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POLICIES TO STRENGTHEN THE RESILIENCE OF GLOBAL VALUE CHAINS

EMPIRICAL EVIDENCE FROM THE COVID-19 SHOCK

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Policies to strengthen the resilience of global value chains: Empirical evidence from the COVID-19 shock

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Widespread supply disruptions in the wake of the COVID-19 pandemic and the Russian Federation's large-scale aggression against Ukraine have raised concerns among policy makers that globalised value chains expose domestic production to shocks from abroad. This paper uses new indicators of global value chain dependencies and exogenous pandemic shocks to econometrically estimate the effects of supply disruptions abroad on domestic output. The results suggest that the adverse effects of supply disruptions are particularly large when concentration of supplying countries and supplying firms is high. Counterfactual simulations of the econometric model suggest that diversification of suppliers would have sizeable benefits in terms of shielding domestic production against country-specific supply shocks, with partial onshoring of production having only small additional benefits. Technological innovation that reduces foreign dependencies, such as the substitution of renewable energies for fossil fuels, can have similar benefits as diversification.

Keywords: Global Value Chains, International trade, Resilience

JEL codes: F14, F68, L52

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Executive summary

Widespread supply disruptions in the wake of the COVID-19 pandemic and, more recently, the Russian Federation's (hereafter, 'Russia') large-scale aggression against Ukraine have raised concerns that globalised value chains expose domestic production to shocks from abroad. This paper analyses econometrically the resilience of global value chains using new indicators of dependencies and discusses the implications for public policies. The main upshots from the analysis are as follows.

- **New indicators of global value chain dependencies used in this paper are accurate predictors of the transmission of foreign shocks:**
  - The impact of foreign supply disruptions on domestic output is systematically larger when foreign dependencies as measured by the new indicators is high.
  - In the average country and industry, a foreign supply disruption corresponding roughly to the average tightening of mobility restrictions observed between February and April 2020 reduces output of downstream producers by about 5% in the quarter of the shock.
- **Foreign supply disruptions have larger adverse effects when suppliers are highly concentrated:**
  - In industries where both geographic concentration (large market shares of the main supplying countries) and industry concentration (large market shares of the main firms within the industry) of suppliers is high, the effect of supply disruptions is about twice the average effect.
  - By contrast, there is no statistically significant effect in industries where suppliers are geographically diversified and industry concentration is low.
- **An illustrative stress test that simulates a large shock (corresponding roughly to the tightening of mobility restrictions between early-March and early-April of 2022) in the People's Republic of China (hereafter, 'China') suggests that:**
  - In most countries that are highly reliant on Chinese inputs, disruptions of supply would reduce output in key manufacturing industries, including motor vehicles, by around 1-4%.
- **Public policies can enhance global value chain resilience by facilitating a quick rebound after a shock occurs, or by mitigating the risk of shocks from abroad:**
  - A **rapid rebound** can be promoted by agility policies before a shock occurs, or by adaptation policies after it materialises.
    - Among the statistically and economically significant agility policies, the promotion of management and worker skills appears to be crucial to allow for a rapid restructuring of production.
    - Among the ex-post measures, well-targeted government fiscal support in the form of grants, loan guarantees and support for workers stands out as highly significant.
  - **Risk mitigation** includes measures to diversify or partially onshore global value chains and to reduce technological dependencies.

        - Diversification would reduce the adverse effects on output of the simulated shock to Chinese production in the most affected downstream industries by about 25%.
        - The partial onshoring of production (in addition to diversification) would only have very limited additional benefits in terms of shielding domestic production from shocks.
    - The shielding effects of technological innovation that reduces dependencies on specific inputs (e.g. fossil fuels) are comparable to diversification but require large technological shifts that may take time to materialise.
- **Policies to address risk should be tailored to the degree of concentration and strategic importance of the relevant value chain:**
    - In value chains with few potential suppliers (or buyers) that are of high strategic value (such as energy, critical minerals, essential medical equipment and pharmaceuticals, semiconductors) risk mitigation may be needed but potential benefits need to be balanced with potential costs.
    - In value chains with many potential suppliers (or buyers) or that are of low strategic importance, agility and adaptation policies may be sufficient to ensure resilience.
    - The vast majority of global value chains (about 96%) are either diversified in terms of suppliers (or buyers) and/or of limited strategic importance.

