmaceutical products and Precious stones display a positive trade gap during most of the last two years, Organic chemicals, Electrical machinery, Plastics, Optical products and Nuclear reactors have recovered the lost ground in the second and third quarter of 2021. These developments reflect a combination of increased volumes of trade as well as rising prices due to increased consumer demand combined with problems in transport and logistics which were impeding supply. In contrast, the large gaps for Mineral fuels and oils and Motor vehicles which appeared in 2020 are still significant, although the gap for mineral fuels has been closing rapidly, also reflecting increases in the prices of fuels that started to emerge towards the end of 2021. For motor vehicles, however, the gap stopped closing from mid-2021.

… while trade in services is slow to catch up

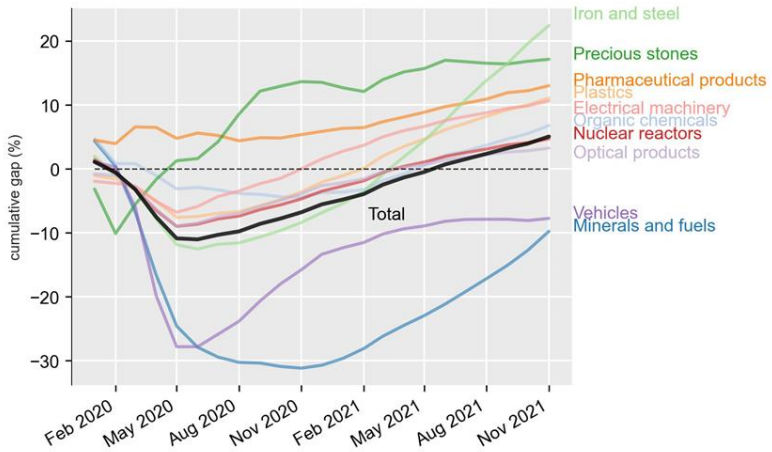
The accumulated services trade gap still showed a negative 17% below pre-pandemic trends at the end of 2021 and a very slow pace of recovery. Services trade that can be delivered digitally, such as Financial- and Insurance services have not been negatively impacted by the pandemic, contrary to services that require personal interaction, such as Travel, Hospitality and some Government services. Government goods and services, other business services, personal, cultural and recreational services as well as Telecommunication services lag to a relatively low extent (less than 5%) behind pre-pandemic level, but three categories still display a steep reduction in trade: Transport (-10%), Maintenance and repair (-22%) and Travel (-60%).

Trade in transport services has not yet fully recovered despite surging freight costs, while travel restrictions continue to have an impact on Travel services (which includes expenditure on accommodation and hospitality, as well as all goods and services acquired by travellers). Trade in Construction and maintenance services that have not yet fully recovered are likely related to backlogs in merchandise trade in raw materials.

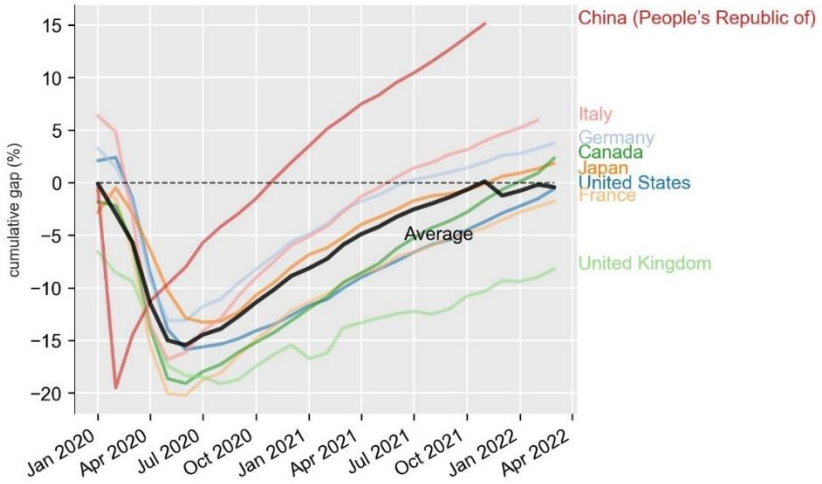
The diverse picture across goods and services translates into differing trade outcomes at the country level. Relative to the pre-2022 trend, China's accumulated merchandise trade gap was at a positive 15% at the end of 2021, followed by positive gaps for Italy, Germany, Canada and Japan. France, the United States and particularly the United Kingdom display negative gaps. All countries show negative gaps in services trade but to different degrees.

Figure 2.3. Accumulated gaps of merchandise trade are closing, but not for services

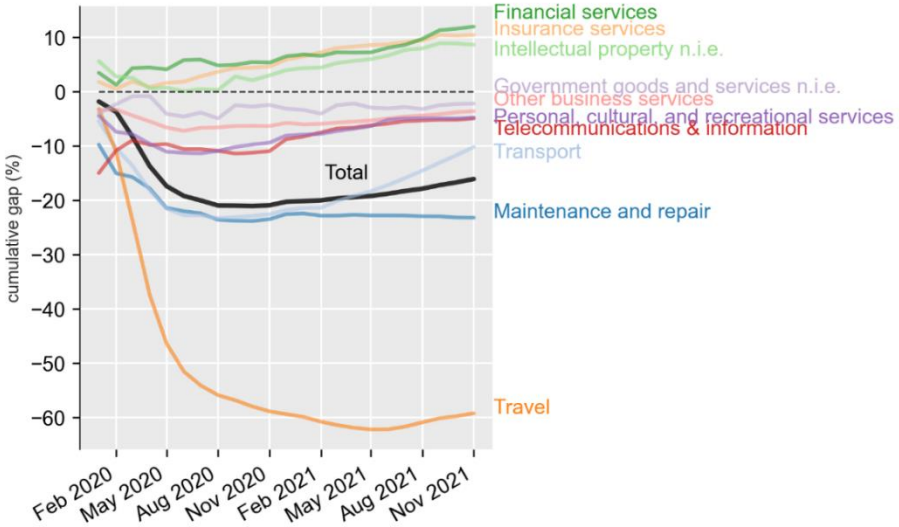
Panel A. Trade gap by product – top 10 traded products trade values, %



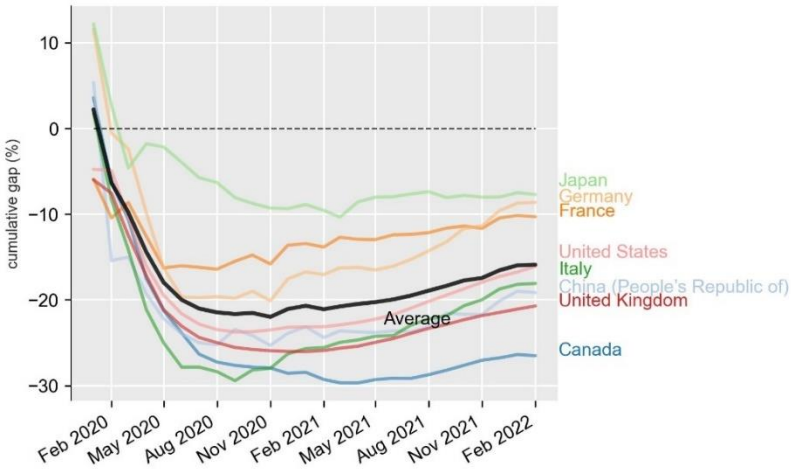
Panel B. Exports gap by country, G7 plus China – export values, %



Panel C. Services gap



Panel D. Services gap by country, G7 plus China



Notes: Panels A and B (Merchandise trade): The gap is calculated as the ratio between cumulated observed imports against cumulated hypothetical imports. Hypothetical imports are estimated using a theta model (with parameter theta equal to 2) with a sample corresponding to the pre-COVID period – from January 2010 to December 2021. Represented products are the top 10 imported products in 2019 based on available data: Argentina, Australia, Austria, Barbados, Belgium, Belize, Bolivia, Brazil, Bulgaria, Canada, Chile, Chinese Taipei, Croatia, Cyprus*, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Guatemala, Hungary, Iceland, Indonesia, Ireland, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Madagascar, Malaysia, Malta, Netherlands, New Zealand, Norway, Paraguay, Poland, Portugal, Romania, Serbia, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Uganda, United Kingdom, United States.
Panels C and D (Services trade): The gap is calculated as the ratio between cumulated observed imports against cumulated hypothetical imports. Hypothetical imports are estimated using a theta model (with parameter theta equal to 2) with a sample corresponding to the pre-COVID period – from January 2015 to December 2021. Represented products are the top 10 imported products in 2019 based on available data: Australia, Bangladesh, Belgium, Brazil, Bulgaria, Canada, China (People's Republic of), Croatia, Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, India, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Malta, Mongolia, North Macedonia, Pakistan, Philippines, Poland, Portugal, Romania, Serbia, Slovak Republic, Slovenia, Sweden, Tanzania, Türkiye, Uganda, Ukraine, United Kingdom, United States.

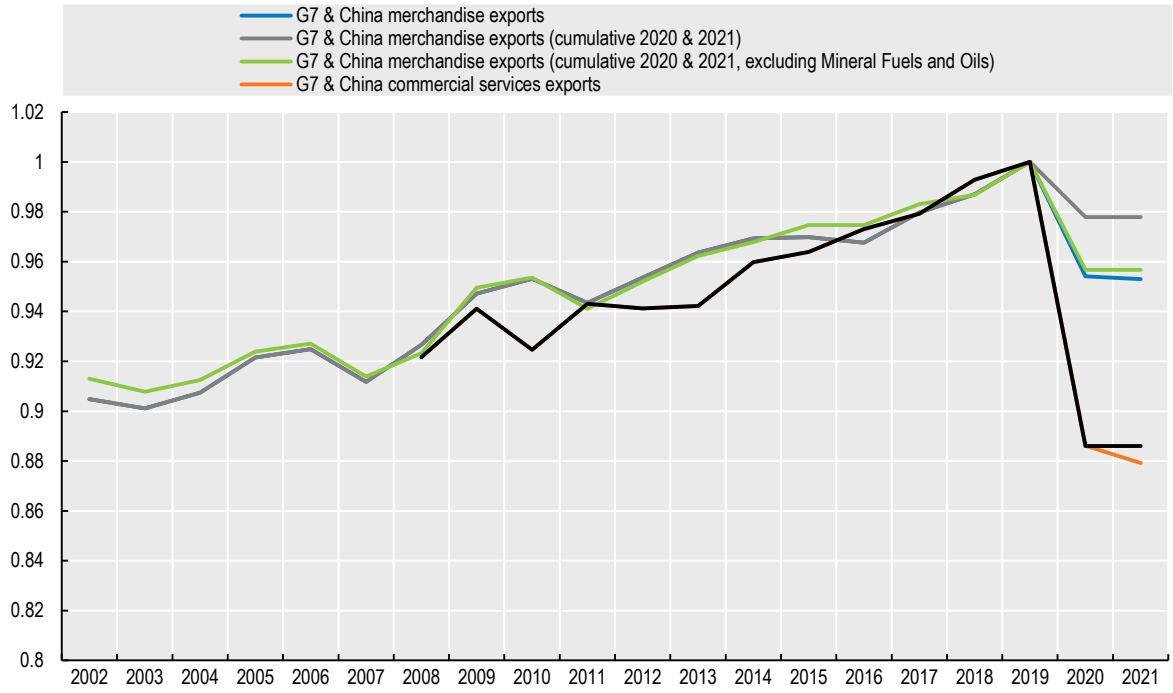
* Note by Türkiye: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Türkiye shall preserve its position concerning the "Cyprus issue".
Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.
Source: OECD calculations based on ITC Trade Map (Panels A and B) and WTO data (Panels C and D).

The structure of trade is different since the pandemic …

With positive growth of trade in the recovery period, all the gaps are expected to eventually close but this does not mean there will be no permanent changes to the structure of trade. More time and data will be needed to see whether there will be such long term changes but the gap data at hand shows for now that only some of the changes observed in 2020 were reversed in 2021 and that in 2021 the composition of trade still differed from that seen in 2019. This can also be seen in the evolution of the Finger-Kreinin export similarity index calculated for trade of the world's eighth largest economies (G7 countries and China) where trade structures in a given year are compared to the structure in the reference year – in this case, 2019. The change in merchandise trade structure caused by the COVID-19 pandemic in a single year was of a similar magnitude to changes otherwise typically seen over a period of five to seven years while changes to the structure of services trade were even larger. While the big and mostly negative changes occurred in 2020, the structure of both goods and services trade in 2021 were even less similar to 2019 (Figure 2.4).

Figure 2.4. The structure of trade of G7 countries and China differs substantially from that in 2019

Finger-Kreinin index of similarity of export structure across products (1 = structure identical to 2019)



Note: This figure shows the Finger-Kreinin for exports of goods and services of G7 countries and China in a given year. The values of the index vary between 0 and 1. A value of 1 means that the group exports different goods (2-digit HS categories for merchandise trade and ten broad commercial services categories) in exactly the same proportions as in the reference period, i.e. product shares are equal (product shares are calculated using trade values). When the indicator is equal to zero this means there are no export products in common in the two periods. A value of 0.5 can be approximately interpreted as representing a 50% overlap in export structures between the two periods. The reference period here is 2019. A value of 1 means that export shares of different HS 2-digit product categories or the 2010 EBOPS services categories in the given period are identical to that 2019 while a value of 0 means that the shares are entirely different from those in 2019. Note that comparable services trade data for the covered economies is only available since 2008 for the following services categories: Goods-related services; Transport; Travel; Construction; Insurance and pension services; Financial services; Charges for the use of intellectual property n.i.e.; Telecommunications, computer, and information services; Other business services; Personal, cultural, and recreational services.
Source: OECD calculations based on ITC Trade Map data for merchandise trade and on WTO Services Trade data for services trade.

To account for the V-shape of the trade collapse in this period as well as for the fact that *Mineral fuels and oils* saw some of the largest declines in 2020 and then recovered rapidly in 2021, two alternative versions of the index were also calculated. The version that treats 2020 and 2021 trade jointly[3] shows that some of the changes of 2020 were indeed reversed in 2021 (hence the smaller decline in the corresponding Finger-Kreinin index), but not so much when *Mineral fuels and oils* are excluded from the share calculation.[4] This suggests that up until the end of 2021 the change in structure of trade cumulated over this period was still quite different from the structure of trade seen immediately before the pandemic. This illustrates that some of the effects of the COVID-19 pandemic are still felt two and a half years after the pandemic started.

[3] This version of the index adds relevant flows of 2020 and 2021 to calculate the trade structure in the whole biennial period of 2020-21 so that those changes that occurred in 2020 and were completely reversed during 2021 would not be picked up.

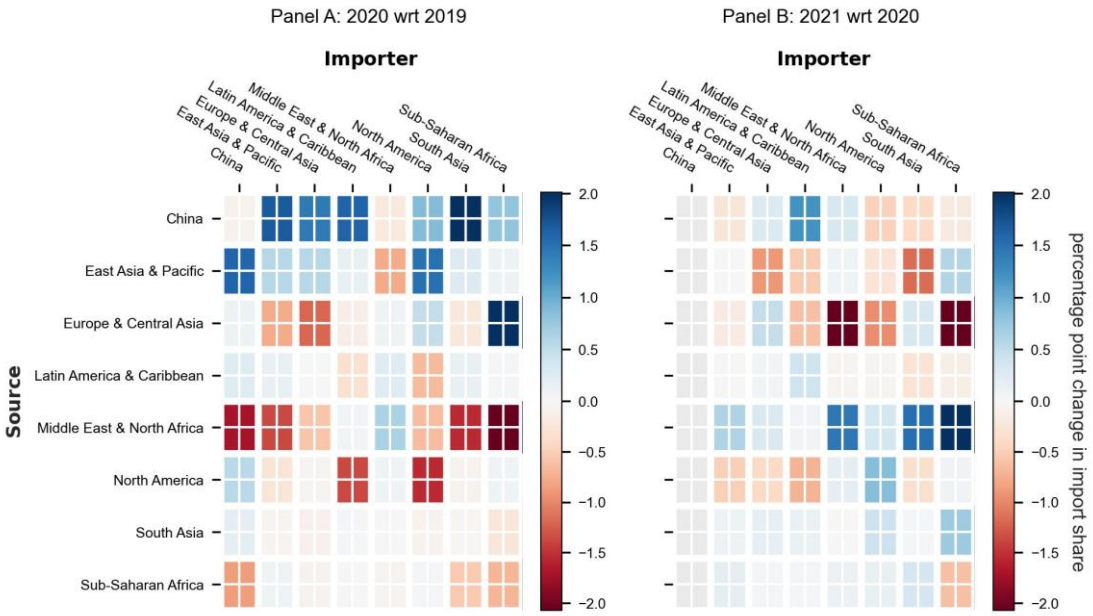
[4] This version excludes from the calculation of shares the HS2 category 27 Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes.

… but the shift towards imports from China is becoming less strong

Because China and countries in East Asia had started to recover earlier than other regions at the end of the first wave of the pandemic, they were the suppliers that could meet the demand that could not at the time be delivered by other suppliers. As a result, imports from the East, particularly China, made up a larger share of 2020 imports into most region relative to the 2019 (Figure 2.5 Panel A). In 2022, while China continues to grow in importance as a source of goods for Europe and Central Asia, Latin America and the Caribbean, and the Middle East and North Africa, the shift towards China is not as strong as it was in the previous year for the remaining regions. Moreover, the shift in import shares between 2020 and 2021 shows a slightly larger share of imports happening within the Asian region (Figure 2.5 Panel B).

Figure 2.5. The structure of trade in 2021 continued the shift towards Asia observed in 2020

Percentage point change in import shares with respect to previous year



Note: Only importers reporting 2019, 2020, and 2021 data included. Exception is China which is missing import information in 2021.
Source: Comtrade bilateral imports.

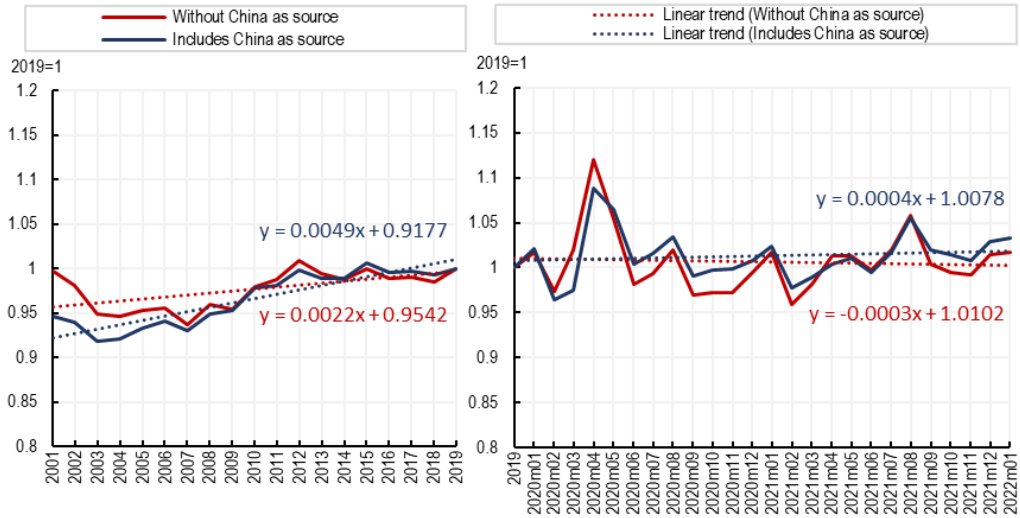
Imported products travelled longer distances – but the growth of distance is plateauing

Continuous competitiveness improvements and outsourcing of production to more distant cost locations have been increasing the trade-weighted distance travelled by imported products. The average distance travelled by imported products in 2020 was higher than in 2019, driven by increased merchandise imports from Asia, and in particular China. The average distance travelled by imported goods continues to be high relative to pre-pandemic levels, but the growth of average distance travelled has slowed (Figure 2.6). Two regions diverge notably from the average: Latin America is importing from more distant places than usual, while East-Asia and Pacific are reducing the distance travelled by imports. In both cases, this reflects an increased orientation of imports towards Asia, as also shown in Figure 2.5.

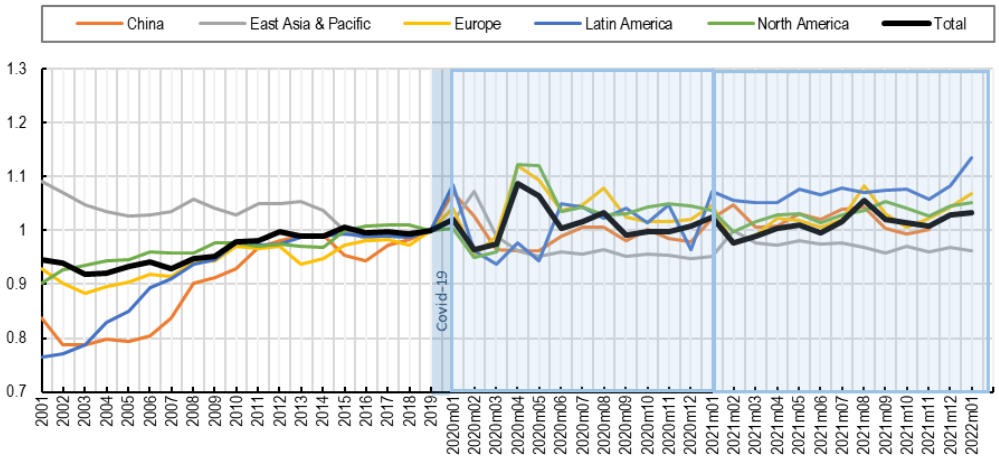
Figure 2.6. The distance of goods imports has increased since the beginning of the pandemic (2019=1)

Trade weighted average distance of imports (2019=1)

Panel A. Total Imports with China excluded and included as source country



Panel B. Average distance of imports by broad destination regions (includes China as source)



Note: import data used for calculations of trade weighted distances covers 55 largest economies for which high-frequency product-level data for trade values was available for the whole 2020. These are: Argentina, Australia, Austria, Belgium, Belize, Bolivia, Brazil, Canada, Chile, China, Chinese Taipei, Colombia, Costa Rica*, Czech Republic, Denmark, El Salvador*, Finland, France, Germany, Guatemala*, Guyana*, Hong Kong (China), Hungary, India*, Indonesia, Ireland, Israel*, Italy, Japan, Kazakhstan*, Korea, Malaysia*, Mexico*, Netherlands, Norway, Paraguay, Peru*, Philippines*, Poland, Portugal, Romania, Russia, Saudi Arabia*, Singapore*, Slovakia, Spain, Sweden, Switzerland, Thailand, Türkiye, Ukraine, United Kingdom, United States of America, Uruguay*. Countries noted with an "*" are not included in the monthly series due to incomplete information. Distances refer to geodesic distances, calculated following the great circle formula, which uses latitudes and longitudes of the most important cities/agglomerations (in terms of population).