Overall, the analysis in this paper suggests that in the overwhelming majority of value chains, public policies should focus on measures to promote a rapid rebound following shocks rather than mitigating risk by reducing foreign exposures. Geographical diversification of value chains and technological innovation can have large beneficial effects in terms of shielding domestic output from GVC shocks. Additionally, onshoring production may have only small additional benefits and must be balanced with potentially large costs in terms of economic efficiency.

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1 Introduction

The globalisation of supply chains – loosely defined as an increasing share of imported intermediate goods and services in output – has raised productivity and boosted the participation of lower-income countries in international trade (OECD, 2013[1]). But widespread supply disruptions in the wake of the COVID-19 pandemic have raised concerns that globalised value chains expose domestic production to shocks from abroad, including by creating strategic dependencies on a small number of key players (OECD, 2021[2]). For instance, widespread shortages of critical medical equipment (e.g. respirators) and critical inputs into manufacturing (e.g. semiconductors) during the COVID-19 pandemic have triggered a debate about the desirability of onshoring and the geographical diversification of inputs.

This paper analyses the resilience of global value chains (GVCs) in the wake of the COVID-19 pandemic with a view to providing insights for public policies. It takes an industry-level perspective in the sense that the relevant unit of observation is an industry in a given country. From an individual firm's perspective, supply chain risk can arise from dependence on a single supplying firm. From a policy perspective, however, the relevant supply chain risk is systemic disruption at the level of an entire industry or market. For instance, from a policy perspective the relevant risk is the disruption of the entire automotive industry in a country by shortages of critical semiconductors rather than the disruption of a single car-maker by the shortage of a semiconductor produced by a specific company.[1]

Private businesses do not fully account for systemic risk in their supply chain management decisions, suggesting a need for public policy intervention. First, private businesses only account for risk to their own operations when taking decisions about their supplier network and inventory management but ignore potential externalities on their downstream clients and upstream suppliers. For instance, a semiconductor producer may accept dependence on a single supplying company despite the risks to its profits from temporary disruptions because it does not internalise the induced losses of downstream automotive industries.[2] Second, private companies typically have very little information on their supply chain beyond their immediate first-tier suppliers, which can lead to the under-estimation of risks. A recent survey of senior supply-chain executives across multiple industries and countries suggests that only about 20% of companies have visibility on their second-tier suppliers, and only about 2% on their third-tier suppliers (McKinsey & Company, 2021[3]).

The analysis in this paper is based on the updated OECD Inter-Country Inter-Industry (ICIO) database that covers 66 countries and 45 industries up to 2018, as well as near real-time data on trade and output. It provides estimates of the extent to which disruptions abroad affect domestic output through input-output linkages. Exogenous measures of output disruptions are constructed by exploiting differences in the severity of the COVID-19 pandemic across countries and over time, as well as differences in required physical presence of workers across industries.

A major innovation of this paper with respect to previous studies is that it not only uses new indicators of GVC dependencies (Baldwin and Freeman, 2021[4]; Schwellnus et al., forthcoming[5]) but estimates the extent to which GVC dependencies act as a transmission channel of shocks abroad. This allows stress testing GVCs by simulating different types of shocks, analysing how they percolate through GVCs, and thus identifying vulnerabilities related to limited substitutability and/or geographic concentration of inputs.

It further allows the analysis of a range of counterfactual scenarios, such as diversification of suppliers, partial onshoring and the technological substitution of specific inputs.

The main upshots from the analysis are as follows. First, adverse effects on domestic production from foreign supply shocks are particularly large when concentration of suppliers, both in terms of supplying countries and supplying firms, is high. Second, a number of public policies facilitate the rapid rebound of domestic production following an adverse foreign supply shock, including ex-ante measures such as the promotion of management and worker skills and ex-post measures such as fiscal policy support. Third, counterfactual simulations of the econometric model suggest that diversification of suppliers would have sizeable benefits in terms of shielding domestic production against country-specific supply shocks, with partial onshoring of production having only small additional benefits. Technological innovation that reduces foreign dependencies, such as the substitution of renewable energies for fossil fuels, can have similar benefits as diversification.

Overall, the analysis in this paper suggests that in the overwhelming majority of value chains, public policies should focus on measures to promote a rapid rebound following shocks rather than mitigating risk by reducing foreign exposures. Geographical diversification of value chains and technological innovation can have large beneficial effects in terms of shielding domestic output from GVC shocks. Additionally, onshoring production may have only small additional benefits and must be balanced with potentially large costs in terms of economic efficiency.