Source: OECD, based on ITC's Trade Map database for trade data (monthly data extracted in May 2022 and yearly data extracted June 2021), CEPII for distance data, and World Bank for classifying countries into broad regions.

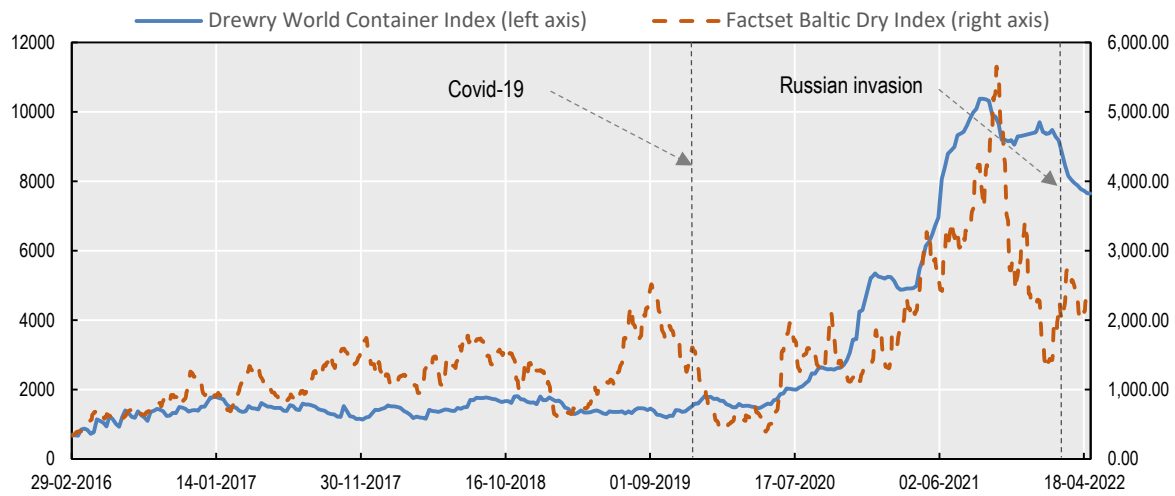
2.1. Maritime transport sector – no end of disruptions in sight?

Global container shipping, which is at the heart of global supply chains, continued to recover in 2021, although constraints on vessel capacity, insufficient containers being available at the right port at the right time, and on-shore logistics bottlenecks, including closures of specific ports due to local COVID-19 outbreaks, remained to create tensions in the market.

The cost of container shipping started to come down from mid-2021, but at an average cost of USD 7650 for shipping a 40ft container rates in mid-April 2022 were still five times higher than in late 2019 and more than twice the five-year average of USD 3 380. Shipping containers from Asia to Europe or to the United States remains far more costly than shipping on the reverse routes. The war in Ukraine and sanctions against Russia have added to containers piling up in European ports.

The dry bulk shipping industry has enjoyed a bumper year 2021, with charter rates rising substantially and reaching a spike of USD 5 488 in early October, with rates more than 3.5 times higher compared with January 2021, where the Baltic Dry Index recorded an average of USD 1 650 (Figure 2.7). In the last quarter of 2021 rates have come down, only to rise again at the start of 2022; as of early May 2022 the Baltic Dry Index stood at USD 2 400. As for container shipping, high freight rates can be partially attributed to pick up of demand in the wake of economic recovery. Another factor are restrictions and problems at ports due to the pandemic, which were tying up ships for longer than usual. April and May saw unseasonal high grains cargo from the United States to Europe, but grains trade remains low overall due to closed ports in the Black Sea.

Figure 2.7. Maritime transport cost



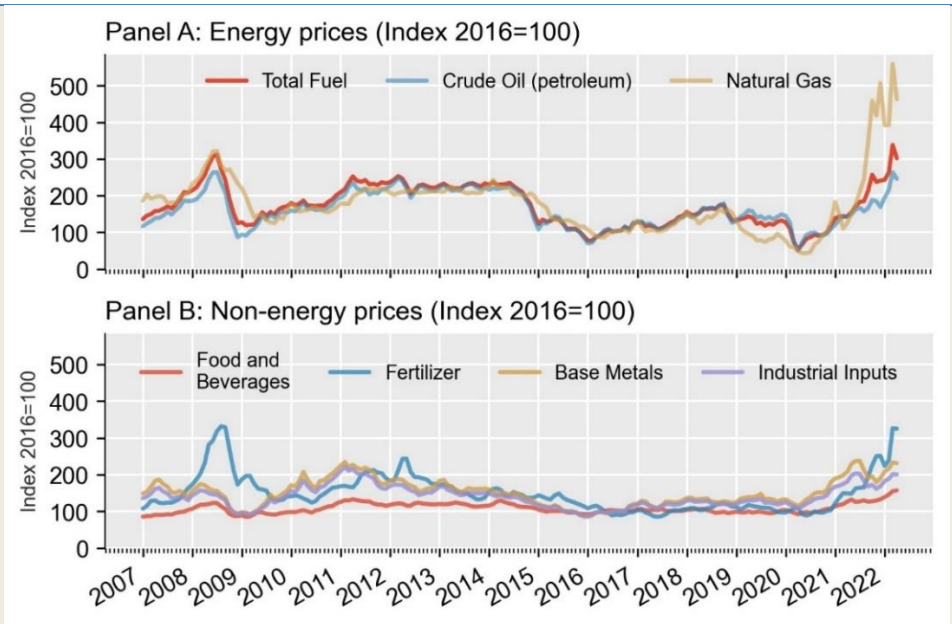
Source: Baltic Dry Index (obtained from Factset), Drewry.

Box 2.1. Commodity prices are high and volatile

Commodity prices have been remarkably volatile during the last two years. Fuel prices in particular, after falling steeply and reaching levels that were among the lowest over the course of the last 30 years at the beginning of 2020, have been trending upward in 2021 and reached historical highs at the beginning of 2022 even before Russia's war of aggression against Ukraine (Figure 2.8 Panel A).

High natural gas prices spill over to (nitrogen) fertilizer prices which where 2.5 time higher at the end of 2021 than a year earlier and have since then even accelerated their climb (Figure 2.8 Panel B).

Figure 2.8. Energy and non-energy commodity prices are at their historical highs (2016=100)



Source: IMF.

2.2. Semiconductors: Despite bottlenecks trade continued to grow

Semiconductors have been reported to struggle to meet surging demand during the COVID-19 pandemic. While trade data indicate that the industry as a whole was able to partly meet the demand surge, bottlenecks have materialised in late 2020 in key sectors such as automobiles. Trade kept increasing throughout 2021 but at a slightly slower pace (Figure 2.9).

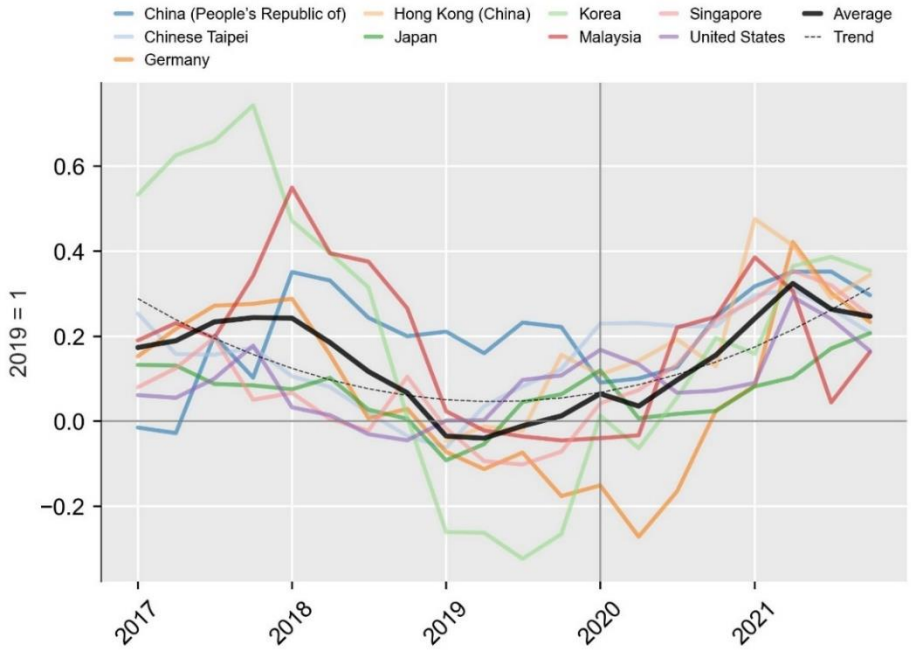
After coming out of a sluggish 2019 trade in semiconductors has been on the rise since 2020. Even if bottlenecks occurred in the last two years, trade in semiconductors has kept increasing and was at a new peak in early 2022. The average year-on-year growth rate of quarterly exports of the top 10 exporters of integrated circuits exhibit a 30% growth rate in the third quarter of 2021 and a 10% growth rate in the third quarter of 2020.

However, the growth of trade in integrated circuits differs across partners. China and Chinese Taipei consistently exhibit above average growth rates since 2019, while Korea and Malaysia, followed by Germany have caught up later. The United States growth rate mostly remains below other countries'.

Semiconductor export prices are trending upwards (Figure 2.10). The price increase is driven by a combination of rising input costs and continued high demand in a period when downstream industries face tight inventories. Prices have increased by more than 40% on average between August 2019 and February 2022. The highest price increases are observed for Germany, China, Hong-Kong (China), and Chinese Taipei, while United States and Korea are at the lower end.

Figure 2.9. Top 10 exporters of integrated circuits

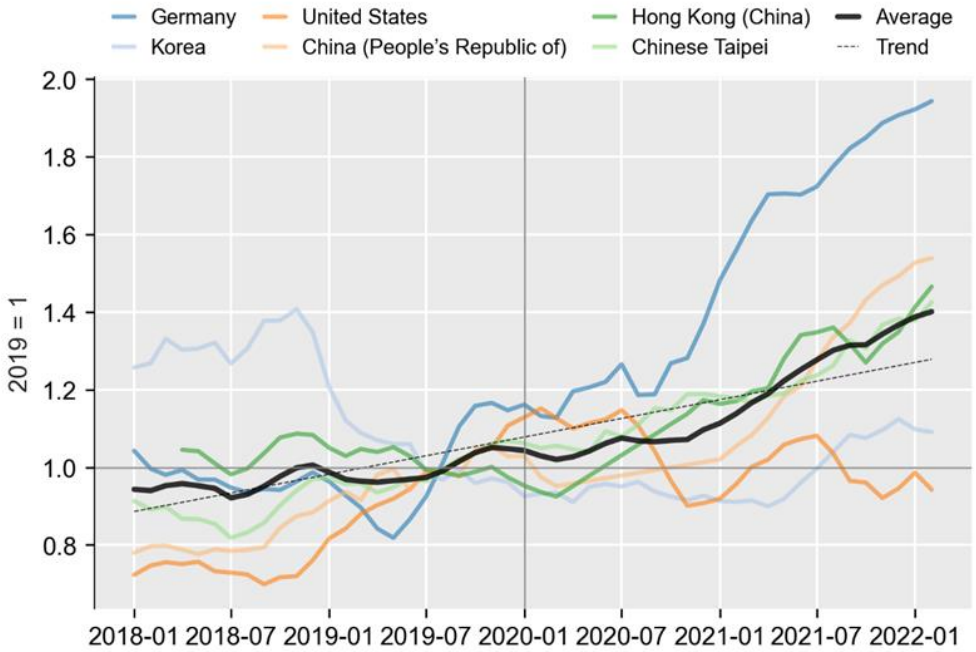
Quarterly year-on-year growth rate (2017-Q1 to 2021-Q3)



Note: The data depict HS4 code 8542; Trend: quadratic trend.
Source: ITC TradeMap.

Figure 2.10. Integrated circuits' prices among top 10 exports

January 2018 to February 2022, average 2019 = 1



Note: Price data are estimated by selecting exports of HS4 code 8542 by country. Prices are calculated as the ratio of exports value to quantities, subsequently normalized to the average price in the year 2019. Missing in-sample values are linearly interpolated.
Source: ITC TradeMap, HS code: 8542.

Box 2.2. Semiconductors: Context

Industries downstream of the semiconductor sector value chains have faced important shortages of integrated circuits. The production of semiconductor products was hit by disruptions in 2020 and 2021 that have intensified pressures on supply. Starting in December 2019, the COVID-19 outbreak triggered the closing of semiconductors factories due to confinement measures. Several local events have added more difficulties: a factory of the Japanese chip producer Renesas Electronics caught fire in March 2021; power shortages in China led to the reduction of the production in October 2021; and extreme cold weather in Texas in February 2021 triggered the standstill of production in NXP factories.

In the meantime, the combination of COVID-19 confinement measures and stimulus packages fuelled demand for electronics appliances like computers, smartphones and IoT (Inter of Things) goods which exacerbated pressures on price. With gradual easing of confinement measures, demand for motor vehicles, which rely more and more on semiconductors, has recovered. Given the shortage of semiconductors, car factories have had to partially stop their production. This was the case for a factory of General Motors in Mexico or Stellantis in France.

Supply chain pressures were intensified by rising prices of raw materials and energy, that translated into a subsequent rise in price of semiconductors. For example, the consumer price index of energy increased by 30% on a year-on-year basis in the United States in April 2022 (Bureau of Labor Statistics), while the price of silicon wafers, an input used in the production of semiconductors, has increased by 10% since January 2021 (UN Comtrade data, own calculations).

While semiconductor production is concentrated among a few companies, the wide array of its usage downstream in other industries makes it a strategic industry. Its production is very complex with high barriers to entry and there is not a single company providing all the different types of semiconductors such as memory chips, microprocessors, graphic processing units, integrated circuits and analog chips.

3. Trade and other economic impacts of Russia's war of aggression against Ukraine

Russia's initiation of large-scale offensives deep into Ukraine on 24 February 2022, has had disastrous impacts on the people and economy of Ukraine, and has wide-ranging international economic and political consequences. The full extent of these impacts will depend on how the war and the international reactions to it evolve and is therefore highly uncertain.

In reaction to Russia's full-scale invasion, many countries have imposed a progressive series of economic sanctions on Russia. International trade of Russia and the associated financial flows are some of the key channels targeted by these sanctions. The sanctions are clearly aiming at hurting Russia economically while making sure that the economic pressure on Russia inflicts as limited damage on the sanctioning countries and the rest of the world as possible although due to their very nature sanctions pursue non-economic objectives with economic means which makes a comparison of their costs and benefits far from straightforward.[5]

Reliable trade data come with delays that do not yet allow a trustworthy analysis of the actual impacts but many relevant insights can be drawn from historical data. This section of the report presents selected early results of work aiming at better understanding the trade dependencies and economic impacts of the war. It relies on four complementary sets of tools: detailed trade data at the product level; OECD Inter-Country Input-Output (ICIO) tables and the associated trade in value added indicators (TiVA); the Analytical

[5] Recently, de Souza et al. (2022[10]) investigated the trade-off for the sanctioning countries between reducing Russia's war capability and the potential harm to their own economies. They argue that the trade-off is non-trivial: the sanctions reduce both Russian exports and the sanctioning country's imports, as goods cannot be fully substituted for non-sanctioned goods, so both sides incur economic losses. The optimal sanctions depend on the sanctioning country's willingness to pay for sanctions, i.e. the amount of own economic loss it is willing to incur per unit of Russian loss. More broadly this trade-off applies also to non-economic effects where costly sanctions may be endured to diminish the aggressor's military capacity or force its retreat, etc.

Activities of MNEs database (AAMNE); and OECD's computable general equilibrium (CGE) model METRO.

3.1. Direct trade dependencies

Accounting for 2.1% and 1.3% of world's merchandise exports and imports in the pre-COVID year 2019, Russia is not a major player in world trade overall but it has a relatively export-oriented economy.[6] Globally, it has also been an important supplier of some agricultural products (e.g. wheat and meslin), inputs into agriculture (e.g. mineral fertilisers) and industrial raw materials (e.g. pig iron, iron, nickel, wood) as well as fuels (oil and oil products, natural gas and coal) (Table 3.1).

Russia's merchandise imports on the other hand were mainly concentrated in more technologically advanced manufacturing (e.g. electronics, motor vehicles, pharmaceuticals) as well as in food and textile products and some industrial raw materials (e.g. inputs into aluminium and steel production) (Table 3.2).

In 2019, Russia's exports of services accounted for 13% of its total exports (with transport and ICT accounting for, respectively, 33% and 17% of services exports). The value of Russia's imports of services was more than double that of exports and they were concentrated in travel (37%), ICT (18%) and transport services (16%), while imports of financial and insurance services accounted for 3%.[7] For the last two decades, Russia has been re-orienting its trade away from Europe and Central Asia towards East Asia Pacific (Figure 3.1).

Table 3.1. Top 30 global imports from Russia

Russia's share in world imports in 2019, %

HS code	Product description (abbreviated)		Russia's share in world imports
2524	Asbestos		77%
7201	Pig iron and spiegeleisen in pigs, blocks or othe	(...)	41%
2612	Uranium or thorium ores and concentrates	(...)	37%
2617	Ores and concentrates; n.e.s. in heading no. 26	(...)	35%
2619	Slag, dross; (other than granulated slag), scalin	(...)	35%
8401	Nuclear reactors; fuel elements (cartridges), no	(...)	34%
1204	Oil seeds; linseed, whether or not broken	(...)	27%
7207	Iron or non-alloy steel; semi-finished products t	(...)	27%
7203	Ferrous products obtained by direct reduction o	(...)	24%
7502	Nickel; unwrought	(...)	22%
507	Ivory, tortoise-shell, whalebone and whalebone l	(...)	18%
2803	Carbon; carbon blacks and other forms of carbo	(...)	18%
7206	Iron and non-alloy steel in ingots or other primar	(...)	18%
2844	Radioactive chemical elements and radioactive	(...)	17%
2814	Ammonia; anhydrous or in aqueous solution	(...)	17%
7501	Nickel mattes; nickel oxide sinters and other int	(...)	17%
3104	Fertilizers; mineral or chemical, potassic	(...)	16%
7110	Platinum; unwrought or in semi-manufactured fo	(...)	16%
3105	Fertilizers; mineral or chemical, containing 2 or	(...)	16%
2701	Coal; briquettes, ovoids and similar solid fuels r	(...)	15%
1512	Sun-flower seed, safflower or cotton-seed oil an	(...)	15%
1001	Wheat and meslin	(...)	15%
8108	Titanium; articles thereof, including waste and s	(...)	15%
4407	Wood sawn or chipped lengthwise, sliced, peel	(...)	14%
3102	Fertilizers; mineral or chemical, nitrogenous	(...)	14%
303	Fish; frozen, excluding fish fillets and other fish	(...)	14%
7601	Aluminium; unwrought	(...)	13%
2503	Sulphur of all kinds; other than sublimed, precip	(...)	12%
4801	Newsprint, in rolls or sheets	(...)	12%
8112	Beryllium, chromium, germanium, vanadium, ga	(...)	12%

Source: UN Comtrade 2019.

[6] As per the World Bank's Global Development Indicators, the share of the Russia's GDP in world GDP in 2019 was 1.9% (in current USD) which was below its export share and above its import share. Its trade balance in the same year was at 7.6% of GDP.

[7] These shares, not presented in tabular form here, were calculated using services trade data for Russia provided by the Harvard Atlas of Economic Complexity.

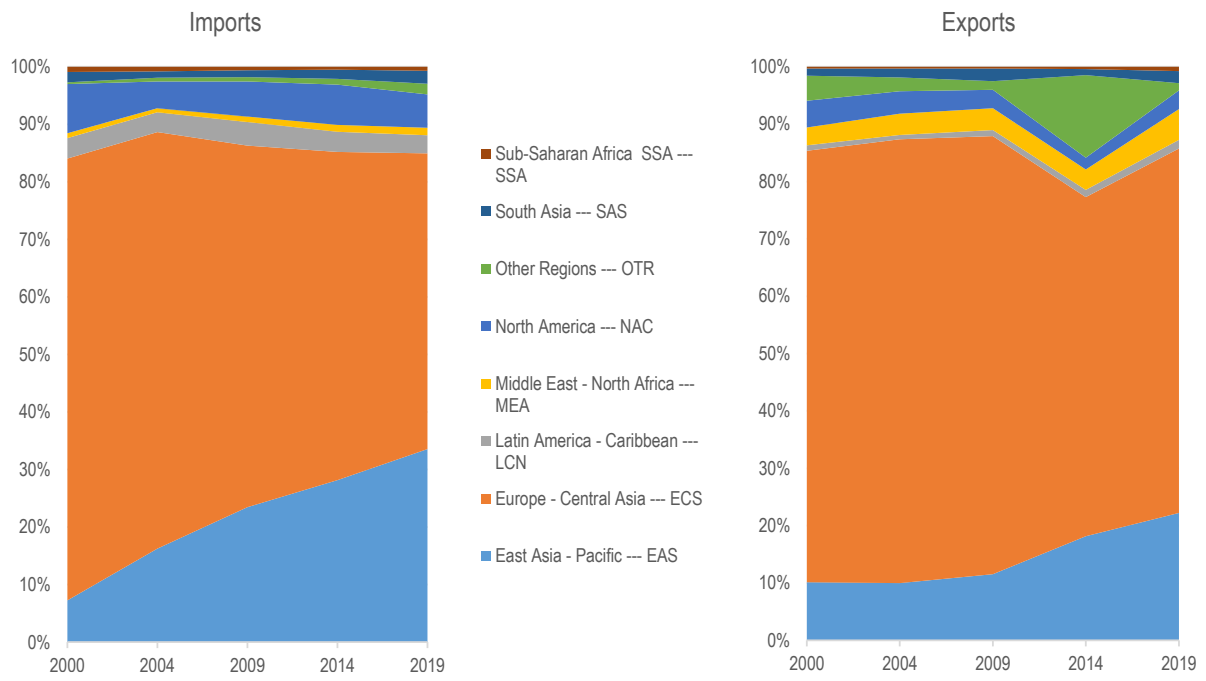
Table 3.2. Russia's top 30 imports from all countries

Share in Russia's imports in 2019, %

HS Code	Product description (abbreviated)		Share in Russia's imports
8517	Telephone sets, including telephones for cellula	(...)	7%
8471	Automatic data processing machines and units	(...)	4%
9999	Commodities not specified according to kind	(...)	3%
8708	Motor vehicles; parts and accessories, of headi	(...)	2%
3004	Medicaments; (not goods of heading no. 3002,	(...)	1%
2818	Aluminium oxide (including artificial corundum);	(...)	1%
9503	Tricycles, scooters, pedal cars and similar whe	(...)	1%
6403	Footwear; with outer soles of rubber, plastics, le	(...)	1%
406	Cheese and curd	(...)	1%
803	Bananas, including plantains; fresh or dried	(...)	1%
8516	Electric water, space, soil heaters; electro-therr	(...)	1%
8528	Television receivers (including video monitors ar	(...)	1%
8704	Vehicles; for the transport of goods	(...)	1%
8529	Transmission apparatus; parts suitable for use s	(...)	1%
8473	Machinery; parts and accessories (other than c	(...)	1%
8542	Electronic integrated circuits and microassemb	(...)	1%
8481	Taps, cocks, valves and similar appliances for p	(...)	1%
805	Citrus fruit; fresh or dried	(...)	1%
8504	Electric transformers, static converters (eg recti	(...)	1%
6204	Suits, ensembles, jackets, dresses, skirts, divi	(...)	1%
1201	Soya beans; whether or not broken	(...)	1%
202	Meat of bovine animals; frozen	(...)	1%
6402	Footwear; with outer soles and uppers of rubber	(...)	1%
7208	Iron or non-alloy steel; flat-rolled products of a w	(...)	1%
6404	Footwear; with outer soles of rubber, plastics, le	(...)	1%
4011	New pneumatic tyres, of rubber	(...)	1%
8443	Printing machinery; used for printing by means	(...)	1%
8703	Motor cars and other motor vehicles; principally	(...)	1%
6110	Jerseys, pullovers, cardigans, waistcoats and s	(...)	1%
8518	Microphones and their stands; loudspeakers, m	(...)	1%

Source: UN Comtrade.