The remainder of the paper is organised as follows. Section 2 sets the scene by framing the policy issue. Section 3 describes the empirical framework and the data. Section 4 presents the empirical results on the propagation of upstream GVC shocks, including the role of in promoting adaptation; analyses a scenario involving a large shock to China, which is a major choke point in GVCs (Schwellnus et al., forthcoming[4]); and describes a range of counterfactual scenarios, including value chain diversification, partial onshoring and technological substitution of specific inputs. Section 5 outlines the key policy implications from the analysis and Section 6 concludes.

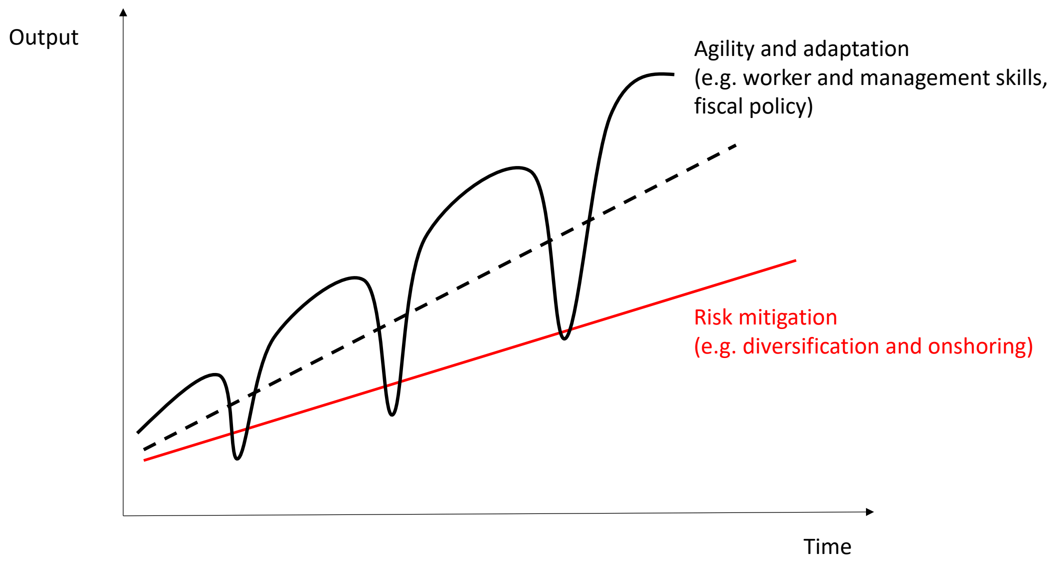
2 The policy issue

Shock propagation through GVCs may call for a public policy response for two broad economic reasons. First, private and public interests may be misaligned because private companies do not internalise the cost of disruptions to their downstream buyers, including to final consumers. For instance, semiconductor companies account for their private profits and losses when deciding about optimal inventory levels but do not internalise the cost of disruptions to downstream automotive producers. Second, private companies may lack information on the complexity of their supply chains, leading to the underestimation of risk. Apart from these market failure rationales for public policy intervention, policy makers may want to limit strategic dependencies for geopolitical reasons.

Agility and adaptation

A range of public policies can influence the resilience of GVCs by facilitating a quick rebound after a shock. These policies accept a degree of risk to domestic production but achieve high average growth (Figure 1). A quick rebound can be facilitated by taking ex-ante measures before a shock materialises (i.e. by promoting agility) and by taking ex-post measures when it materialises (i.e. by promoting adaptation,). An ex-ante agility policy could, for instance, involve the upskilling of workers and managers to allow them to rapidly re-organise production and supply chains in the event of a foreign supply disruption. Fiscal policies, e.g. through loan guarantees or grants, can act as an ex-post adaptation policy by providing support to solvent firms that are experiencing temporary liquidity issues as a result of foreign supply disruptions.

Figure 1. Policy channels



Source: OECD based on Brunnermeier (2021[5])

Mitigating the risk of value chain shocks from abroad

Public policies can also enhance GVC resilience, by shielding domestic production from foreign shocks (risk mitigation), accepting lower average growth in return (Figure 1).[3] For instance, industrial policies can affect the cost of domestic production relative to production abroad. This may change the balance of risks between domestic and foreign shocks but may also affect overall economic efficiency. Trade policies can affect the relative costs of suppliers from different countries and thereby raise or reduce the degree of geographical concentration of GVCs.