Figure 3.1. Geographical orientation of Russia's merchandise imports and exports, 2000-2019



Note: the large increase of the share allocated to "Other regions" is due to the fact that in 2014 and 2015—the two years following Russia's invasion of the Crimea in 2014 - large shares of Russia's exports (13.4% and 15.4%) were reported as destined to a 'unspecified' country category.
Source: UN Comtrade.

Which OECD countries depend on Russia for their imports?

Russia being an important supplier of some agricultural and industrial raw materials as well as fuels creates potential problems for countries who depend heavily on Russia for specific products, especially where supply is concentrated around only a few suppliers.

Currently, there are few product categories where supply is highly concentrated and a high share of it comes from Russia. These products are defined here as belonging to the Harmonised System (HS) 4-digit product categories for which shares of global imports from Russia exceed 10% in 2019 and which are characterised by a relatively high global concentration of suppliers, i.e. Herfindahl-Hirschman Indices (HHI) values exceeding a threshold of 0.2 (left panel of Figure 3.2).[8] These include products such as asbestos, pig iron, uranium, nuclear reactors, sunflower seed and sunflower oil, mineral fertilisers and coal (Table 3.3).

It is worth noting however that if the same criteria are applied at the 6-digit level of HS classification, there are fifty-five systemically important products, including several specific ones from the just mentioned HS Sections, but also products from other sections, including several types of wood, fish, synthetic rubber, nickel, molybdenum, different types of metals and fuels but also wheat and meslin (Table 3.4).

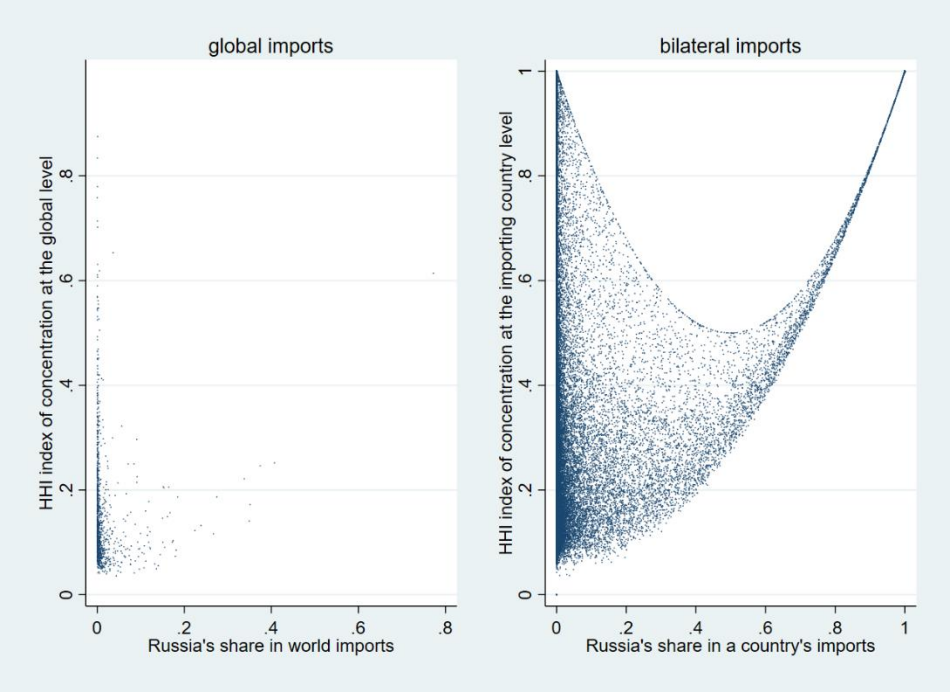
Table 3.3. HS 4-digit products with high global concentration ratios and where a high share comes from Russia

HS code	Product description (abbreviated)	HHI Concentration Index value	Russia's share in imports
2524	Asbestos	0.6	0.8
7201	Pig iron and spiegeleisen in pigs, blocks or other primary forms	0.3	0.4
2612	Uranium or thorium ores and concentrates	0.2	0.4
8401	Nuclear reactors; fuel elements (cartridges), nonirradiated, for nuclear reactors, machinery and apparatus for isotopic separation	0.2	0.3
1512	Sunflower seed, safflower or cottonseed oil and their fractions; whether or not refined, but not chemically modified	0.2	0.2
3104	Fertilizers; mineral or chemical, potassic	0.2	0.2
2701	Coal; briquettes, ovoids and similar solid fuels manufactured from coal	0.2	0.2

Source: Authors' calculations based on UN Comtrade data for 2019.

[8] The Herfindahl-Hirschman Index (HHI) is commonly used to measure market concentration. It is the sum of squared market shares and lies between 1/*n*, when all of the *n* suppliers have equal shares, and one, when there is only one supplier, a monopoly. The threshold of 0.2 used here is arguably somewhat arbitrary and a choice of a different threshold would result in a selection of a different range of products that qualify as concentrated. Note, however, that the US Department of Justice (DOJ) and US Federal Reserve, for example, which use the HHI index for analysing the competitive effects of merges, consider markets with a HHI between 0.15 and 0.25 to be moderately concentrated and markets with HHI equal to or more than 0.25 to be highly concentrated. See: Herfindahl-Hirschman Index (justice.gov).

Figure 3.2. Concentration of imports and Russia's shares at the global and bilateral level



Note: HHI denotes the Herfindahl-Hirschman Index of concentration which is the sum of squared markets shares and lies between 0 (no concentration) and 1 (only one supplier).
Source: Authors' calculations based on UN Comtrade data for 2019.

Table 3.4. HS 6-digit products with high global concentration ratios and where a high share comes from Russia

HS code	Product description (abbreviated)	HHI value	Russia's share in imports	HS code	Product description (abbreviated)	HHI value	Russia's share in imports
290383	Halogenated derivatives of cyclanic, cyclenic or cyclotei (…)	0.9	1.0	720280	Ferro-alloys; ferro-tungsten and ferro-silico-tungsten (…)	0.3	0.3
30367	Fish; frozen, Alaska pollack (Theraga chalcogramma), ((…)	0.8	0.9	750110	Nickel; nickel mattes (…)	0.3	0.3
252490	Asbestos; other than crocidolite (blue asbestos) (…)	0.6	0.8	30332	Fish; plaice (pleuronectes platessa), frozen (excluding f (…)	0.3	0.2
440395	Wood; of birch (Betula spp.), in the rough, whether or n (…)	0.5	0.7	440396	Wood; of birch (Betula spp.), in the rough, whether or n (…)	0.3	0.2
50710	Animal products; ivory, unworked or simply prepared bu (…)	0.5	0.6	440690	Wood; railway or tramway sleepers (cross-ties), impre (…)	0.3	0.2
440796	Wood; of birch (Betula spp.), sawn or chipped lengthwi (…)	0.4	0.6	860692	Railway or tramway goods vans and wagons; open, wit (…)	0.2	0.2
252410	Asbestos; crocidolite (blue asbestos) (…)	0.4	0.6	30339	Fish; frozen, flat fish, n.e.c. in item no. 0303.3, excludin (…)	0.3	0.2
270111	Coal; anthracite, whether or not pulverised, but not agg (…)	0.4	0.6	251020	Natural calcium phosphates, natural aluminium calcium p (…)	0.2	0.2
880521	Ground flying trainers and parts thereof; air combat sim (…)	0.4	0.6	310420	Fertilizers, mineral or chemical; potassic, potassium chl (…)	0.2	0.2
400260	Rubber; synthetic, isoprene rubber (IR), in primary form (…)	0.3	0.5	681293	Asbestos or mixtures with a basis of asbestos (other th (…)	0.2	0.2
30363	Fish; frozen, cod (Gadus morhua, Gadus ogac, Gadus (…)	0.3	0.5	30312	Fish; frozen, Pacific salmon (Oncorhynchus gorbuscha/I (…)	0.4	0.2
30821	Aquatic invertebrates; sea urchins (Strongylocentrotus s (…)	0.3	0.4	151211	Vegetable oils; sunflower seed or safflower oil and thei (…)	0.3	0.2
261710	Antimony ores and concentrates (…)	0.3	0.4	270112	Coal; bituminous, whether or not pulverised, but not agg (…)	0.2	0.2
30633	Crustaceans; live, fresh or chilled, crabs, whether in sh (…)	0.2	0.4	290110	Acyclic hydrocarbons; saturated (…)	0.3	0.2
120760	Oil seeds; safflower seeds, whether or not broken (…)	0.2	0.4	230630	Oil-cake and other solid residues; whether or not groun (…)	0.3	0.2
720110	Iron; non-alloy pig iron containing by weight 0.5% or les (…)	0.3	0.4	30475	Fish fillets; frozen, Alaska pollack (Theragra chalcogran (…)	0.3	0.1
30391	Fish; frozen, livers, roes and milt (…)	0.3	0.4	151511	Vegetable oils; linseed oil and its fractions, crude, not c (…)	0.2	0.1
261210	Uranium ores and concentrates (…)	0.3	0.4	284130	Salts; sodium dichromate (…)	0.2	0.1
440397	Wood; of poplar and aspen (Populus spp.), in the rough (…)	0.2	0.4	100111	Cereals; wheat and meslin, durum wheat, seed (…)	0.2	0.1
400231	Rubber; synthetic, isobutene-isoprene (butyl) rubber (III (…)	0.2	0.4	441232	Plywood; consisting only of sheets of wood (not bambo (…)	0.3	0.1
30311	Fish; Pacific salmon, sockeye salmon, (red salmon), (O (…)	0.4	0.4	810294	Molybdenum; unwrought, including bars and rods obtair (…)	0.2	0.1
440320	Wood; coniferous, in the rough, whether or not stripped (…)	0.2	0.4	720390	Ferrous products; spongy ferrous products and iron hav (…)	0.2	0.1
30624	Crustaceans; not frozen, crabs, whether in shell or not, (…)	0.3	0.4	284590	Isotopes (excluding those of heading no. 2844); compo (…)	0.2	0.1
840130	Fuel elements (cartridges); non-irradiated (…)	0.3	0.4	10612	Mammals; live, whales, dolphins and porpoises (mamm (…)	0.4	0.1
681292	Asbestos or mixtures with a basis of asbestos (other th (…)	0.2	0.4	30368	Fish; frozen, blue whitings (Micromesistius poutassou, M (…)	0.2	0.1
30614	Crustaceans; frozen, crabs, in shell or not, smoked, co (…)	0.2	0.3	440795	Wood; ash (Fraxinus spp.), sawn or chipped lengthwise (…)	0.2	0.1
841210	Engines; reaction engines, other than turbo-jets (…)	0.2	0.3	711019	Metals; platinum, semi-manufactured (…)	0.2	0.1
30364	Fish; frozen, haddock (Melanogrammus aeglefinus), ex (…)	0.5	0.3				

Source: Authors' calculations based on UN Comtrade data for 2019.

When bilateral import relationships of specific countries are considered, there are many cases where Russia accounts for more than half of imports of a given country and where the importing country's supplies are heavily concentrated, as seen in the upper-right corner of the right panel in Figure 3.2. This illustrates an important reality: the negative impacts of cutting imports from Russia may be concentrated in a few specific countries and sectors. However, the economic importance of these dependencies cannot be judged fully from trade shares alone, as this will depend on the technical and geographical possibilities of substitution for non-Russian alternatives, as well as on systemic importance of the activities in question (see also Sections 3.2 and 3.4).[9]

It is possible that for some of these products (e.g. fuels or critical raw materials) substitution will be difficult and overall costs of adjustments may be high. Some redirection of trade will, however, be possible and international co-operation on how to fill in the missing supplies may be crucial. In some cases, OECD countries that are exposed to imports from Russia will be able to source these products from other OECD countries. Such substitution towards OECD suppliers can arguably be considered as being relatively easy if OECD suppliers collectively account for relatively high shares of supply to a given country. In line with this idea, Figure 3.3 identifies the OECD countries with the largest number of 'dependent' products where imports rely significantly on Russia (import share greater than 10%) and, among these, it further identifies the products for which such substitution involving other OECD countries might be possible. Imports from Russia of such dependent products are considered 'replaceable' if the share in a given country's imports of this product sourced from OECD countries is equal or greater than 20% (i.e. twice the share of imports from Russia)[10] and, additionally, the value of the corresponding HHI is smaller or equal than 0.2 (i.e. imports are not overly concentrated). Correspondingly, 'somewhat replaceable' products are defined as those where the share in a given country's imports of this product sourced from OECD countries is greater than 20% but the HHI is greater than 0.2. Finally, 'hard to replace' products are defined as those where OECD countries' share in a country's imports of this product is smaller than 20% and the corresponding HHI is greater than 0.2. Figure 3.4 presents the same data but organised by product.

Countries in the east and north of Europe are among the most exposed to imports from Russia but for a large number of products such substitution might be possible (light green and light blue bars in Figure 3.3 and Figure 3.4), indicating that sanctions on imports from Russia of these products may be relatively less painful for the sanction-imposing countries. With the exception of Türkiye, where 'replaceable' products account for only 40% of the exposed products, in the other top 10 most exposed countries the joint share of 'somewhat replaceable' and 'replaceable' products typically exceeds 55%.

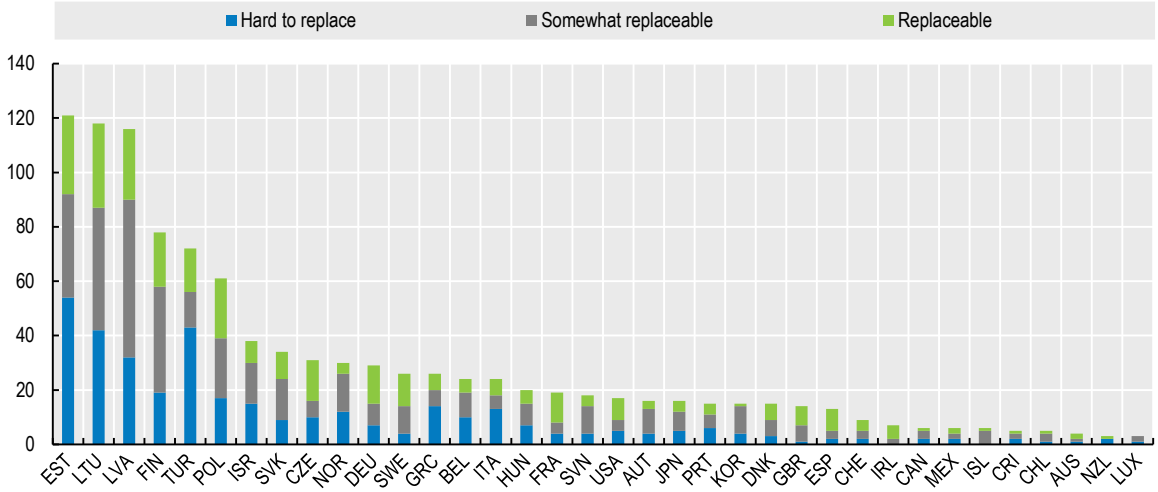
Products in which OECD countries are most frequently exposed to imports from Russia include certain types of coal, petroleum oils, mineral fertilisers, plywood (Figure 3.4). Products where substitution within the OECD membership may be more problematic are imported from Russia by a small number of OECD countries and include some specific fuels, and most notably natural gas, but also several kinds of metals, including pig iron and several steel-related products, as well as aluminium and platinum.

[9] In addition, similarly to other analyses of gross trade flows, this approach does not account for the fact that some countries may depend on trade with Russia indirectly, that is when they rely on products that are first shipped to other countries and only then imported to countries where they are used in production or consumed. The ICIO and CGE analyses that follow in the next subsections do away with this problem albeit at a higher level of product aggregation.

[10] An implicit assumption here is that an OECD share of 20% or more offers enough space for substituting away from Russia towards alternative OECD suppliers by increasing imports from these directions.

Figure 3.3. OECD countries and products where exposure to imports from Russia is significant, by country

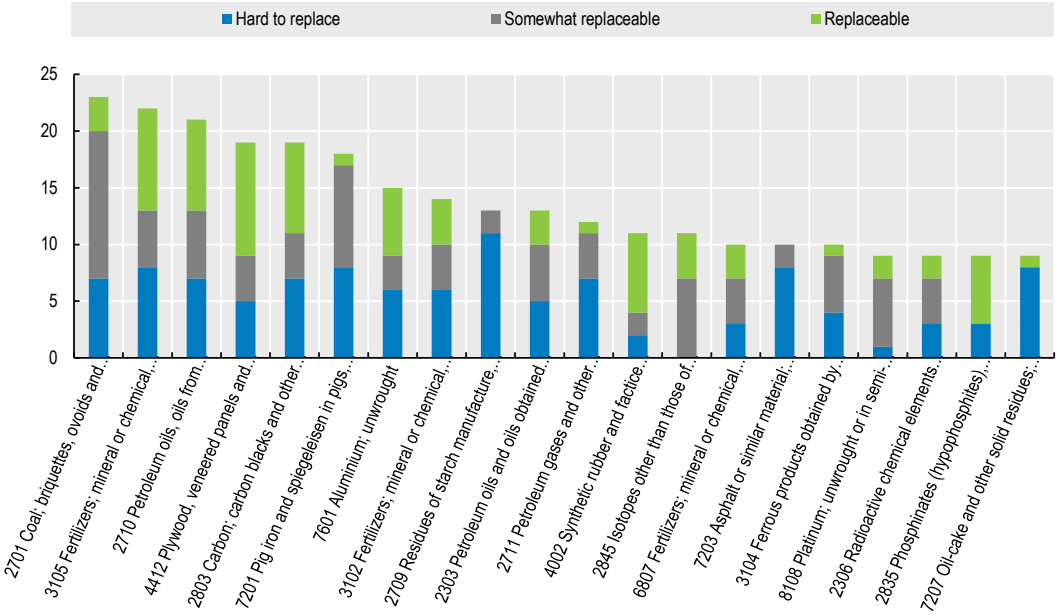
Count of products by ease of substitution away from Russia



Note: Count of 4-digit products where Russia's share in country's imports >=0.1 and which are: either 'hard to replace' (OECD's share of the country's imports <=0.2 and the corresponding HHI>=0.2); 'somewhat replaceable' within the OECD (OECD's share of the country's imports >=0.2 and the corresponding HHI>=0.2) and 'replaceable' (OECD's share of the country's imports >=0.2 and the corresponding HHI<=0.2).
Source: OECD, based on UN Comtrade data.

Figure 3.4. OECD countries and products where exposure to imports from Russia is significant, by product

Count of OECD countries by ease of substitution



Note: Count of OECD countries where Russia's share in country's imports >=0.1 and which are: either 'hard to replace' (OECD's share of the country's imports <=0.2 and the corresponding HHI>=0.2); 'somewhat replaceable' within the OECD (OECD's share of the country's imports >=0.2 and the corresponding HHI>=0.2) and 'replaceable' (OECD's share of the country's imports >=0.2 and the corresponding HHI<=0.2) (for top 20 products with highest number of exposed countries). The numbers at the beginning of the abbreviated product descriptions are 4-digit HS codes.
Source: OECD, based on UN Comtrade data.

How does Russia depend on OECD countries for its imports?

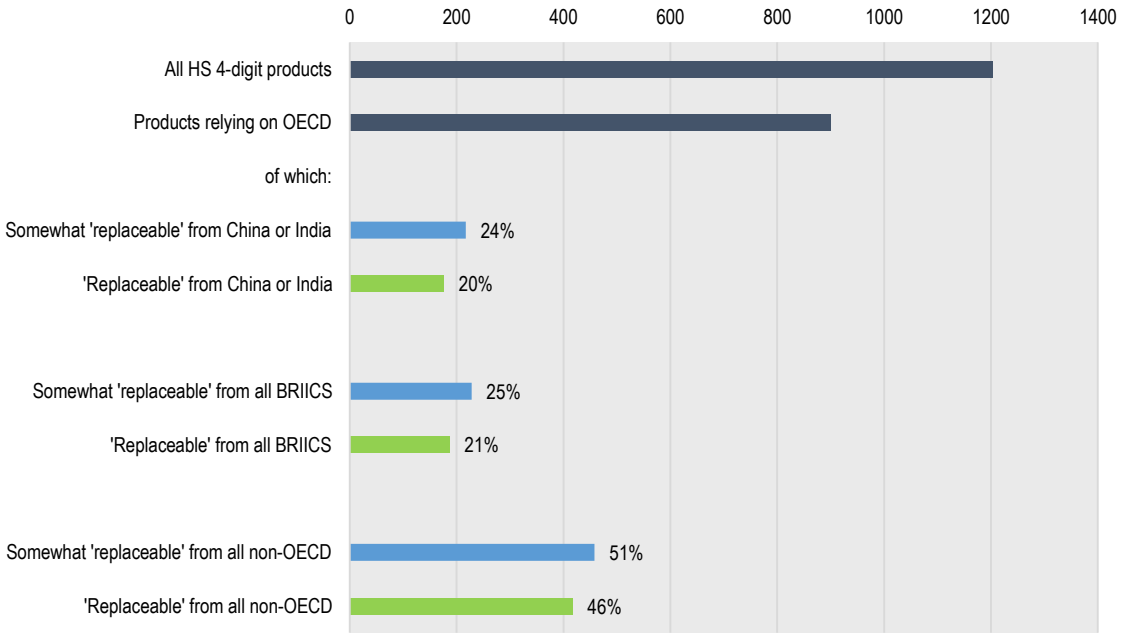
Similar analysis looking at Russia as an importer shows that the country is exposed much more to imports from OECD countries than OECD countries are to imports from Russia: OECD accounts for more than 10% of Russia's imports for some 900 out the total 1,200 4-digit HS product, i.e. 75% of products. This is close to ten times more than for the most exposed OECD countries. In addition, for 140 (12%) products imported by Russia, the OECD share exceeds 50%.

The idea of replaceability can also be applied to Russia but now considering some country groups which might co-operate with Russia on such substitution away from imports from the OECD countries (e.g. China, India, other BRIICS countries, or other non-OECD countries). 44% of the exposed products appear somewhat replaceable or replaceable with imports from China or India, 46% are somewhat replaceable or replaceable with imports from the other BRIICS countries (including China and India) and, perhaps most importantly, almost all of these products (97%) can be more or less easily replaced from alternative non-OECD countries (Figure 3.5).

The idea of replaceability assumes among others that the quality and technical and other characteristics of products imported from non-OECD countries are similar to those imported from the OECD. However, Russia tends to rely more intensely on OECD for products characterised by higher product complexity[11] (Figure 3.6) and it is not clear how easy it will be for Russian importers to find alternatives to OECD products in non-OECD economies.

Figure 3.5. Products where Russia's exposure to imports from OECD countries is significant

Count of HS 4-digit products, 2019

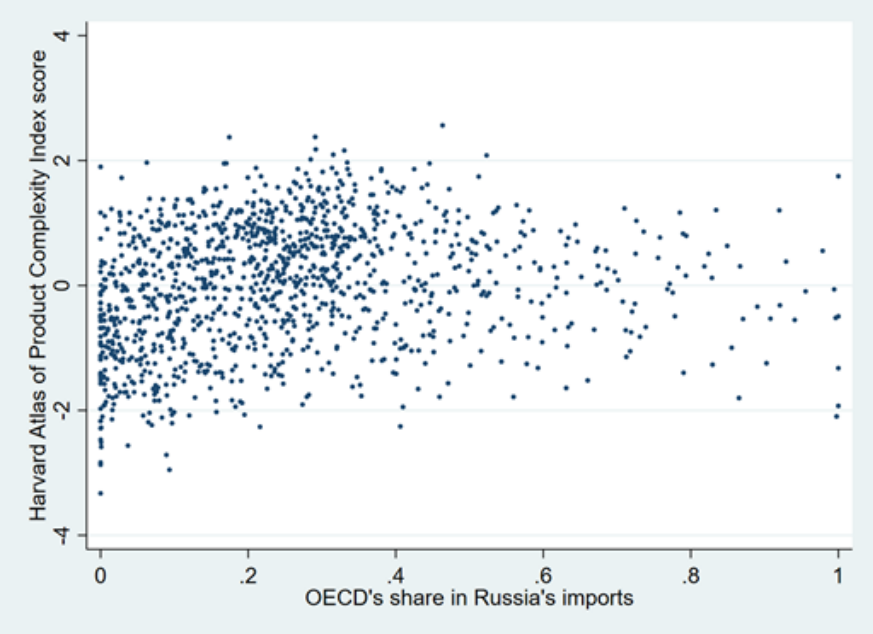


Note: Count of 4-digit products where OECD countries' share in Russia's imports >=0.1 and which are either 'somewhat replaceable' within the given country group (share of these countries in Russia's imports >=0.2) or 'replaceable' (share of these countries in Russia's imports >=0.2 and HHI<=0.2). BRIICS in this case denotes: Brazil, India, Indonesia, China and South Africa.
Source: OECD, based on UN Comtrade.

[11] The product complexity scores used here were estimated at the HS 4-digit level using the economic complexity methodology (Hausmann, 2014[11]) and provided by the Harvard Atlas of Economic Complexity (https://atlas.cid.harvard.edu/explore).

Figure 3.6. : Technological advancement of products and Russia's dependence on imports from the OECD

Product complexity scores and Russia's dependence on imports from the OECD countries (4-digit HS)



Note: values greater than zero indicate greater complexity.
Source: Authors' calculations based on UN Comtrade data for 2019.

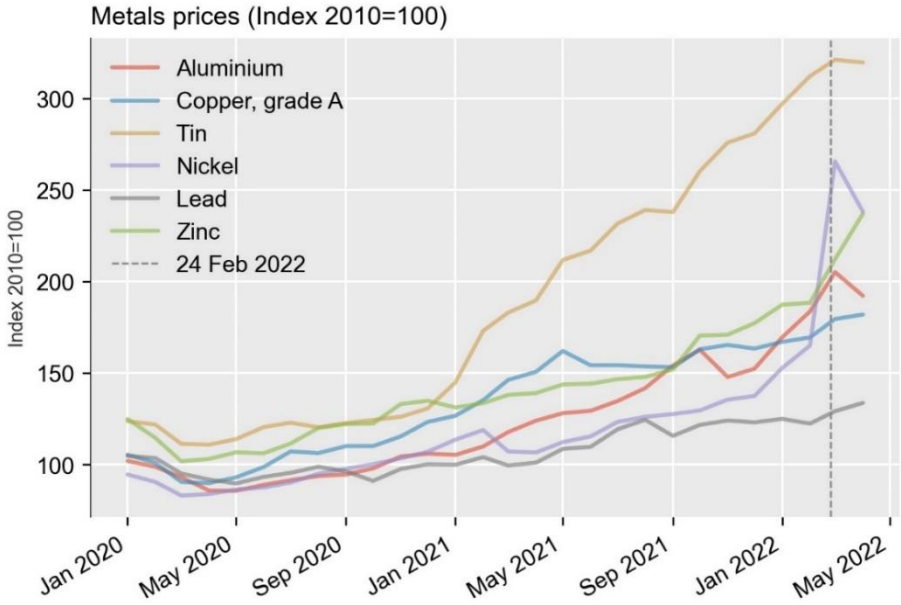
What do recent commodity price data reveal?

Even if it is too early for a comprehensive assessment of trade flow impacts as trade statistics become available with some delay, more timely data are available on commodity prices.

As discussed in Box 2.1, commodity prices have been trending upward in 2021 and reached historical highs at the beginning of 2022 even before Russia's war against Ukraine. Following the aggression and amidst high uncertainty about future supplies of coal, oil and natural gas from Russia – one of the world's leading suppliers of these fuels prior to the aggression – energy prices jumped even further in March 2022 (Box 2.1).

Prices of many non-energy commodities had also attained historical highs already at the beginning of 2022. This was the case for example for base metals such as copper, iron ore, molybdenum and tin while prices of other metals such as aluminium, nickel and zinc have risen beyond pre-pandemic levels. The Russia's war against Ukraine is having an additional price-rising effect on those typically volatile commodity markets, especially since Russia is a substantial producer of some key raw materials. Prices of aluminium were the first to react in early March, followed by nickel and tin which reached new peaks around the second week of March. The initially dynamic metal price increases in reaction to Russia's invasion have been partially reversed since then but uncertainty about future supply remains elevated (Figure 3.7).

Figure 3.7. Prices of key commodities were rising already before Russia's full-scale invasion of Ukraine



Source: INSEE, OECD calculations.

Agricultural commodity prices are of the highest concern, in particular wheat prices. Due to draughts in Canada in 2021 among others, at the end of 2021 wheat prices were already approximately 30% higher than at the end of 2019. Russia and Ukraine are among the largest net exporters of grains, accounting respectively for 13% and 9% of global exports. Ukraine's summer harvest of wheat this year is of course endangered by the dynamically evolving military operations on its territory but the continuing blockages of the ports and traffic in the Black Sea are impacting exports of both Ukrainian and Russian crops. In May 2022 wheat prices were more than 30% higher than the February average, and around 50% higher than May 2021 average. While the price of wheat exported from Russia has increased, it was traded in June 2022 at a discount of about 10% to 15% relative to European and American wheat due to higher transport and insurance costs incurred by importers (Figure 3.8 Panel A).

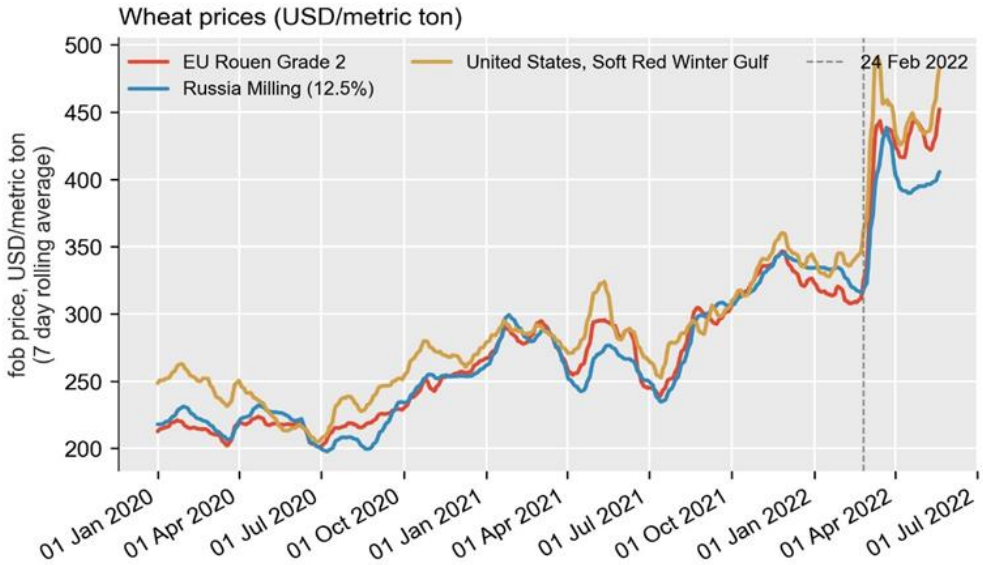
Some countries (in particular in North Africa and Near East) are heavily reliant on wheat imports from both Ukraine and Russia. This has already resulted in supply shortages and important price increases for net wheat importing countries. Export restrictions on wheat by Russia and India have added to market volatility and price rises.

Vegetable oil prices, too, have been rising particularly sharply since March 2022. Both Russia and Ukraine are major players in the sunflower oil market and combined account for approximately 60% of global sunflower oil production and approximately 80% of global sunflower oil exports. There has been a severe impact on global sunflower oil supply due to transport disruptions from the Black Sea region, following Russia's full-scale invasion of Ukraine. This resulted in sunflower oil prices soaring to unprecedented levels in Q1 2022.

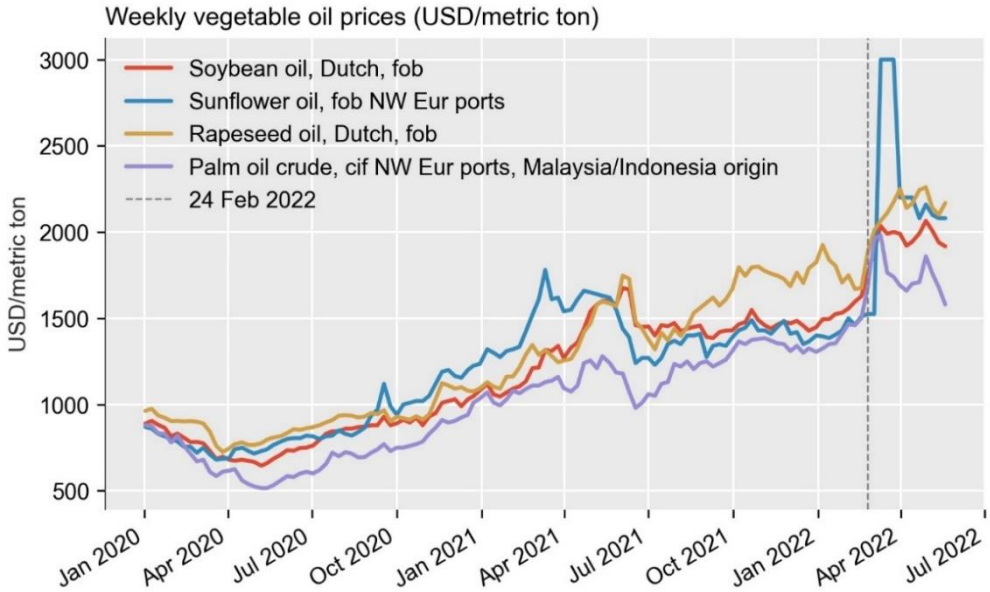
EU sunflower oil prices rose sharply in the first week of March 2022 following an announcement by the government of Russia to implement an export quota (1.5 million tons on sunflower oil, effective from 15 April). Palm oil prices were impacted by Indonesian policy changes (alternating between a relaxation of domestic-use requirements and an export ban), while elevated rapeseed oil prices are mainly due to a very low Canadian harvest in 2021 (a third less compared to the previous year).

Figure 3.8. Agricultural commodity prices rose sharply at the start of 2022

Panel A



Panel B



Source: Panel A: International Grains Council, Panel B: oilworld.de.

3.2. Supply chain dependencies

Further insights into economic impacts through international supply chain dependencies can be gained from inter-country input-output (ICIO) analysis which allows tracing where value added is generated and where it is consumed, including indirect trade links. This section relies on preliminary OECD ICIO tables

that have been modified to include Ukraine and Belarus[12] and that are used to assess the dependency of Russia and its trading partners on trade with Russia.

In value added terms, Russia's trading partners may rely on Russia in two principal ways. First, they may rely on Russian inputs for production and these inputs enable their own value addition. Second, the value added embodied in final or intermediate products these countries produce may be consumed by Russian firms or consumers. Russia depends on its trading partners in the same way and such dependencies may be direct or indirect (i.e. involving trade flows passing through other countries). The OECD ICIO tables and TiVA data trace value added from their country of origin to the country of final consumption and are thus a useful accounting framework for considering the economic implications of Russia's war against Ukraine and the ensuing sanctions.

Two exercises involving manipulation of the OECD ICIO tables have been performed to, first, estimate the extent of economic dependency on Russia and, second, to assess the significance of the announced sanctions.

Dependencies on and of Russia

The reliance of different countries and industries on Russia has been assessed through a 'hypothetical extraction' which consists of setting to zero all trade flows involving Russia (as exporter or importer) both for trade in intermediate products and final products. As a summary indicator of dependencies, the hypothetical changes in value added are calculated and added up to yield a hypothetical GDP. While for several reasons the resulting difference with the actual GDP cannot be directly interpreted as a GDP impact of Russia's full trade isolation and therefore it is not directly comparable with the results of the CGE modelling presented in Section 3.4, it is an indication of the overall reliance on trade with Russia.[13]

As far as OECD economies are concerned, the most dependent economies are the Baltic States (Lithuania, Estonia and Latvia), followed by Finland and Slovenia. However, the overall difference in GDP remains relatively small (-3.1% for Lithuania, the most exposed country to trade with Russia). The difference in GDP stems both from the lower final demand in Russia (no imports of final goods) and lower demand for intermediate products used by Russian industries (no imports of intermediate inputs). GDP is also reduced through Russian intermediate inputs that are no longer available in OECD countries and reduce the gross output of industries using such inputs.[14] The relatively small GDP differences reflect the fact that the Russian economy is relatively small and closed. It is also not well integrated in global value chains and trade sanctions were already put in place after the annexation of Crimea in 2014. European

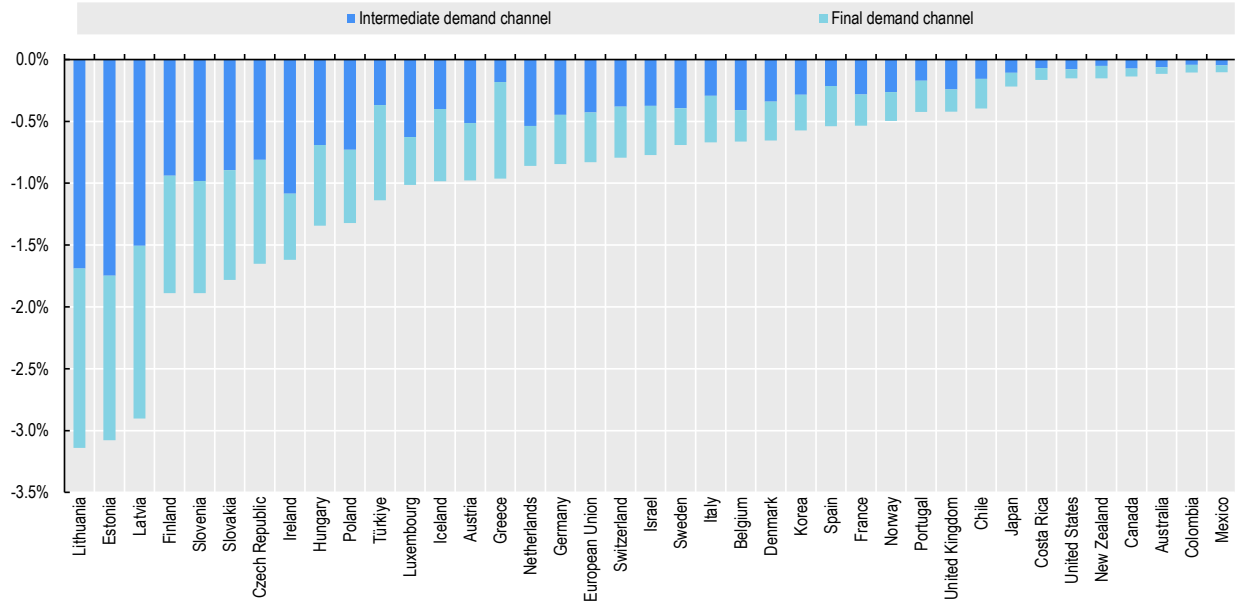
[12] This is joint work between the Trade and Agriculture Directorate and the Directorate for Science, Technology and Innovation. The data are preliminary, as the full inclusion of Ukraine in the TiVA database (and Belarus, an important 'country of transit' for Russian and Ukrainian value added) is ongoing. In particular, some trade flows and sectoral information for Ukraine and Belarus are still roughly estimated and are likely to change when the analysis is refined in the future. However, as compared to the 2021 edition of the TiVA database, value-added trade flows for Russia (and other countries for which Russia plays an important role in supply chains) are better estimated with these preliminary tables because of the inclusion of Ukraine and Belarus (two countries that are otherwise merged into a broader 'rest of the world').

[13] The hypothetical GDP that was calculated should not be interpreted as the expected decrease in GDP if Russia was to become an autarkic economy. The input-output model does not include elasticities and substitution effects to properly model the way economies would adjust if no trade were possible with Russia (see below the sub-Section 3.4 on CGE modelling of reduced Russian trade which allows for such adjustments). The results are thus rather an indication of the extent to which the GDP of each country relies on trade with Russia based on the current configuration of trade relations and global value chains (and not trying to assess the change in trade or GVCs that would result from no trade with Russia). The simulations are run over five years (2014-2018) and an average is calculated because the first trade sanctions were imposed on Russia in 2014 (annexation of Crimea) and the price of oil and other commodities had significant fluctuations between 2014 and 2018. ICIO tables are in current prices and affected by the change in prices in addition to the structure of GVCs. Moreover, there was a slowdown in the fragmentation of production in 2014-2016 and an expansion again in 2016-2018. The average helps to smooth out these short-term trends.

[14] Since there is no substitution effect, Russian inputs are not replaced. Gross output is lowered so as to remove the part accounted for by Russian intermediate inputs and to keep the share of value added in gross output unchanged (so the value added of industries using Russian inputs also becomes lower). The impact on value added is small as Russian inputs generally account for a low share of gross output.

economies and Türkiye are the most dependent while OECD countries from Asia and the Americas are less so, with GDP differences below 0.5%.

Figure 3.9. Difference in GDP (%) for OECD countries, when trade flows with Russia are set to zero



Source: OECD calculations based on modified OECD inter-country input-output tables.

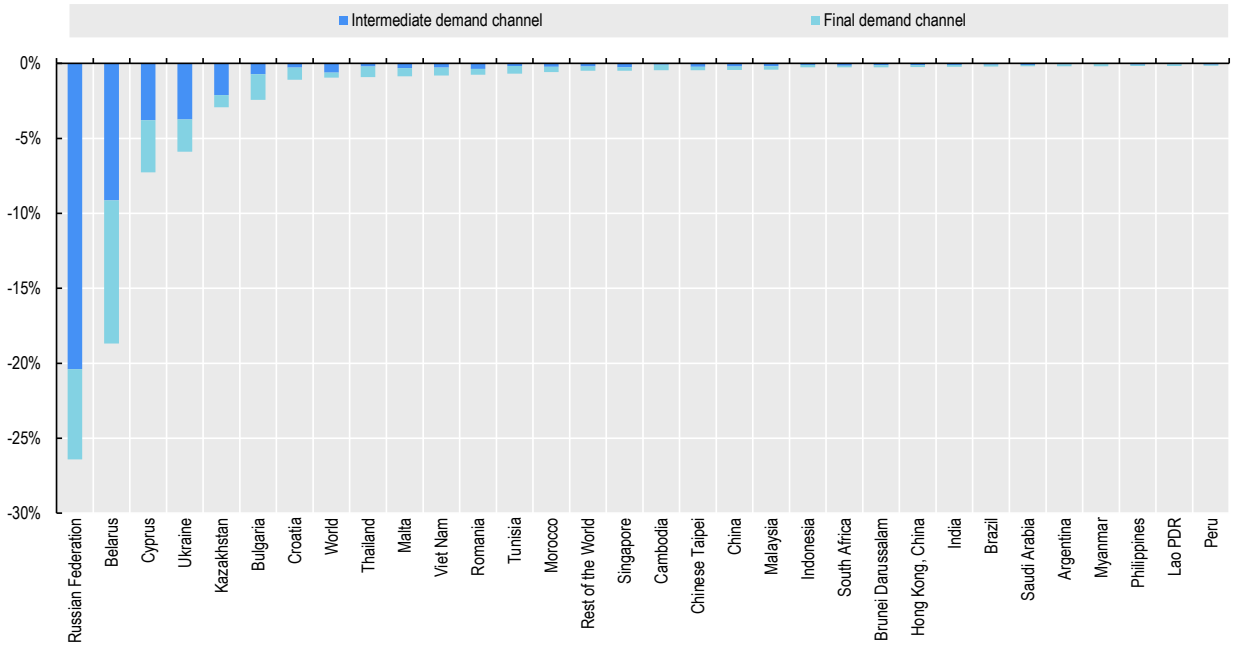
Among non-OECD economies, Russia is not surprisingly the most dependent country as indicated by the 26.4% difference in GDP which is in fact the share of its GDP that depends on trade.[15] Because of their linkages with the Russian economy, Belarus and to a lesser extent Cyprus and Ukraine are also economies where a significant dependency is observed (Figure 3.10). For the world as a whole, however, trade with Russia accounts for a tiny share of GDP (0.9%) and for countries like China or Brazil, trade with Russia is even less important.