3 Methodology and data

Baseline

The baseline empirical model estimates the effect of upstream GVC shocks on domestic output. The key identifying assumptions are (i) the exogeneity of upstream supply disruptions; and (ii) a larger response of domestic output when foreign input reliance is high. With respect to exogeneity, the model uses the insight that pandemic-related supply disruptions abroad can be viewed as exogenous do domestic output developments (Baldwin and Freeman, 2021[6]; Santacreu, Leibovici and Labelle, 2021[7]; Thorbecke, 2021[8]).[4] With respect to the larger domestic output response at higher foreign input reliance, the rationale is that, in autarky, foreign supply disruptions should have no effect on domestic output, whereas, at high reliance of domestic production on foreign inputs, the effect should be large.

Foreign demand and supply shocks hit imports and exports with a lag, e.g. shutdowns in China likely hit imports in France with a lag of 1-2 months (Lafrogne-Joussier, Martin and Mejean, 2021[9]). In order to account for the delayed response, the relation between output and upstream supply chain shocks is estimated using the local projections method (Jordà, 2005[9]). The method has been widely used as a flexible alternative to autoregressive distributed lag specifications (Auerbach and Gorodnichenko, 2012[10]; Romer et al., 2017[11]; Ramey and Zubairy, 2018[12]) and allows directly obtaining the response of the dependent variable at horizon *t+k* to the shock at time *t* by estimating a different regression specification at each horizon. Impulse response functions are then constructed by plotting the estimated coefficients as point estimates and their standard errors as confidence bands.

The baseline estimating equation is as follows:

$$y_{c,j,t+k} - y_{c,j,t-1} = \beta^{u,k} up_{c,j,t} + \beta^{x,k} x_{c,j,t} + \boldsymbol{\varphi^{k} dyn_{c,j,t}} + \mu_{cj} + \mu_t + \varepsilon_{c,j,t}$$

Equation 1

where subscripts *c*, *j*, and *t* denote, respectively, country, industry and time; $y_{c,j,t}$ is a measure of (log) real output; $up_{c,j,t}$ is a measure of the upstream foreign supply shock; and $x_{c,j,t}$ are control variables for domestic and downstream demand shocks; $dyn_{c,j,t}$ is a (column) vector of leads and lags of the explanatory variables included to make the model dynamically complete;[5] μ_{cj} and μ_t are country-industry and time fixed effects; $\beta^{u,k}$, $\beta^{d,k}$, $\beta^{x,k}$ and $\boldsymbol{\varphi^k}$ are estimated coefficients; and $\varepsilon_{c,j,t}$ is the error term. Equation 1 is estimated at the monthly frequency over the period January 2020 to September 2021.[6]

The upstream supply shock is defined as the weighted average of all foreign supply disruptions as follows:

$$up_{c,j,t} \equiv \sum_{c' \neq c}^{N} \sum\nolimits_{j'}^{J} (FIR_{cjc'j',0} \times disruption_{j'c't}) \quad \textbf{Equation 2}$$

where $FIR_{cjc'j',0}$ (foreign input reliance) can be viewed as weights measuring the reliance of country-industry *cj* on inputs from foreign country-industry *c'j'*. Foreign input reliance is calculated in gross terms rather than value added terms to account for the fact that the effect of a foreign supply disruption may depend on both the size of the foreign exposure and the length of the value chain (Schwellnus et al., forthcoming[4]). $disruption_{j'c't}$ is a measure of foreign supply disruptions that combines measures of exogenous country-level mobility shocks and industry-level required physical presence. The basic idea is that a country-level mobility shock should reduce output by more in industries with high required physical presence (low potential telework), with the effect on upstream industries abroad being transmitted through GVC dependencies. The construction of the explanatory variables is described in Annex A1.

The coefficient of interest is the elasticity of output with respect to foreign supply ($\beta^{u,k}$). The expected sign of the estimated elasticity is negative, given that negative supply shocks (as approximated by an increase in mobility restrictions) should reduce domestic output. However, in contrast to the input-output approach, the estimated relation between shocks and domestic output is not based on restrictive assumptions on substitution between inputs. Instead, the estimated elasticities implicitly account for substitution patterns. In the case of low substitutability, the estimated elasticities will be large, whereas in the case of high substitutability the estimated effect of foreign supply shocks on domestic output will be close to 0.