At the aggregate level, trade dependencies on Russia are moderate but results for specific industries and specific countries can highlight more important links. Starting with Russia itself (Figure 3.11)), energy products (oil & gas and coal & lignite) and non-energy products, as well as coke and petroleum (which is the industry further downstream where oil, gas and coal are processed) are highly dependent on exports. Basic metals, chemicals and wood are also industries where more than half of value added depends on trade. Lower shares are observed for processed goods (that are coming from industries not contributing a high share of value added in Russian GDP). For services, some sectors such as transport services (land transport in particular) are significantly trade dependent while also being in absolute terms important industries in Russian GDP.

This analysis suggests that trade sanctions matter for Russia as they affect the energy sector which has a high share in its GDP and where substitutability in terms of export destinations may be limited. For example, exports of oil and natural gas are constrained by the network of existing pipelines with bottlenecks in infrastructure for alternative exports (see also Section 3.4 for the results of CGE modelling of an embargo of imports of Russian oil).

[15] Note that this statistic is different from the traditional 'trade to GDP ratio' which is not a value- added concept and involves some double counting. According to World Bank data, Russia's gross trade to GDP ratio was 49% in 2019. The figure is higher than the estimated 26.4% because of the double counting of intermediate inputs and foreign value added included in Russian exports. Trade accounts for a lower share of Russian GDP in value-added terms when those elements are netted out.

Figure 3.10. Difference in GDP (%) for non-OECD economies, when trade flows with Russia are set to zero



Source: OECD calculations based on modified OECD inter-country input-output tables.

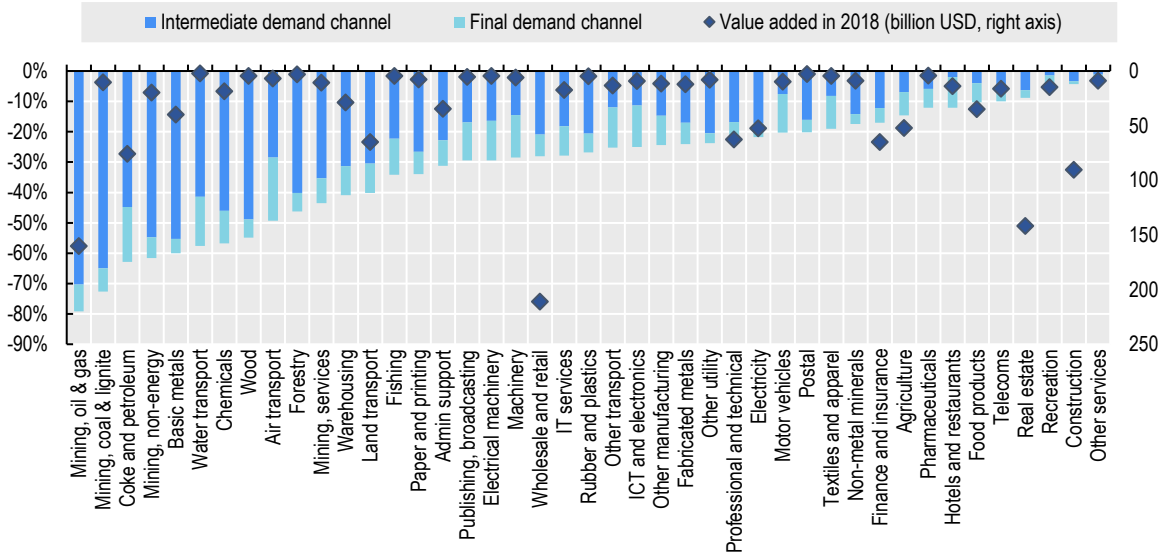
Large differences in value added are also observed for some industries in Belarus (not shown here) and Ukraine (Figure 3.12) illustrating the important role of supply chain linkages between these countries before the war. For example, 62% of value added in the Belarus' electrical machinery depends on Russia. For the motor vehicles industry (which is also an important sector in Belarus), a high difference in value added is also observed (-53%) driven by Russia's final demand. These results highlight the high interdependence between the Russian economy and Belarus.

A somewhat lower - but still overall substantial - interdependence is observed between Ukraine and Russia signalling potentially severe consequences for the Ukrainian economy in the post-war period. Mining services, IT services or air transport are the industries which are the most connected to the Russian economy (Figure 3.12). Paper and printing, machinery, water transport, publishing and broadcasting, as well as other manufacturing (including furniture, jewellery, toys and repair activities) are also strongly connected (15% or more of value added depending on trade with Russia). In absolute terms, wholesale & retail is the sector with the highest decline in value added when there is no trade with Russia, despite a marginal dependency. IT services is the sector where the relatively high dependency on Russia translates into significant GDP loss (about half a billion USD).

Beyond Belarus and Ukraine, there are very few industries where more than 15% of value depends on trade with Russia. The highest values are for ICT & electronics in Kazakhstan, mining services in Cyprus and air transport in Lithuania. In absolute terms, one can see the dependencies of some European countries in energy-related sectors. Moreover, some industries in China are also closely linked with Russia. This is the case for China's wholesale and retail trade (minus USD 7.7 billion) and ICT & electronics (minus USD 5.3 billion). But these figures are still rather small.

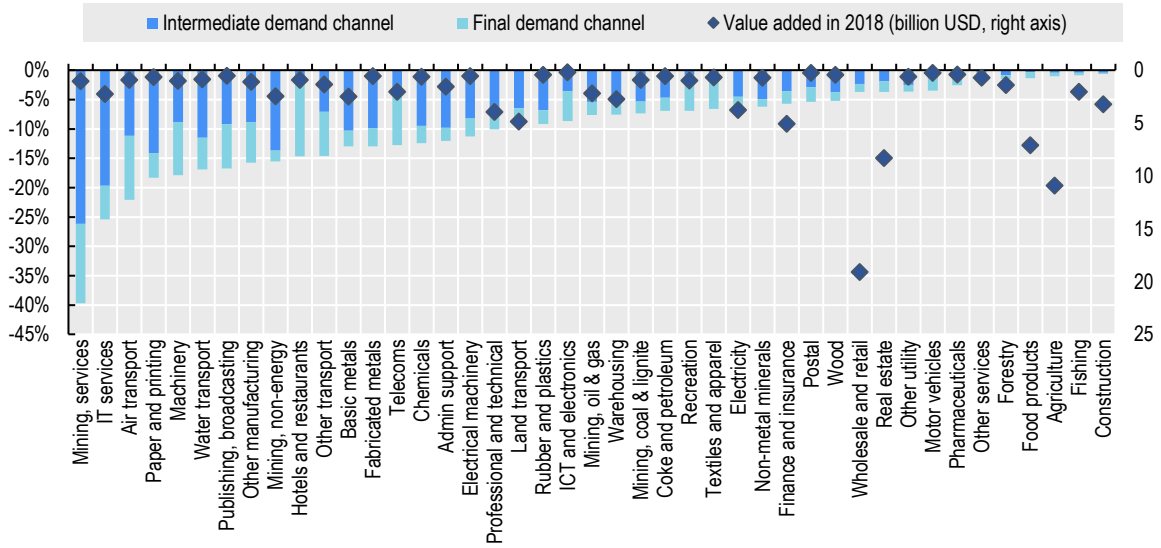
When considering the impact of reducing the flow of inputs imported from Russia an important caveat needs to be made. The hypothetical extraction approach only accounts for a reduction in the value of output in importing countries proportional to their (usually small) value. However, among these small values can be essential specialised inputs with limited alternative sourcing (Section 3.1). Breaking linkages between industries involving Russian trade could still lead to significant disruptions, with potentially larger economy-wide implications, if whole assembly lines are stopped because certain specific key inputs are not available. TiVA data and ICIO techniques used in this report cannot adequately account for this type of very specific criticality.

Figure 3.11. Difference in value added (% and USD billion) for Russian industries, when trade flows with Russia are set to zero



Source: OECD calculations based on modified OECD inter-country input-output tables.

Figure 3.12. Difference in value added (% and USD billion) for Ukrainian industries, when trade flows with Russia are set to zero



Source: OECD calculations based on modified OECD inter-country input-output tables.

3.3. Trade implications of the war and reduced trade relations with Russia

Assessing the trade implications of the war and associated sanctions is complex, not least because some of the measures are targeted to specific products, for example bans on exports of certain products from the European Union to Russia, or are working through restrictions on finance, and, more recently, impacting transport costs through restricting access to ship cargo insurance. Some of the sanctions might also be circumvented, for example via transhipments. Added to this is the difficulty of assessing the trade impact of the war on the Ukrainian economy, including its exports and imports. While it is certainly not a complete assessment, this report uses two related and complementary approaches.

The first is using the ICIO and TiVA approach used already in Section 3.2. This helps to identify the exposure to trade disruptions as a consequence to war and the channels through which trade and production may be impacted (including through departure of multinational firms from Russia). This method keeps prices fixed and does not allow for any substitution, domestically or through trade, to cushion the impacts of disruptions. It also does not account for product and factor market adjustments that are expected to be at work when factors of production are less than fully employed. This approach can thus be considered as portraying maximum exposure or short term impacts when typical economic adjustments have not yet occurred. The second approach relaxes some of those rigidities using the OECD METRO model to gauge the impacts in the medium term, when markets adjustments can play out. Allowing for adjustments in the sourcing of inputs, the re-balancing of product markets as well markets for labour and capital enable a more comprehensive picture of the trade and economic impacts to be drawn. It should be noted that neither approach can estimate the full cost of the war. The loss of lives and destruction of capital, infrastructure, livestock and farm grounds is not in the scope of the analysis, which is more limited to assessing some of the trade and broad macro-economic implications.

Exposure to trade disruptions using the Inter-Country Input-Output tables approach

The first approach builds on the hypothetical extraction approach introduced already in Section 3.2 and involves an additional scaling of the trade dependencies on Russia and Belarus so as to reflect the coverage of some of the announced trade and financial sanctions.[16] In addition, some broad assumptions with respect to the impact of Russia's war against Ukraine's trade flows are also reflected. While this approach cannot reliably indicate the GDP impacts of the trade sanctions, it can help identify the most directly exposed countries and sectors through final demand and input-output linkages, this time reflecting more closely how countries decided or are planning to limit their trade with Russia in the context of sanctions (Box 3.1).[17]

Box 3.1. Parameters for the second hypothetical extraction using the ICIO approach, war and trade reduction

To gauge the exposure to trade sanctions on Russia and Belarus, as well as retaliatory measures from Russia and the impact of the war on Ukrainian trade, trade flows in the input-output matrix are modified in the following way (with the same changes for intermediate products and final products).

- Trade flows between Russia, Australia, Canada, Chinese Taipei, Japan, Korea, Switzerland, the United Kingdom, the United States, and all European Union countries are reduced by 40% for all industries. The same reduction is applied to trade with Belarus. This is meant to reflect the combined impact of tariffs, bans on trade in specific products and devaluation of the rouble, as well as retaliatory measures from Russia.
- Trade flows between Russia and Australia, Canada, Chinese Taipei, Japan, Korea, Switzerland, the United Kingdom, the United States, and all European Union countries are reduced by 50% in the financial services sector. A higher percentage is applied to this industry to mimic the consequence of financial sanctions.
- Trade between Russia and the United States is set to zero for industries producing energy products (Mining of coal and lignite, Extraction of crude petroleum and natural gas, Coke and refined petroleum products). The same applies to bilateral trade between Russia and

[16] Here we rely on the list of sanctions compiled by Chad Bown at the Peterson's Institute for International Economics: https://www.piie.com/blogs/realtime-economic-issues-watch/russias-war-ukraine-sanctions-timeline#.Yi-v_CEx3o0.linkedin (as of June 2022).

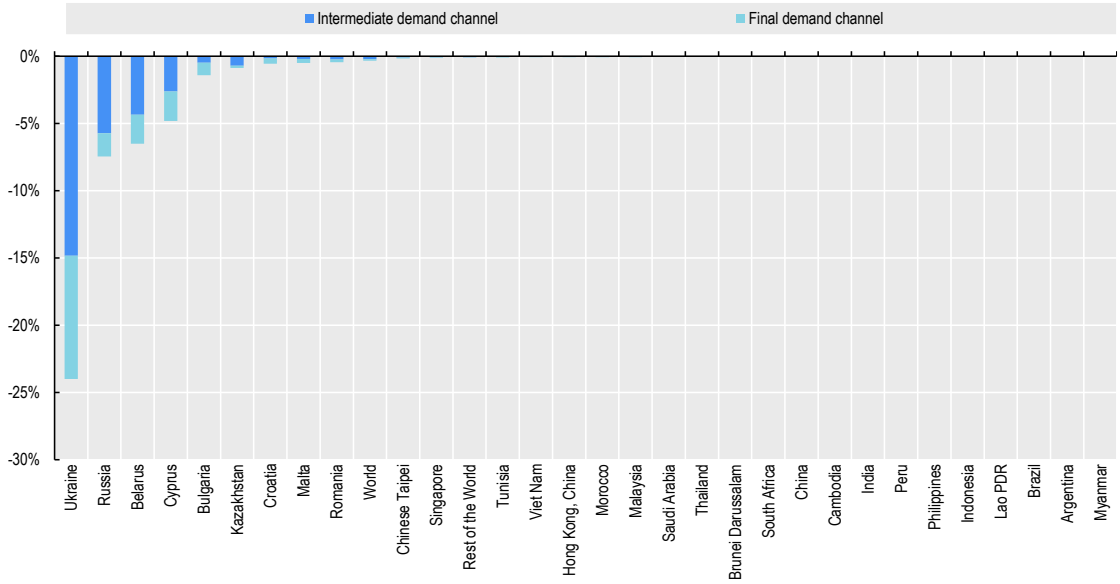
[17] While the calibration of trade dependencies due to sanctions is based on the best available information, their modelling in the input-output model has considerable limitations. These include: the aggregation of industries (where products under sanctions are mixed with other products); the fact that some of these sanctions affect access to finance or exchange rates; and the fact that there are no substitution effects in the framework, implying that import tariffs for example cannot be accurately modelled.

Canada. This reflects the ban on imports of energy products implemented by the United States and Canada.

- Trade flows between Russia and Australia, Canada, Chinese Taipei, Japan, Korea, Switzerland, the United Kingdom, the United States, and all European Union countries are set to zero for air transport, as a consequence of the airspace being closed for their respective aircrafts.
- Trade flows between Ukraine and all countries are reduced by 70%, to approximate the consequences of the war. Trade between Ukraine and Russia and Belarus is set to zero.

Ukraine, with a 24% decline in its simulated GDP, is most impacted and this is mainly due to the assumption of the significantly reduced trade flows in the context of the war (Figure 3.13). Russia and Belarus are also significantly exposed (with overall impacts respectively -7.4% and -6.5%). This already signals that the impact of trade reductions that were announced on Russia is lower than the trade impact of the war on Ukraine, which in itself is only a part of the wider economic cost. This is even if the latter is still assessed narrowly by considering only trade impacts and not accounting for all the wider destruction in Ukraine that affects domestic activities and will in all likelihood lead to much higher reductions in GDP than those that can be gauged from the trade dependencies.

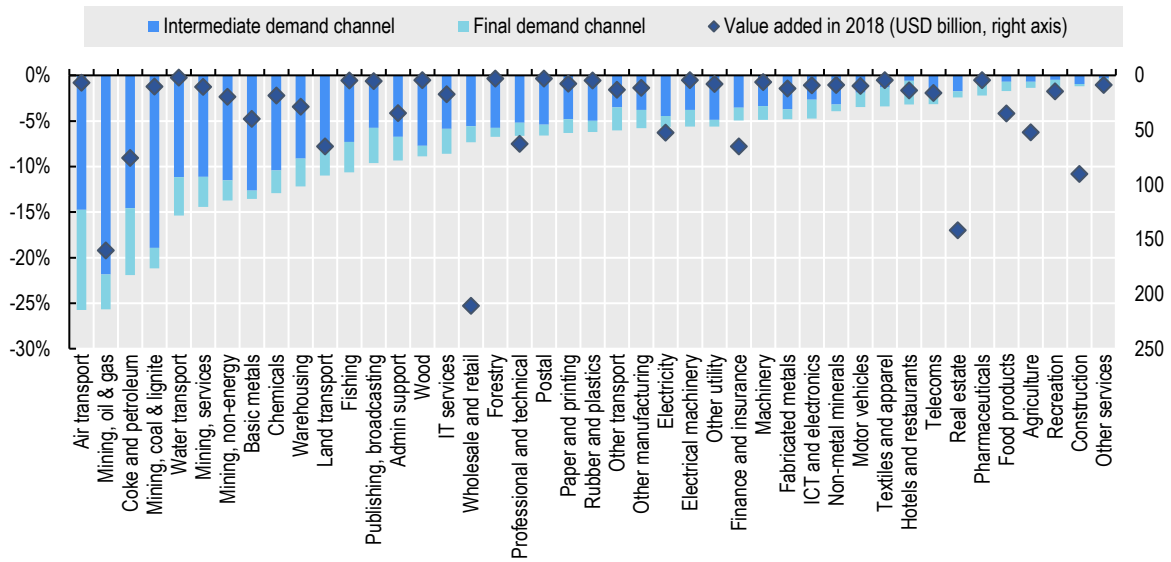
Figure 3.13. Difference in GDP (%) of non-OECD economies, considering the trade reduction and the possible impact of the war



Source: OECD calculations based on modified OECD inter-country input-output tables.

The comparison of differences in GDP for Russia between Figure 3.10 and Figure 3.13 suggests that approximately less than one third of Russia's exposure is covered by trade reductions. While 26.4% of Russian GDP depends on trade overall, only 7.4% of GDP is exposed to the trade-related measures considered here (see Box 3.1 for the scope of the trade reductions considered). As far as industries are concerned, air transport is the most exposed industry in Russia (with a 25.7% difference in value added), due to the ban of Russian aircrafts from the airspace of countries implementing measures (Figure 3.14). But extractive industries and coke and petroleum are significantly exposed in relative terms and carry a much higher weight in Russia's economy, leading to high absolute value-added reductions (minus USD 31 billion for mining, oil & gas).

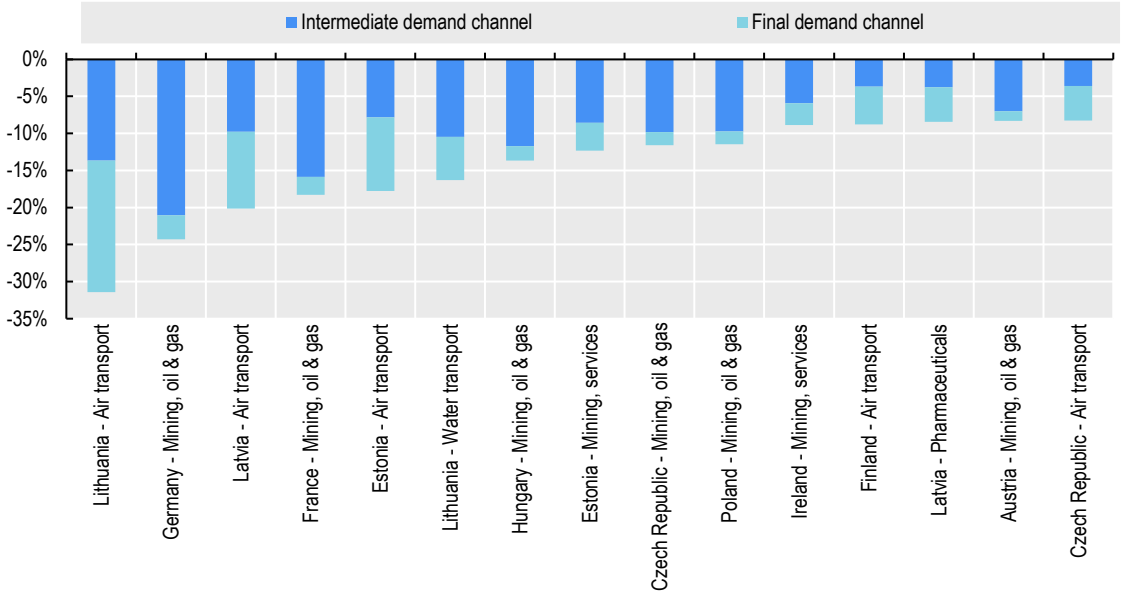
Figure 3.14. Difference in value added (% and USD billion) for Russian industries, considering the trade reduction and the possible impact of the war



Source: OECD calculations based on modified OECD inter-country input-output tables.

Within OECD economies, the biggest exposures are found in the air transport industry for Lithuania, Latvia and Estonia, as well as in the oil and gas extraction industries in Germany and France (Figure 3.15). While oil and gas are coming from Russia, Germany and France are home to related activities in the operation of the infrastructure needed to import and process the primary energy inputs. In the case of air transport, countries with previously a significant number of flights to or from Russia (such as Lithuania, Latvia or Estonia) also appear among the most exposed.

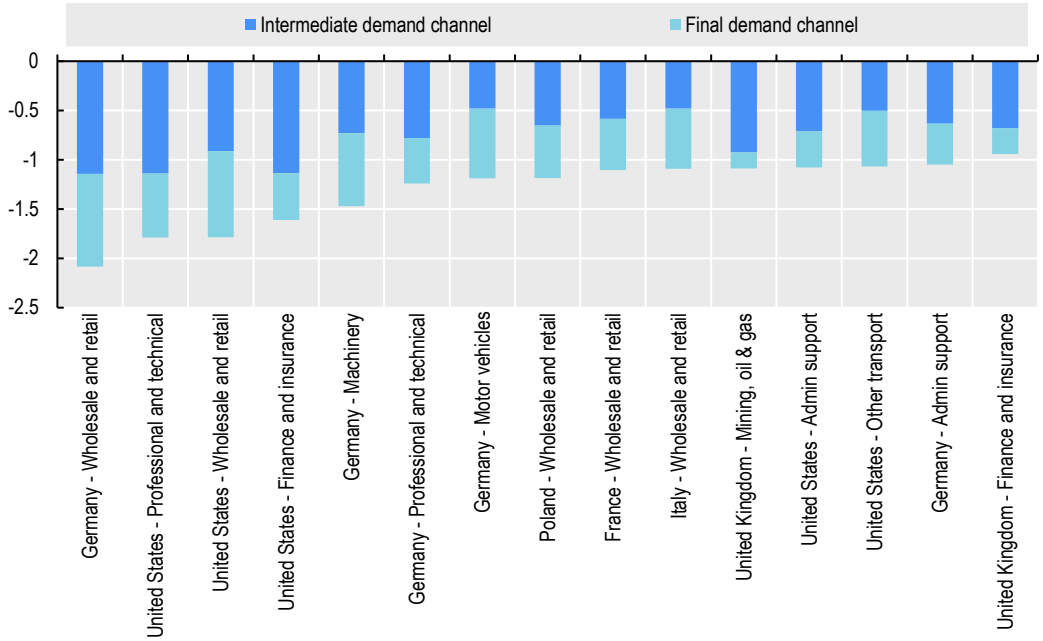
Figure 3.15. Difference in value added (%) for industries in selected OECD countries, considering the trade reductions and the possible impact of the war (top 15 highest differences)



Source: OECD calculations based on modified OECD inter-country input-output tables.

In value terms (using 2018 value added data), some other industries are also significantly exposed, including wholesale & retail trade in Germany and the United States, professional, scientific and technical services in the United States or finance and insurance in the United States (Figure 3.16). Direct exports of such services are exposed to the war and trade sanctions but the exposure is also indirect through input-output linkages (e.g. professional, scientific and technical services provided to the mining industry). In absolute terms, the difference in value added observed in the mining industry for oil and gas appears higher in the United Kingdom than in Germany or France.

Figure 3.16. Difference in value added (USD billion) by industry for selected OECD countries, considering the trade reductions and the possible impact of the war (top 15 highest differences)



Source: OECD calculations based on modified OECD inter-country input-output tables.

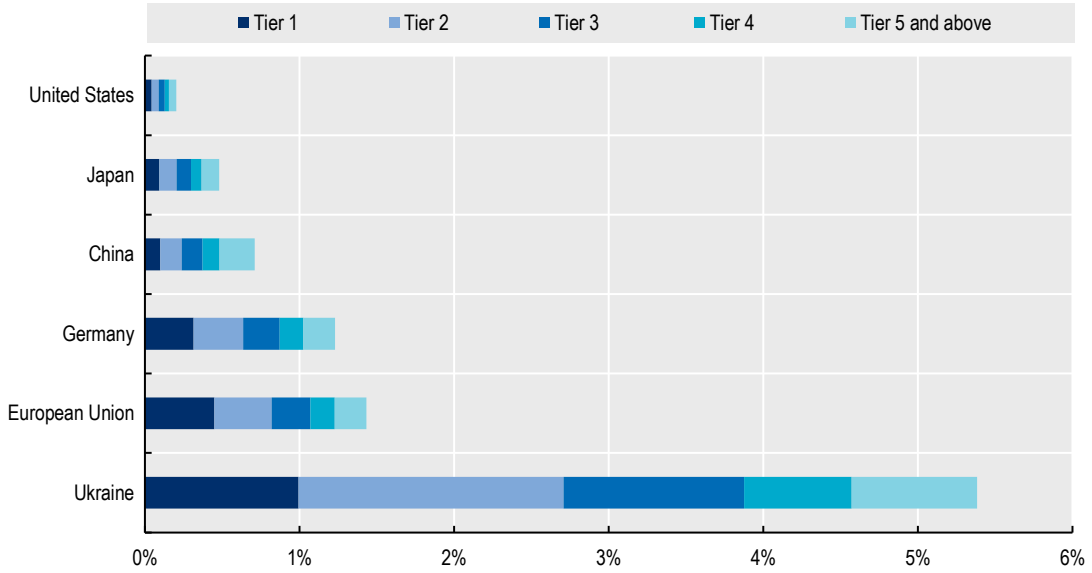
Russian value added in exports, a decomposition by production stage

The Russian value added embodied in exports of OECD countries is generally small.[18] For the OECD as a whole, the Russian value-added content of total exports is 0.9%. It tends to be higher for European countries (1.4% for the European Union as whole, Figure 3.17). In addition, this value added is often not part of direct imports from Russia but is coming indirectly through imports from other countries and the ICIO approach allows estimation of exposure to indirect trade with Russia. Figure 3.15 presents a decomposition by production stage, where Tier 1 corresponds to direct imports of intermediate inputs from Russia while Tier 2, Tier 3, etc., involve intermediate inputs more upstream in the value chain. The implication is that trade measures on Russia would be more efficient if applied to upstream imports than to direct imports.

The same chart highlights also that, before the large-scale war, Ukraine had a significant share of Russian value added in its exports (5.4%) with one percentage point coming from direct imports of intermediate inputs. Diversifying away from Russia would therefore involve identifying the transit countries from which most of Russian value added is coming from more upstream in the value chain.

[18] Note that the value-added content of gross exports and the value-added content of gross output is the same when expressed as a share.

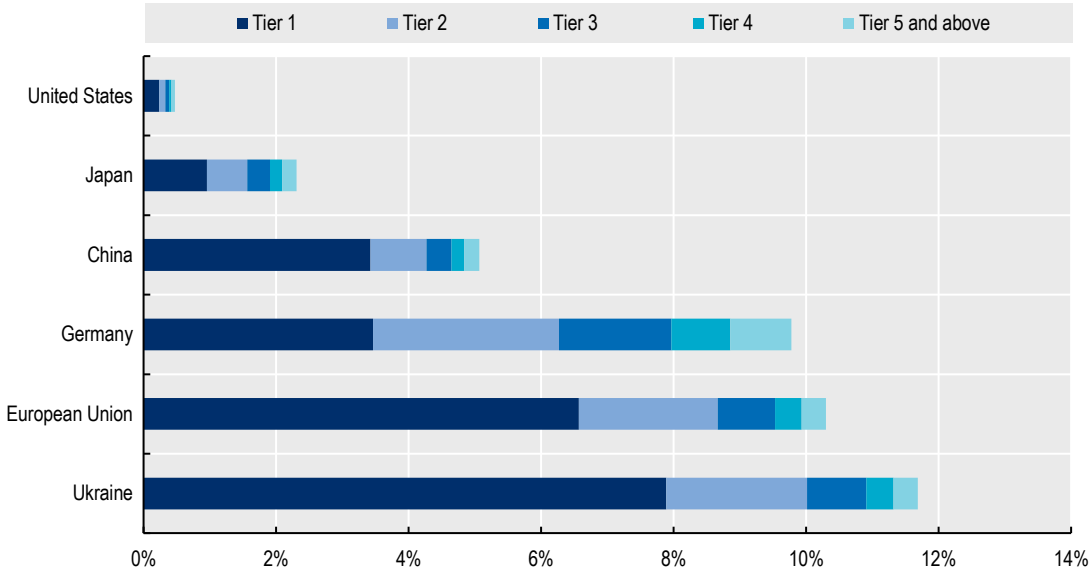
Figure 3.17. Russian value added in total exports, by production stage (2018)



Source: OECD calculations based on modified OECD inter-country input-output tables.

Some specific industries have higher shares of Russian value added in their exports. This is, for example, the case for coke and refined petroleum products, which is the industry relying most on Russian oil (Figure 3.18). 11.7% of the gross exports (or output) of the European Union is value added originating in Russia. The figure for Germany is 10.3%. Unlike for total countries' exports, Russia's contribution to this industry's value added tends to be concentrated in direct imports from Russia. It suggests that trade bans on oil and gas might be particularly effective, but they are also likely to have a higher economic impact for the countries relying on Russian inputs.

Figure 3.18. Russian value added in exports of coke and refined petroleum products, by production stage (2018)



Source: Authors' calculations based on modified OECD inter-country input-output tables.

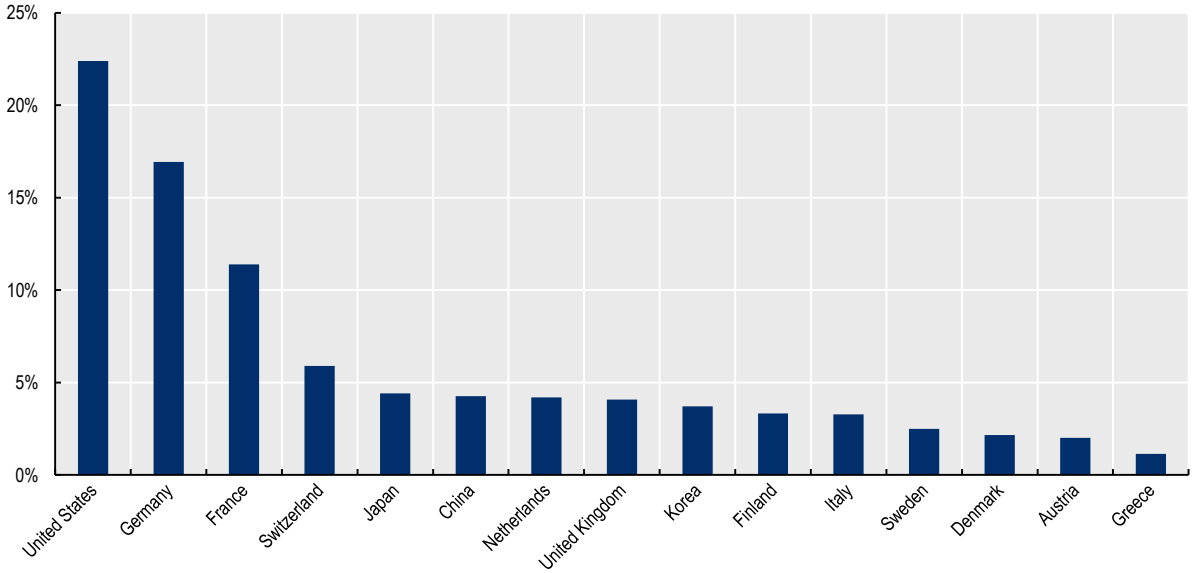
Russia's exposure to departure of multinationals – insights from the OECD analytical AMNE database

The possible consequences for Russia of multinational enterprises (MNEs) leaving the country, be it as a consequence of the sanctions or voluntarily, can be gauged using similar ICIO techniques but applied in this case to the analytical AMNE database which is an extension of the OECD TiVA database that includes data on activities of foreign affiliates.

In 2016 (the latest year available), foreign affiliates established in Russia accounted for 4.8% of gross output (as compared to an average of 11% for the world) and OECD countries that have implemented sanctions are the main foreign investors in Russia (Figure 3.19). China is the only non-OECD parent economy with a share of output above 1% and it accounts for a relatively modest share of multinational production (4.3%). Most of the output of foreign affiliates in Russia involves companies from the United States (22.4%), Germany (16.9%) and France (11.4%).

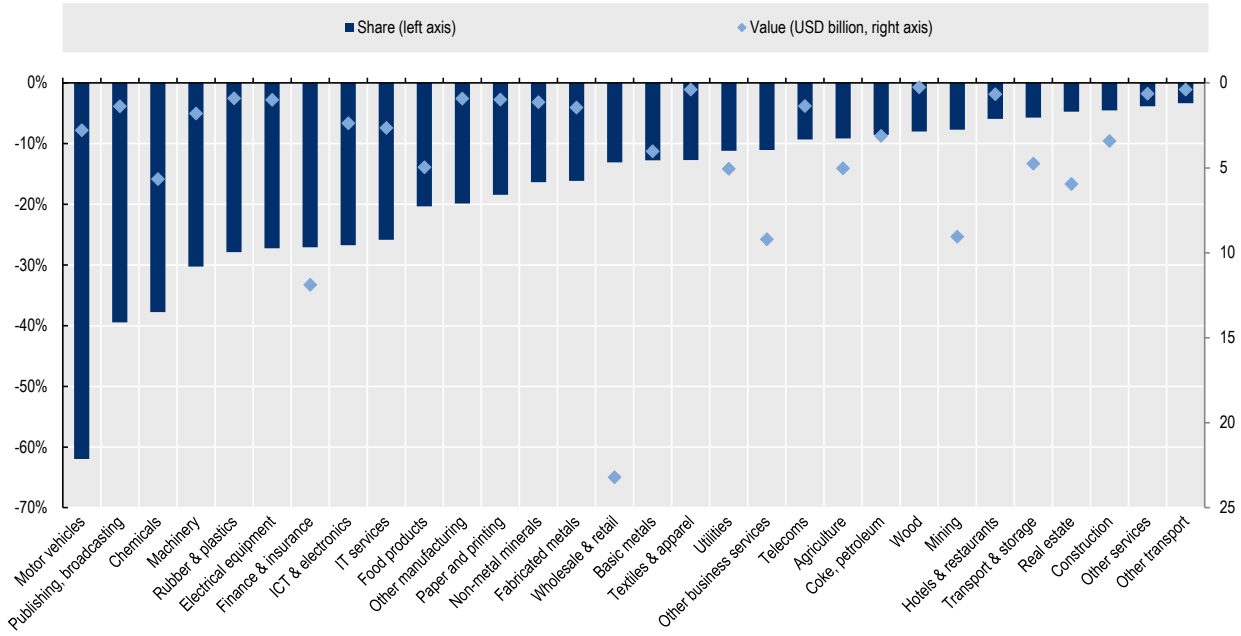
As it was done with trade flows, a hypothetical extraction in the inter-country input-output tables of the analytical AMNE database can be undertaken to remove all the output of foreign-owned firms and assess the impact on Russian industries. As a result, a very high difference is observed in the motor vehicles industry (-62%), followed by publishing, audiovisual and broadcasting activities (-39.5%) and chemicals (-37.8%) (Figure 3.20). In absolute terms, however, wholesale & retail trade is the sector recording the highest difference in value added, followed by finance and insurance, and mining (Figure 3.20).

Figure 3.19. Output of foreign affiliates in Russia, by parent country (2016)



Source: OECD analytical AMNE database.

Figure 3.20. Decrease in value added when removing the output of foreign affiliates in Russia



Source: OECD analytical AMNE database.

Economic impacts and adjustments to trade disruptions using the OECD METRO model

Taking the ICIO analytical assessment of trade and economic impacts a step further to account for adjustments in input sourcing and on output and factor markets, this subsection uses an economy-wide general equilibrium model.

The OECD METRO model (OECD, 2020[1]), like other global CGE models, is well suited to analyse economy-wide implications of trade measures with complex links and interactions between sectors and economies. CGE models can measure the direct and indirect effects on output, income and prices (which are not captured in ICIO analysis) with greater detail at the sector level than macro models. Accordingly, the analyses presented in this subsection adds to the literature of CGE analysis looking into the past and current economic sanctions on Russia (Kutlina-Dimitrova (2015[2]), Chepeliev, Hertel and van der Mensbrugghe (2022[3]), Mahlstein et al. (2022[4]), WTO (2022[5]), Nilsson, Antimiani and Schmitz (2022[6])).

The METRO model is comparative static and in this exercise it is set up so as to account for adjustments that occur in medium term where production factors are mobile across sectors but the overall endowment of labour and capital remain fixed and fully employed (normally understood to be five to ten years). In the oil dependency scenarios, substitution between trade partners and domestic versus imported products is further constrained by reducing substitution elasticities across all products and partners to account for, among other things, infrastructure requirements that might be required for such large changes in the level and direction of trade.[19] In addition, under the 'short-term scenario', the ability of G7 plus countries and China to quickly change their suppliers of oil and oil products is limited (see Section 3.3 for more detail).

Like with all models, there are some limitations to keep in mind. CGE models may not capture the full cost of the transition away from trade with Russia of certain products (e.g. the cost required for building new

[19] Elasticities are sourced from the GTAP database. In the short run analysis presented in the document, import elasticities on all products were reduced by 30% under the assumptions that substitution between exporters, particularly oil and oil products, are more difficult in the short run. Reducing elasticities to further emphasise the short-term nature of the analysis is common approach applied by recent studies on the Russia-Ukraine crisis including WTO (2022[5]) and Chepeliev, Hertel and van der Mensbrugghe (2022[3]). As a sensitivity check, the simulation on the 'medium term' oil ban scenario was run using the default GTAP elasticities. While the macro effects are generally slightly smaller with the larger substitution elasticities, the direction and relative magnitude of the results remain largely the same.

pipelines needed to access non- Russian oil). The static nature of the analysis implies fixed capital stocks. Moreover, there is no foreign direct investment in the model. Changes to the amount of capital in an economy either through domestic capital accumulation or changes in foreign direct investment, due to for example foreign companies refusing to do business in Russia, are not captured in the analysis. This could underestimate the medium-term impact of scenarios looking at the highly capital intensive energy sector. Additionally, while the model has a relatively high degree of sector disaggregation, it is not at the detail that can well capture trade dependencies or measures targeting specific products at the HS 6 level or higher. While typically specified at an industry level and therefore incapable of capturing the product or firm-level detail that can be accounted for using detailed trade or firm-level data, they build on economic theory and incorporate adjustment mechanisms which can be considered under different assumptions about how the economy functions, including elasticities which determine the magnitudes of such adjustments. Lastly, results can be sensitive to elasticities.

Two sets of "what if" simulations with METRO are used to assess the economic impact of reduced trade relations between Russia and a select group of countries. Given the importance of oil and oil products in Russian exports and the importance of Russia in global exports of oil, an oil embargo was one of economic sanctions considered first after Russia's full-scale invasion of Ukraine. Accordingly, the first analysis examines the economic impact of a scenario where G7 and Europe[20] cut oil imports from Russia by 100%. The second set of simulations examines the economic impact of a stylised scenario of reduced bilateral trade with Russia in all sectors. In this scenario, trade volumes in all sectors between Russia and G7, Europe, and Australia are reduced by 40%.

Box 3.2. METRO database and model configuration

For both sets of simulations, the model database with reference year 2017 is configured to allow for representation of major energy producers and importers as well as energy linkages in domestic industries and between economies. Non-energy sectors relevant in the current context (e.g. wheat, minerals, metals, and motor vehicles) were also considered when determining the database aggregation.

The resulting analysis database contains 25 countries and 29 sectors. Countries include Australia, China, Japan, India, Canada, United States, Mexico, Argentina, Brazil, United Kingdom, Norway, France, Germany, Italy, rest of Europe, Russia, Ukraine, rest of CIS, Saudi Arabia, Türkiye, Iran, Rest of Arab Gulf States, rest of MENA, Egypt, and Rest of the World. Sectors include Wheat, Cereal grains, Oil seeds, other Crops, other Agriculture, Oil, Gas, Coal, Other Extraction, Food and beverages, Other manufacturing, Petroleum and coal products, Chemicals and pharmaceuticals, Mineral products, Ferrous metals, Metal and metal products, Electronics, Machinery and equipment, Motor vehicles and parts, Gas manufacture and distribution, Trade, Transport nec, Water transport, Air transport, Communication, Financial and insurance services, Business services, Public Administration and defence, and Other services.

The database is also configured to reflect the post-2017 situation of lack of imports of gas, oil and oil products from the Islamic Republic of Iran into G7 countries and Europe. No particular assumptions about a post-COVID-19 economic recovery path are made.

In the configuration of the model used for the simulations — referred to as the model 'closure'— capital and labour stocks are assumed fixed, and factors are mobile between industries, but not between economies. All factors, including capital and labour, are fully employed and returns to land and capital and wage rates are flexible. Tax rates are fixed. Government expenditure as a share of final demand is fixed while the government balance is allowed to adjust. The trade balance is assumed flexible. Investment demand is also flexible, while the household savings rate is fixed.

[20] In the METRO Model analysis, reference to "G7" include the following countries which are separate regions in the model database: Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States. Reference to "Europe" covers the model regions Norway, Ukraine, and Rest of Europe. For the analysis in this document, rest of Europe is an aggregation of regions that include all EU27 regions except France, Germany, and Italy, as well as Albania, Serbia, GTAP regions rest of EFTA, and rest of Europe.

Reduced oil dependency on Russia

The first hypothetical scenario examined is one of reduced dependency on Russian oil. For this analysis, G7 and Europe are assumed to impose a ban on imports of Russian oil and oil products.[21] In this medium-term scenario, it is assumed the extra demand for non-Russian oil can be met from most existing alternative sources.

In addition to the medium-term scenario, rigidities which may arise when adjusting to the Russian oil import ban are assessed under alternative short-term assumptions about which regions can step in to fill the supply and demand gap created by the reduction in Russian oil imports of select economies (Table 3.5). In the short-term scenario, it is assumed the extra demand for non-Russian oil cannot be met from most existing alternative sources (including Canada, Mexico, the United States, Norway, Saudi Arabia, Rest of Gulf countries, and others, accounting together for about 80% of world oil and oil products exports). In addition, in this scenario, China's imports of Russian oil and oil products are capped at current levels so that China does not step in to absorb the excess supply of Russian oil and, at the same time, the increased demand for non-Russian oil by the OECD countries is not offset by a corresponding decline in Chinese demand for non-Russian oil. In this case, the adjustments are mainly through higher prices of imported oil from non-Russian sources and through lower prices of the now less demanded Russian oil.

Table 3.5. Oil dependency scenarios and their alternative adjustment assumptions

Scenario name	Countries which are restricted in filling the gap in oil supply by exporting more to G7 and Europe
Medium term	None
Short term	Canada, Mexico, United States, Norway, Iran, Saudi Arabia, Rest of Gulf countries, Rest of Europe, rest of CIS, rest of MENA, Rest of the World, and China maintain their imports from Russia at the base level

Note: In all scenarios, G7 and Europe reduce oil imports from Russia 99.9%. Countries banning Russian oil imports include: Canada, France, Germany, Italy, Japan, United Kingdom, United States, Rest of Europe, Norway, and Ukraine. Rest of Europe is an aggregation of regions that include all EU27 regions except France, Germany, and Italy, as well as Albania, Serbia, GTAP regions, rest of EFTA, and rest of Europe.
Source: Authors' compilation.

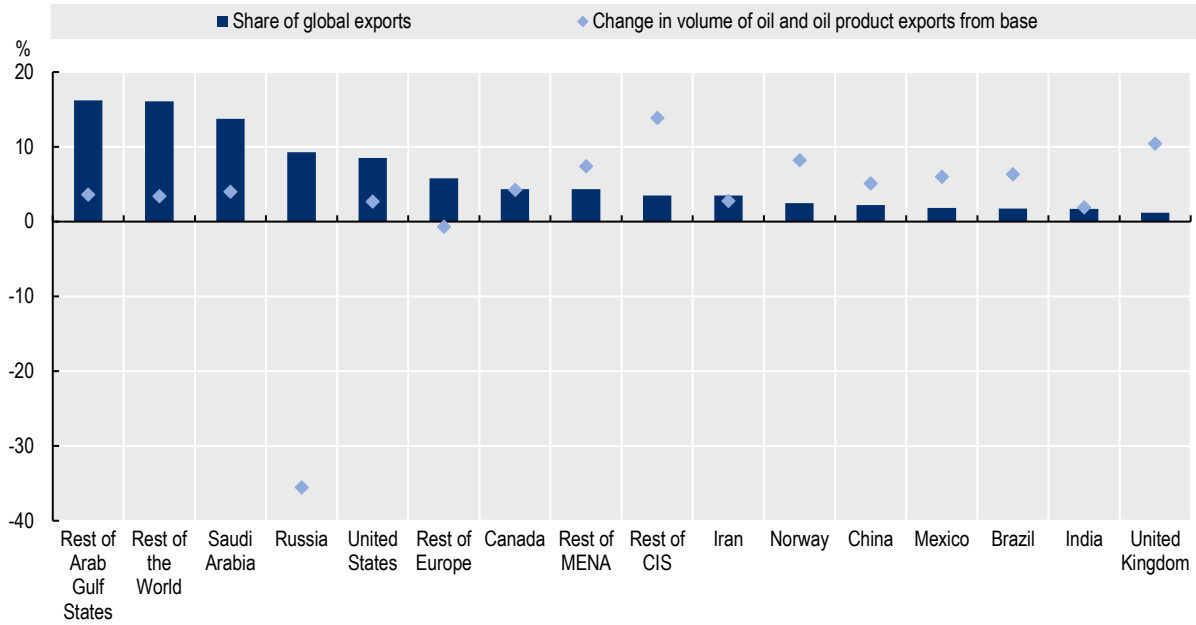
What would be the costs of drastically reducing dependency on Russian oil in the medium-run when supply increases and international trade of oil adjusts?

In the medium-term scenario, higher prices induce greater non-Russian oil production by all the other current exporters along existing oil supply chains to satisfy the extra demand for non-Russian oil in the G7 and Europe. The increase in supply is in line with the model's standard supply and substitution elasticities and reflects market shares and costs. The countries supplying more oil include the traditional large oil producers outside the G7 countries and Europe, such as Saudi Arabia and the Rest of Gulf countries, as well as smaller producers (Figure 3.21). However, even if OPEC Gulf States decided not to ramp up production, simulations which are not presented in this document indicate that increased sourcing of oil from G7 and within Europe, including Norway as well as from Mexico, would greatly contribute to minimizing the costs of the reduction in Russian oil dependency.

[21] Technically, this is implemented in the model through an introduction of a near prohibitive tariff while also making an assumption that the extra tariff revenue is not spent but set aside in the form of government savings (so it does not directly influence the aggregate demand).

Figure 3.21. Other producers would have price incentives to increase export volumes in the medium-term in the case of drastically reduced imports from Russia by the G7 and EU

Oil and oil products export shares in the baseline and changes of export volumes, %



Source: OECD METRO model medium-term simulation. Showing only countries accounting for over 1% of world export supply.

These increases in production and exports from other oil producing countries in the medium-term scenario limit the costs of sanctions imposed on Russia for the rest of the world. The rebalancing is particularly important for countries like Germany and Italy, where the production increase and adjustment from the consuming country reduces the medium-term cost markedly (e.g. from 2.9% of household income loss in the short-term to 0.8% in the medium-term for Germany and from 2.1% to 0.5% for Italy).

The medium-term scenario shows also that there is a large rebalancing of bilateral oil trade flows (Figure 3.22). While the countries reducing Russian oil dependency source more oil from established suppliers in existing trade links, other countries absorb some, but not all, of the excess Russian oil: China, Türkiye and many less developed economies increase their imports, at a price discount for Russian oil that the model estimates at above 30%. India also slightly increases its imports, but the volumes are not substantial.

The model produces several metrics that can be used to evaluate the overall economic impact of policy changes. The impact on real GDP, which is a commonly reported performance statistic, measures the income of the economy, accounting for changes in production (in value added terms) generated in different sectors of the economy. Nevertheless, in the context of this study a different measure is considered to be more appropriate. In a natural resource-dependent economies such as Russia where the structure of production can be very different form the structure of consumption, real GDP does not capture well the impact on purchasing power. This is why in this analysis the focus is on 'real household income changes', a measure which is defined as the adjustment in household income[22] that would be required at the base prices after the considered policy to attain the new level of utility (i.e. reflecting the concept of equivalent variation) and thus measures changes in economic welfare.

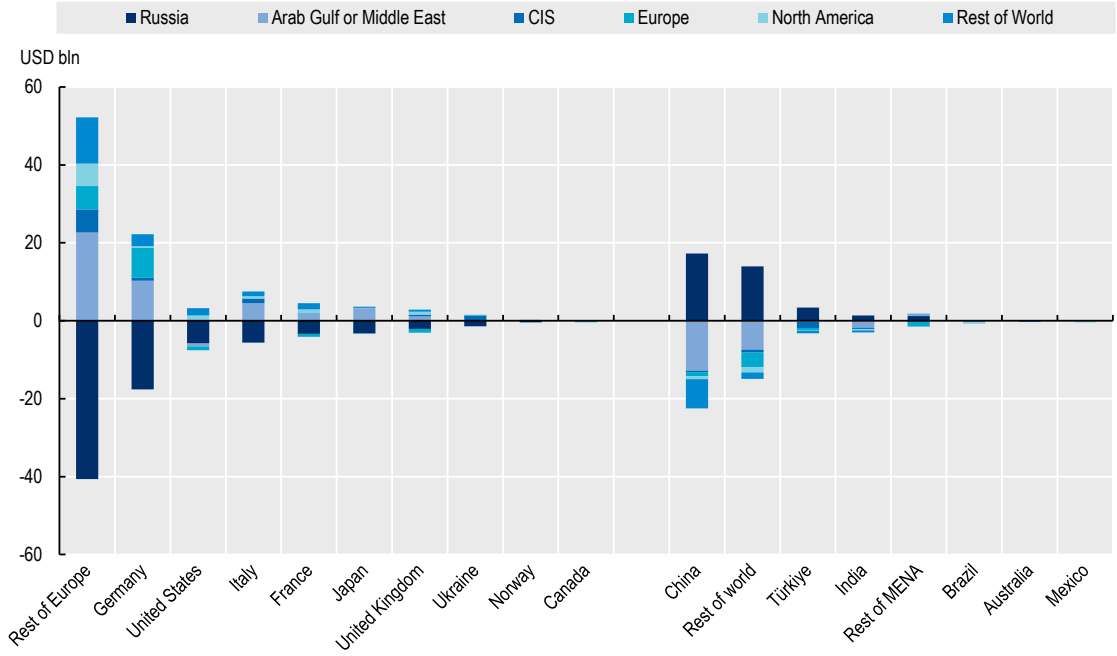
Overall, the economic cost as measured in the loss of real household income estimated under the medium-term adjustment assumptions due to higher prices in countries restricting oil imports from Russia are moderate but they are also unequally distributed across (and within) countries (Figure 3.23). In relative terms, Russia is impacted the most negatively in medium term and, among the other countries, the highest

[22] The household's income accrues from labour, capital, land, and natural resource incomes.

economic costs of restricting oil imports fall on European countries,[23] with non-EU G7 members less affected. Other oil exporters in the global economy on the other hand benefit through higher oil prices.

Figure 3.22. EU countries would massively reduce imports from Russia, while China and others would increase them in the medium term

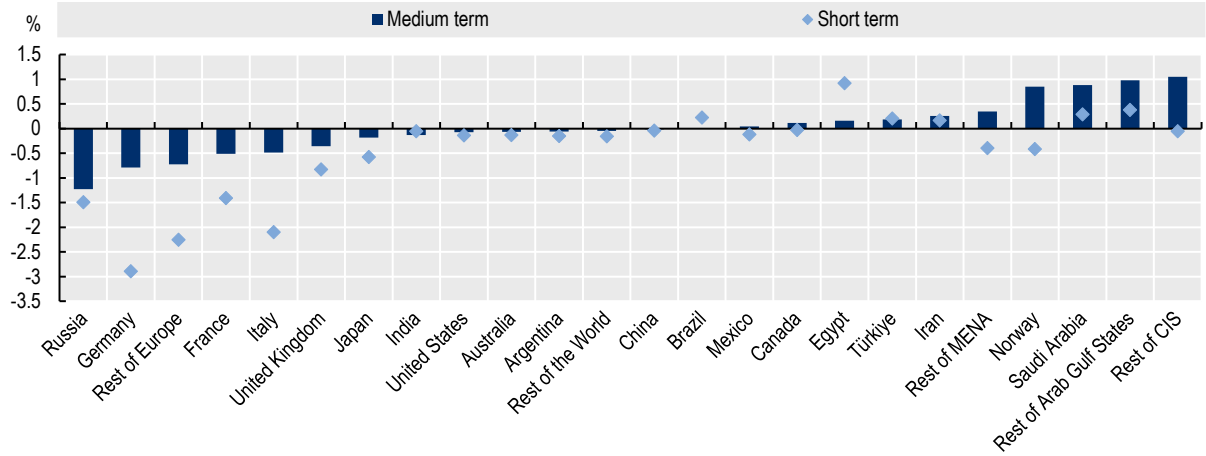
Bilateral imports of oil and oil products, constant USD billion



Source: OECD METRO model medium-term simulation.

Figure 3.23. Reducing oil dependency by G7 and Europe: Costs are unequally distributed and higher in the short term

Real household income, change relative to base, %



Source: OECD METRO model simulations.

[23] The dependency on Russian oil varies within Europe. Some of the countries that are included in a 'Rest of Europe' for modelling purposes (this is all of Europe except Ukraine, Germany, France, Italy, United Kingdom, and Norway, which are kept as separate economies in the analysis) may face household income losses that significantly exceed the average for this group.

Short-run costs for countries reducing Russian oil dependency

Finding alternative sources of oil in the short term may be challenging due to inexistent or insufficient oil transport or production infrastructure (i.e. lack of pipelines or additional oil tankers). Substitution of different kinds of oil products might also be difficult because different products are used for different purposes and refineries are specialised in processing certain grades of crude oil and final products (diesel, petrol, kerosene, heating oil). Mismatches between alternative crude supplies and requirements of existing infrastructure could lead to shortages in final products and in production and transport bottlenecks (e.g. kerosene for aircraft). Altogether, the volume adjustment via rebalancing of bilateral oil trade flows may take time and require additional resources.[24]

In the short-term scenario therefore, adjustments are assumed to mainly occur through higher prices of imported oil that have knock on effects on other prices in the economy and reduce household purchasing power. In reality, the costs in the short term could be large (shortages, high prices and rationing, industry shutdowns) and unequally distributed between and within countries depending on their current energy and industry mix. Under these assumptions and depending strongly on the share of Russia in the country's imports of oil as well as on the concentration of oil imports from other providers, household income losses go up to around 3% (Figure 3.23). The income loss is three or more times higher than in the medium-term scenario, emphasising the importance of adjustments to global production and directions of international trade of oil which minimise the costs of the embargo.

How could the reactions of China and India affect the economic impact on Russia in the short term?

Could a large increase in China's imports substantially offset the economic impact on Russia in the face of such an embargo? In the short-run this may be challenging because of the large size of the entailed increases. Such an offset would require China to more than double its pre-war imports of Russian crude of 1.6 million barrels per day (Mbd) to almost 4 Mbd, or 40% of their total oil imports.[25] Industry sources nevertheless point to very limited spare capacity in oil pipelines connecting China to Russia, and it is unclear where China would procure the oil tankers required for shipping more oil to China and at what cost.

In this context, the short-term scenario assumption that Chinese imports of Russia oil and oil products are capped at current levels is estimated to drive down Russian oil exports by a further 13% relative to its post-embargo oil export revenues for a total loss of USD 67 billion (55% of pre-embargo oil revenues) and adds to Russian household income losses.

What about an increase in Indian imports offsetting the effects on Russia? India is a large consumer of imported oil with net oil imports of 4 Mbd, however, imports of Russian crude have been very minor.[26] Since the war started, Indian imports from Russia have risen to 0.95 Mbd in April and May suggesting, in this case, that adjustment towards the medium-term may be rather quick.[27] However, these amounts still remain modest relative to Europe's pre-war imports from Russia of around 3.4 Mpd and reported logistical hurdles may slow further increases.[28,29] In addition, imports from Russia were purchased at a reportedly steep discount of USD 30 per barrel reducing the positive revenue effect for Russia.[30] The modelling results confirm that the likely offsetting effect for Russia would be overall modest.

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[24] Note, however, that, compared to natural gas, it is easier to switch between alternative sources of imported oil because due to its liquefied natural state, there are in principle more relatively inexpensive transportation options.

[25] See Oil Market and Russian Supply – Russian supplies to global energy markets – Analysis - IEA.

[26] IEA (2021) India Energy Outlook 2021 India Energy Outlook 2021.

[27] Indian imports from Russia averaged 0.1 Mbd in 2021 but this had increased to 0.95 Mbd by May 2022 (IEA (2022), Oil Market Report June 2022).

[28] European Import data from IEA (2022), Oil Market Report June 2022.

[29] India's ONGC struggling to move Russian oil to Asia as sanctions bite.

[30] Ukraine crisis: Why is India buying Russian oil? - BBC News.

Short-term pain for countries reducing Russian oil is likely but the medium-term costs are manageable

While the income effects of the oil embargo derived from the CGE analysis can be seen as moderate overall, the bottom line for countries reducing their oil dependency on Russia is that the medium-term costs after markets adjust are smaller than the short-term ones which will be mainly felt when the global oil price temporarily increases. The urgent policy challenge for these countries would be therefore to plug short-term shortfalls and find energy alternatives for the most acutely affected countries and industries. The key to addressing this challenge is close international co-operation, which is already taking place. Preparing for the policy shift in advance by lining up alternative sources, as many OECD countries are doing, will also help.

Europe unsurprisingly faces the highest medium-term costs, after Russia. The region is more dependent on Russian oil than others and has less diversified alternatives. In Germany, where simulated effects are the largest, household income is reduced by less than 1%, although the short-term cost could be three times as high. The costs to countries of reducing their dependency on Russian oil are less than shocks to incomes in the wake of the COVID-19 pandemic though they may last longer.

Reduced bilateral trade between Russia and select economies

In the next set of scenarios, a wider suite of hypothetical, highly stylised 40% reductions in bilateral trade is modelled in all industries between Russia and G7, Europe, and Australia (also referred to as G7 plus regions).[31] It is not the aim of this second scenario to specifically assess applied or announced sanctions on Russia. Many of the announced sanctions are aimed at specific individuals or products at a very detailed level (e.g. dual-use goods), are highly difficult to translate into policy shocks to incorporate into a model without strong assumptions (e.g. the SWIFT ban), and they continue to quickly evolve over time. Instead, the scenarios are designed to gauge the exposures of sectors and regions to a reduction in bilateral trade with Russia and to compare the economic impact of the different types of trade reductions (e.g. limiting exports to Russia versus imports from Russia).

To help decompose and compare the effects, reductions in exports and imports on goods and services trade are simulated separately. The four scenarios considered are:

- Scenario 1: Imports of goods from Russia to G7 plus regions are reduced by 40%
- Scenario 2: Imports of services from Russia to G7 plus regions are reduced by 40%
- Scenario 3: Exports of goods to Russia from G7 plus regions are reduced by 40%
- Scenario 4: Exports of services to Russia from G7 plus regions are reduced by 40%

Reducing trade across all industries doubles the negative effect on Russia

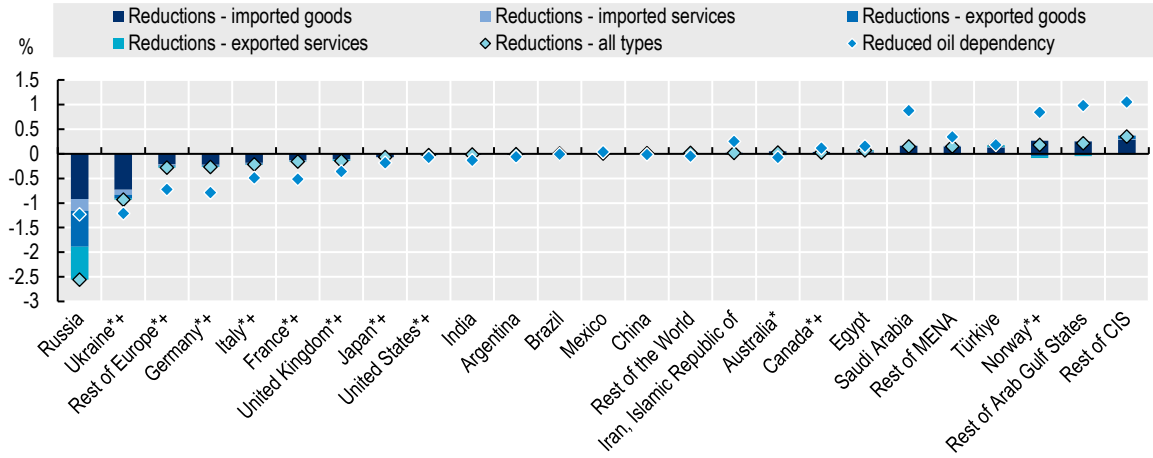
Compared to the previous simulation of eliminating dependency on Russian oil, reducing bilateral trade by 40% on all industries approximately doubles the negative real income effect on Russia in the medium term (Figure 3.24). This suggests that sanctions related to energy trade are indeed important, even if they are not the only lever that the G7 plus countries can use.

For regions reducing all bilateral trade with Russia, the cost remains unevenly distributed, but household income losses are consistently lower compared to the reduced oil dependency scenario. This reinforces the point about the relative appeal of the broader trade reductions from the point of view of the sanctioning countries. Outside Russia, most of the economic costs of throttling trade fall on the G7 plus regions, while other countries which maintain their trade relations with Russia are hardly impacted. The exception is Norway, which is reducing bilateral Russian trade in these scenarios, but as an energy exporter benefits from higher energy prices (particularly oil and gas extraction).

[31] These scenarios are implemented using export taxes and import tariffs in countries applying the sanction calibrated so as to reduce bilateral trade by 40%. As in the previous oil scenarios, it assumed that the extra government revenue is not spent but set aside in the form of government savings.

Figure 3.24. Reducing trade across all goods and services has a large impact on Russia

Real household income, change relative to base, %



Note: * Reduces imports from and exports to Russia by 40%. + Reduces Russian oil dependency.
Source: OECD METRO model simulations, medium-term.

Russia is a net exporter whose main exports are energy products, but it relies heavily on G7 and other economies for imports of among other things electronics, motor vehicles and parts, machinery and equipment, chemicals, and business services. At least 70% of these imports are sourced from G7, Europe, or Australia. From the Russian perspective, restricting imports of Russian goods and reducing exports of goods and services to Russia have roughly the same impact – reducing household purchasing power by 0.92%, 0.73%, and 0.67% respectively (Figure 3.24). Added together, restrictions on exports to Russia of G7, European and Australian goods and services have an almost 50% larger impact on Russia than restrictions of these countries on imports from Russia.[32] This applies to both consumption products as well as imports of intermediate inputs used for production in Russia. Reducing exports to Russia, especially exports of technology-intensive goods, can be expected to have even deeper consequences for Russia in the longer run than suggested by the modelling in this study. Slower capital accumulation and lower productivity following reduced imports of intermediate goods and technology will negatively affect the Russian economy over time. This also highlights another important point: the benefits of trade (and here the harm potentially inflicted with trade sanctions) is at least as much about imports as it is about exports.[33]

Reducing trade across all industries has little impact on world trade but a large effect on Russia

World trade is only slightly negatively affected when G7, Europe, and Australia reduce trade with Russia. Trade across all sectors declines on average 0.5% (Figure 3.25 Panel A). Unsurprisingly, exports of manufacture and distribution of gas, where Russia accounts for a third of world exports, decline the most (2.8%). Global wheat exports increase by 0.2% which is explained by the fact that Russia – an important player in wheat markets – allocates additional domestic resources to wheat and produces and exports more wheat. While this effect may not materialise in reality due to weather effects and logistical problems

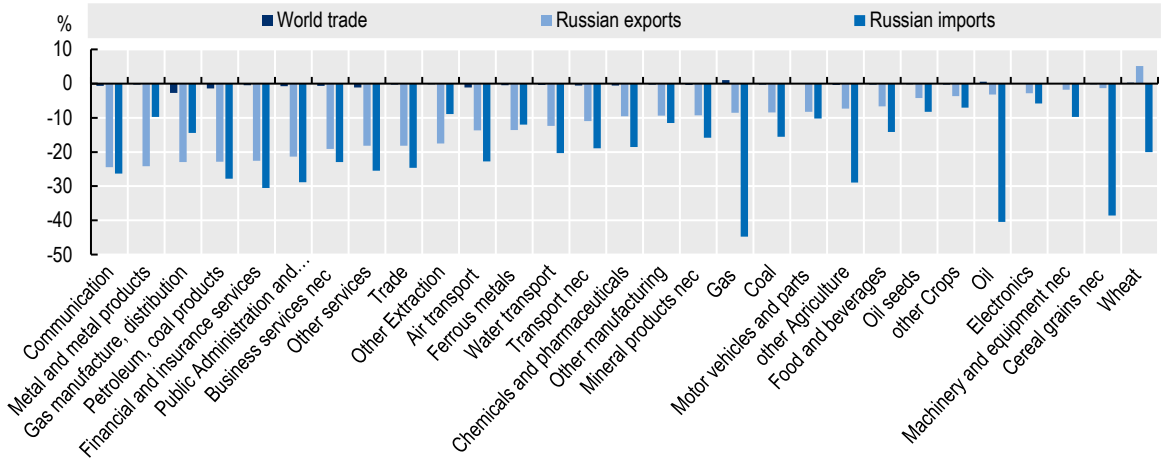
[32] It should be noted however that reductions of Russia's exports and imports may have also other effects which are not captured well or fully in the current modelling exercise. For example, there is some evidence that strong energy exports, in combination with expansionary fiscal policy and capital controls have made the Russian currency much stronger. A stronger rouble limits the government income effect of higher oil prices, because the rouble-denominated tax revenues from oil exports do not increase at the same pace as oil export revenues which are paid in foreign currency. The rouble's strength gives Russia additional purchasing power to source imports via new supply chains or routes. Also, import constraints may have more acute effects on Russia in the short run but in the medium run those constraints may start to erode if Russia can find new supplies – and the strength of the rouble (as a result of strong energy exports) may accelerate that transition.

[33] Note also that this has practical implications, as it may be more difficult to design and implement export sanctions, for example because third countries might not honour the sanctions and may act as transit points.

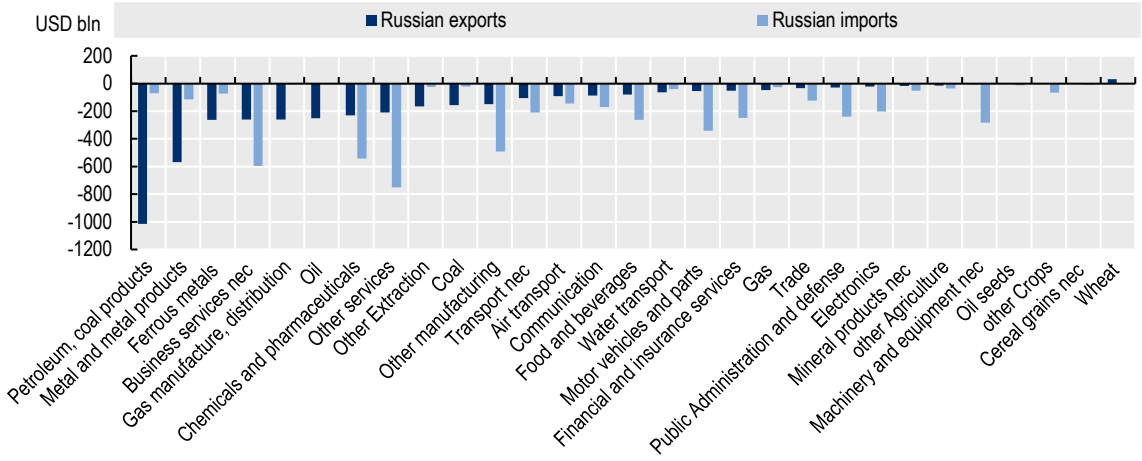
with exporting Russian wheat, it shows that, under certain assumptions, Russia could become an even more important player in wheat markets due to international reactions due to its war against Ukraine.

Figure 3.25. Change in sectoral trade resulting from reduced bilateral trade with Russia in all sectors

A. Percentage change from base



B. Level change from base (at base prices) (USD billion), Russian exports and imports



Source: OECD METRO Model simulations, medium-term.

Russian total exports decline by 12% and total imports decline by 16% when sanctions are imposed (in volume terms). Export losses centre around merchandise trade – Russia's main exports (Figure 3.25 Panel B). The exports of petroleum and coal experiences the largest volume decline in Russia with real losses of USD 1 trillion (at base prices). Russian exports of metal products also make up a large share of the total decline in exports – decreasing USD 567 billion. These two sectors account for almost 40% of the USD 4 trillion decline in Russian exports resulting from the reduction in trade with the G7 plus regions.

Most of the decline in Russian imports are accounted for by services and products which are mainly sourced from sanctioning countries. Imports of other services,[34] business services, and financial services

[34] "Other services" is an aggregated sector which include electricity, water, construction, accommodation, food and service activities, warehousing and support activities, real estate activities, recreational and other services, and dwellings.

decline by USD 752 billion, USD 597 billion, and USD 248 billion respectively which is explained by the fact that at least 70% of the imports of these sectors come from G7, Europe, and Australia. Similarly, chemicals and pharmaceuticals as well as motor vehicle and parts imports are among the sectors with the largest decline in value terms. The majority of the imports in each of these two sectors (76% and 70%) is sourced from countries reducing bilateral trade with Russia in all sectors.

There is also some redirection of trade (Table 3.6). Some of those goods and services no longer exported by Russia to the sanctioning countries are being diverted to regions not imposing trade measures, mainly China, rest of CIS, Türkiye, and India. Similarly, goods and services that Russia can no longer source from Australia, G7 and rest of Europe, are imported from other regions (e.g. China, rest of CIS, India, or Türkiye). However, as Table 3.6 shows not all the decline in trade between Russia and countries restricting trade will be replaced by trade from other regions because this involves paying higher prices and incomes in most countries are also reduced in these scenarios.

Table 3.6. Trade redirection is inevitable

Exporter	Importer	Sector	Base (USD bln)	Reduction type (change from base, USD bln)				
				Imported goods	Imported services	Exported goods	Exported services	All
Russia	G7 plus	Oil and petroleum	80.4	-32.1	0.2	0.1	0.2	-31.7
Russia	Not	Oil and petroleum	40.9	17.3	0.1	0.2	0.2	17.8
Russia	G7 plus	Gas	4.3	-1.7	0.0	0.1	0.1	-1.4
Russia	Not	Gas	1.1	0.8	0.0	0.1	0.1	1.0
Russia	G7 plus	Other goods†	65.7	-25.9	0.2	1.5	0.5	-23.7
Russia	Not	Other goods	87.0	3.3	0.4	1.7	0.7	6.0
Russia	G7 plus	All services±	31.7	0.0	-12.7	0.1	0.8	-11.8
Russia	Not	All services	16.3	0.1	1.3	0.0	0.3	1.8
G7 plus	Russia	Cars and parts	20.4	1.3	0.2	-8.2	-0.5	0.5
Not	Russia	Cars and parts	8.9	0.5	0.1	4.1	-0.2	0.1
G7 plus	Russia	Chem and pharma	20.5	-0.1	0.0	-8.2	-0.3	0.0
Not	Russia	Chem and pharma	6.4	0.0	0.0	3.8	-0.1	0.0
G7 plus	Russia	Business services	18.7	0.3	0.3	-0.4	-7.5	0.2
Not	Russia	Business services	7.3	0.1	0.1	-0.2	1.6	0.1
G7 plus	Russia	Other services*	19.9	0.2	0.0	-0.4	-7.9	0.2
Not	Russia	Other services	9.7	0.1	0.0	-0.2	0.9	0.1

Note: "G7 plus" are all the countries reducing trade with Russia by 40%: Canada, France, Germany, Italy, Japan, the United Kingdom, and the United, Norway, Ukraine, and Rest of Europe. "Not" refer to other regions excluding Russia. † "Other goods" cover all primary and manufactured goods in the database excluding Oil, oil products (Petroleum), and gas. ± "All services" cover all the services sectors in the model database. * "Other services" is an aggregated sector which include electricity, water, construction, accommodation, food and service activities, warehousing and support activities, real estate activities, recreational and other services, and dwellings.
Source: METRO model simulations, medium-term.

The impact on output of industries of the countries reducing bilateral trade is small, but output in some Russian sectors declines significantly depending on the scenario

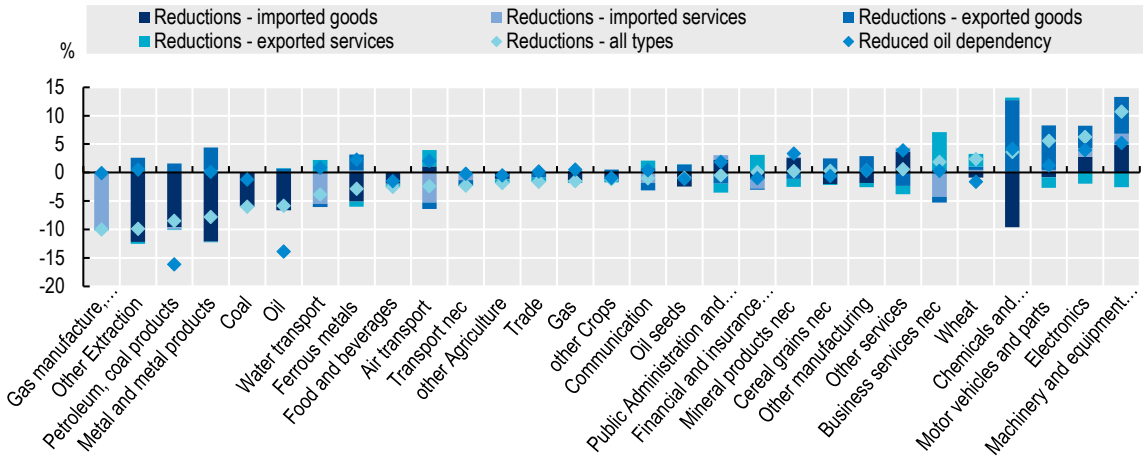
The impact on sectoral production in countries reducing all bilateral trade by 40% with Russia are smaller and notably much less severe than a full reduction of imports of Russian oil (Figure 3.26 Panel B). The transportation sector is most negatively affected, particularly by the 40% reduction of goods imported from Russia, which results in higher oil prices. Production in the chemicals and pharmaceuticals sectors is also negatively impacted by restrictions on Russian trade, but more so by limiting exports of goods to Russia than other types of trade reductions. However, some sectors benefit from reduced trade with Russia. The energy sectors gains from higher prices and higher demand from the countries restricting trade.

Output in some Russian sectors declines significantly depending on the scenario. Restricting exports to Russia has mixed effects which include increases in Russian production to replace the loss of imports. The chemicals and pharmaceuticals, motor vehicles and parts, as well as machinery and equipment

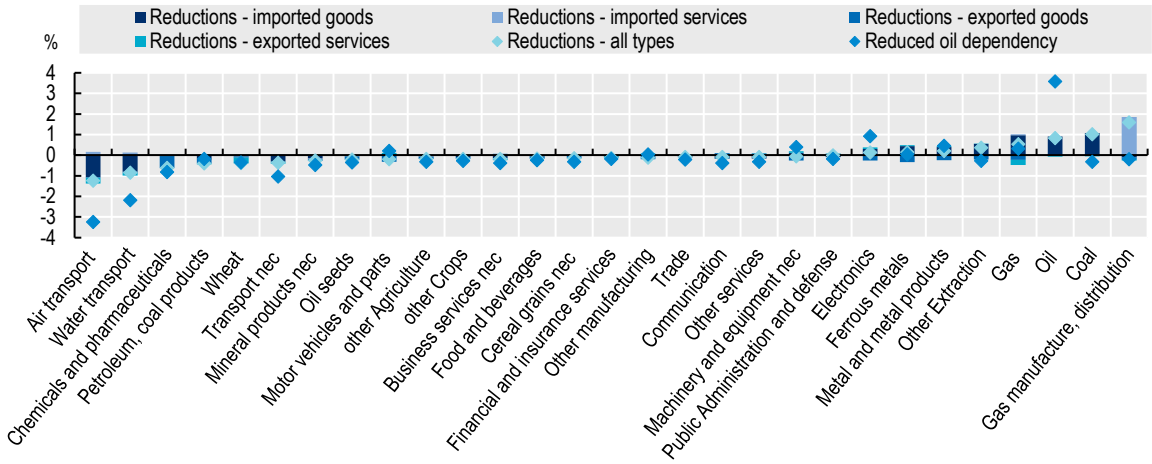
sectors in Russia see positive output effects ranging from 4% to 13% when G7 plus regions restrict merchandise exports to Russia (Figure 3.26 Panel A). However, sanctions on exports of services from G7, Europe, and Australia have a negative impact on production in almost all sectors in Russia with the exception of air transport, business, and financial services. These gains are however reduced, or even eliminated in the case of air transport, when countries also restrict exports of goods to Russia or reduce imports of Russian services. Lastly, reducing imports from Russia have a negative effect on the production of Russia's main exports including gas manufacturing and distribution, oil and oil products, and metals. Import sanctions, on goods and services, reduce output in these sectors around 10%.

Figure 3.26. Changes in sectoral production

Panel A. Russia, percentage change from base



Panel B. Countries reducing trade with Russia, percentage change from base



Source: OECD METRO model simulations, medium-term.

Reducing Russian trade on a broader range of industries is more impactful than oil sanctions

Overall, over the medium-term, reducing trade with Russia on a broader range of products and services has less of a negative effect on countries imposing trade reductions than a full reduction of oil imports from Russia. While a 40% reduction of goods imported from Russia, much of which consists of oil and oil products, would have a negative impact on sectors that heavily rely on fuel, the impact on households in countries applying the sanctions is much less than a 100% reduction of Russian oil. Moreover, including restrictions on exports of goods and services to Russia adds at least as much economic pressure as oil sanctions on Russian households and a broader range of industries would face even larger losses.

The impact of sanctions diminishes when markets adjust

Two complementary analyses are used in this section to assess the exposure of sectors and regions to sanctions on Russia. The ICIO analysis identifies regions and sectors dependent on trade with Russia which could be harmed most directly by sanctions announced by several countries at the start of the war. By setting trade to zero in all industries and final demand between Russia and these countries, the ICIO analysis is able identify regions and sectors which are most directly exposed to sanctions on Russia, measured by the impact on value added. Russia and Eastern European regions who are among the most dependent on Russian trade, are particularly negatively impacted by sanctions. Total value added – "hypothetical GDP" in the ICIO analysis – declines by 7.4% in the ICIO analysis of sanctions (among the highest decline, second only to Ukraine).

Because there are no price effects, no substitution, no trade re-direction and no reactions of economic actors, such as private business and governments, the ICIO analysis is only a first step in understanding the full impact of sanctions. Economic agents and markets will adjust to sanction environment, and this is what the CGE analysis captures. It allows for the possibility for Russian producers to find alternative markets for their products, domestically or abroad. The model allows also for producers in countries reducing trade with Russia to find other sources of inputs for Russian goods over the medium term. Producers and consumers react to changes in relative prices and income and all these adjustments occur under the assumption of full employment of production factors which is a key analytical concept in long-term economic analysis. The latter assumption in particular implies that resources released from sectors that decline under sanctions on Russia ultimately end up in other sectors. The macroeconomic impact of such resource reallocations will depend on the relative productivities of declining and growing activities, but the full employment of factors mitigates the overall macro-level changes. These additional features of CGE analysis provide more insights on the economic impact of Russian sanctions in the medium run, that is, when markets and the Russian economy will have adjusted to the initial shocks.

In particular, in the CGE analysis presented here, some of the real income losses in Russia are mitigated by domestic industries' increased access to more and cheaper inputs, particularly Russian oil and oil products as well as labour and capital released from the declining oil and oil products sectors. The CGE analysis thus brings to light how some of the potential severity intended by sanctions on imports might be diminished over the medium term.[35] It also highlights that restrictions on exports to Russia are potentially more effective in the longer term. Even without taking knock-on productivity effects on Russian industries into account, curbing exports that serve as intermediate inputs diminish its production potential.

4. Concluding remarks

The understanding of the impact on trade and the wider economy by the war continues to develop. This report contributes to this understanding by tracing trade dependencies and trade exposure, both direct and indirect through supply chains, and by making a preliminary assessment of the wider economic effects of trade disruptions. The combination of different complementary methods allows a more comprehensive assessment than would be possible by relying on one specific set of tools, and the methods used for such assessments will undoubtedly be refined over time, and insights will sharpen.

Further analyses could be undertaken to expand the countries reducing trade dependency with Russia to include all OECD countries, thereby examining the impact on both Russia and OECD economies when a larger set of countries reduce trade links with Russia. Furthermore, the model could be used to analyse the impact of a scenario where OECD economies would contemporaneously increase trade links among each other. Would this lessen the effect of reduced trade links with Russia? To what extent would the increase in trade links with other OECD economies insulate members from future external disruptions?

[35] Recall also that the ICIO and CGE analysis have slightly different assumptions on how much trade will be reduced between Russia and sanctioning countries. See Box 3.1 and Section 3.3. The METRO assumptions reduced trade 40% between all industries while ICIO analysis had higher reductions in trade between Russia and sanctioning countries in the air transport industry, the finance sector, and in some cases the energy sector. Applying the same percentage change in reduction in the METRO model, the change in real GDP (-0.87%) is well below the results from the ICIO analysis due to the reasons explained in the text.

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Annex A. Gap methodology

This annex explains in more detail the methodology for the construction of the trade gaps reported in the main body of the text. The gap calculates the difference between accumulated trade observations and the trend estimation based on pre-pandemic levels, starting in January 2020. The time series have a monthly frequency.

The main hurdle is to project trade for the pandemic period based on the pre-pandemic levels. Because the quality of the projection determines the size of the trade gap, this Annex provides a comparison between three methods: historical period, Hodrick-Prescott (HP) filter (Hodrick and Prescott, 1997[7]), and theta modelling (Assimakopoulos and Nikolopoulos, 2000[8]).

The *Historical period* method replicates every month during the year before the shock. The method assumes the same monthly value for the months in the years in the forecasted period.

The *HP filter* decomposes the time series between a deterministic trend, a cyclical trend and errors. It uses a λ parameter that dictates the variation from the trend components (for this exercise using monthly data, the retained lambda parameter is the usual 129600). To generate a forecast from the HP filter, a linear equation with a constant and time as independent variable is estimated on the HP trend component and projected forward in time.

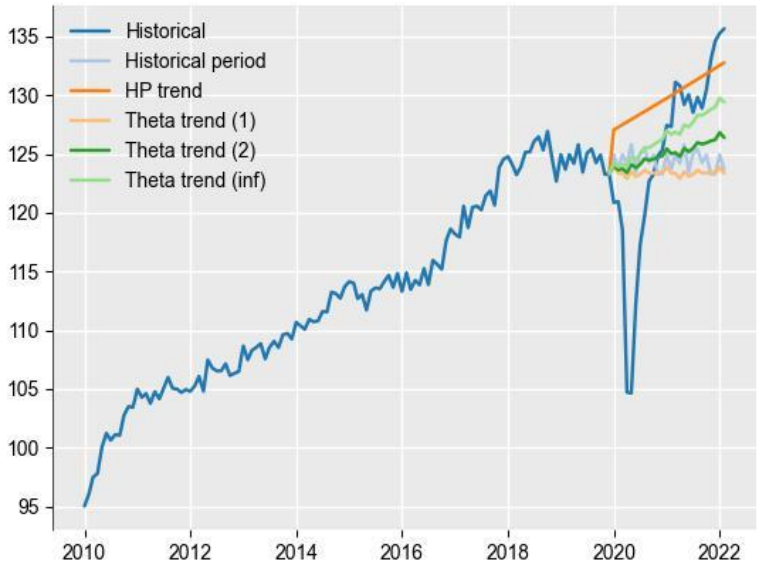
The *Theta* forecast is a combination of a simple exponential smoothing and deterministic trend components after having deseasonalised the series (Assimakopoulos and Nikolopoulos, 2000[8]; Hyndman, 2003[9]). A large theta increases the role of the deterministic trend. Results of the theta model with three different values of the theta parameter indicators (1, 2, infinite) are presented below.

Figure A A.1 Panel A shows the predictions against the raw monthly trade volume index from the CPB World Trade Monitor. The historical period replicates 2019 where trade was flat and provides a benchmark for a scenario where trade does not evolve in subsequent periods. The forecast from the HP filter provides the most optimistic forecast. The Theta forecasts differ based on the value of the theta parameter. With a large theta (*inf* line on the graph), the forecast follows the same growth rate as the HP trend while a low theta dampens the deterministic trend.

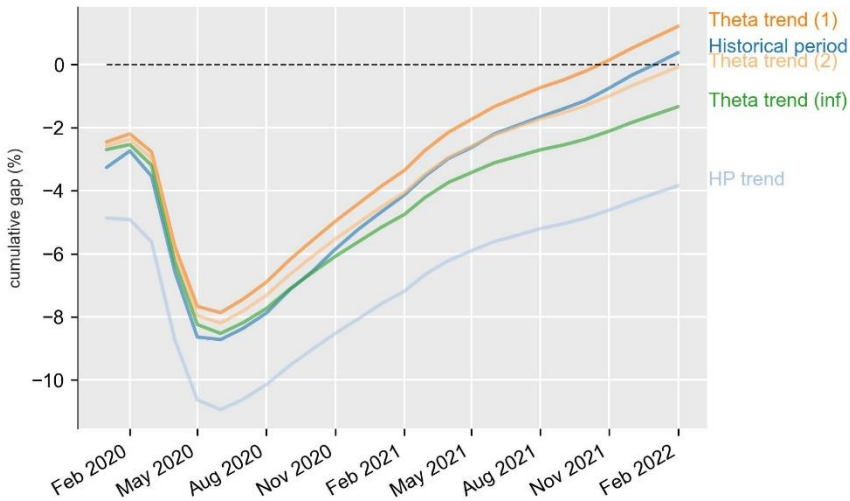
Based on the pessimistic estimations, the trade gap has entirely closed. This is the case for our benchmark *historical period* as well as for the theta trend (with theta parameter set to 1). On the contrary, optimistic previsions such as HP filter and theta trend with large theta parameter translate into a gap that has not been closed yet.

Figure A A.1. Trade index forecast based on different methodologies

Panel A. Forecasts



Panel B. Gaps



Source: CPB trade volume index.

To guide the selection of the model, a training sample with values between 2010-2018 was selected for an out-of-sample prediction in 2019 is calculated; alternatively, a training sample 2010-2017 and out-of-sample predictions for 2018 are generated. As a goodness of fit measure the root mean square of error (RMSE) for out-of-sample predictions is taken.

The method with the lowest RMSE is *historical period* for the 2019 prediction but it is theta trend (2) for the 2018 and theta trend (1) for 2018-2019 while the HP filter forecast remains the one with the highest RMSE. This shows the superiority of the Theta method that combines an estimate of the deterministic trend with a simple exponential smoothing that assigns a bigger weight to the most recent observations. The very low RMSE for the historical period method on 2019 out-of-sample is due to the weak growth during that period. Theta trend (2) is the best prediction method based on the 2010-2018 sample, and hence this model is used.

Table A A.1. Root mean square of errors by method, training sample and out-of-sample

	Train sample: 2010-2018 Out-of-sample: 2019	Train sample: 2010-2017 Out-of-sample: 2018	Train sample: 2010-2017 Out-of-sample: 2018-2019
RMSE for method Historical period	**1.35**	22.82	21
RMSE for method HP trend	11	6.85	5.11
RMSE for method Theta trend (1)	3.07	2.2	**1.5**
RMSE for method Theta trend (2)	1.65	**1.54**	2.8
RMSE for method Theta trend (inf)	1.87	2.32	9.32

Source: CPB trade volume index.

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Comments are welcome and can be sent to tad.contact@oecd.org.