Extensions: Accounting for concentration and policies

In principle, the effect of GVC shocks on domestic production is expected to increase with the geographic concentration of supplying countries and the within-industry concentration of supplying firms. In the case of geographic concentration, if supplying firms in one country are hit by an adverse country-level shock, such as a natural disaster, buying firms cannot easily switch to alternative supplying firms in other countries (Handley, Kamal and Monarch, 2021[13]). The effect of GVC shocks on domestic production should also be larger when the within-industry concentration of supplying firms is high. In the case of industry concentration, a small localised shock abroad may have much larger consequences for domestic production when foreign supply is concentrated in a single firm than when there is a large number of alternative suppliers (Di Giovanni, Levchenko and Mejean, 2014[14]). For instance, a fire in a semiconductor plant may have a much larger effect on downstream buyers than a fire in a plant producing plastic packages.

Public policies that promote adaptation are expected to dampen the adverse effect of GVC shocks on domestic production. For instance, public policies that provide adequate fiscal support to firms (e.g. through loans and grants) and workers (e.g. through short-time work) are expected to allow firms to maintain production despite temporary supply disruptions.

Differences in concentration and public policy settings can be accounted for by interacting the supply shock variables with indicators of concentration and public policies:

$$y_{c,j,t+k} - y_{c,j,t-1} = \beta^{u,k} up_{c,j,t} + \beta^{u,c,k} p_{c,j} \cdot up_{c,j,t} + \beta^{x,k} x_{c,j,t} + \boldsymbol{\varphi}^{\boldsymbol{k}} \boldsymbol{dyn_{c,j,t}} + \mu_{cj} + \mu_t + \varepsilon_{c,j,t} \qquad \text{Equation 3}$$

where $p_{c,j}$ is an (industry-level) measure of geographic or industry concentration, or a (country-level) measure of public policy.[7] The estimated coefficients on the interaction terms ($\beta^{u,c,k}$) measure the extent to which upstream shocks have larger effects on output when sales or geographic concentration is high. Given that the measures of concentration and public policy may be correlated with other industry-level and country-level variables that are omitted from Equation 3, results from the extensions in this section should be viewed as mere correlations rather than causal effects.

Data

Estimating the regression model in Equation 1 requires information on output, GVC integration, mobility restrictions and workers' required physical presence. Monthly industry-level output is obtained from Eurostat, which provides a calendar and seasonally-adjusted volume index of production. This data is available for the large majority of EU countries and industries up to early 2022 but coverage does not extend to agriculture, trade and some services.[8] Additionally, monthly or quarterly data on production by industry are available for Canada, Korea, Mexico and the United States.[9] Foreign input reliance and foreign market reliance are computed from the OECD ICIO data using an average of the year 2016 to 2019. Overall, monthly output data, foreign input reliance and foreign market reliance are available for 35 countries and 36 industries. The list of countries and industries that is currently used in the analysis is reported in the Annex (Table A A.1).

Country-specific mobility restrictions are proxied by the Oxford COVID-19 Government Response Tracker constructed by Hale et al. (2021[15]). The overall stringency index ranges from zero to 100 and measures the extent of school, workplace and public transport closures, restrictions to public events, gatherings and internal movements, requirements to stay at home, controls of international travel and public information campaigns.[10] Monthly averages are constructed for the countries available in the OECD ICIO database and for the "rest of the world" aggregate in the OECD ICIO database. In the regression analysis, the change in the stringency index between two months is used. As shown in the Annex (Figure A A.1), the biggest increases in mobility restrictions are observed in the early stages of the pandemic.

The time-invariant and industry-specific measure of workers' required physical presence is proxied as 1 minus the share of teleworkable jobs in an industry. In other words, required physical presence is assumed to decline with the share of potentially teleworkable jobs. Dingel and Neiman (2020[16]) develop an approach to distinguish teleworkable from non-teleworkable occupations based on whether an occupation can be fully carried out from home using US O*NET classifications. Using this classification and employment shares by industry and occupation from the 2019 EU Labour Force Survey, an EU wide industry-specific share of teleworkable jobs is constructed.[11] This measure is reported in Figure A A.2.

Geographic concentration is computed from ICIO data as the share of the top-5 producers in total gross output. The measurement of industry concentration is based on past and ongoing work at the OECD (Bajgar et al., 2019[17]; Bajgar, Criscuolo and Timmis, 2021[18]). The data measures concentration as the sum of sales of the top 4 firms over total production by 2-digit industry in 14 countries between 2016 and 2018.[12] From this data, a simple average of sales concentration across countries and years is constructed by industry in order to be able to assign measures of industry concentration to all supplying industries in the OECD ICIO data (Figure A A.3). Hence, industry concentration should be viewed as a general technological characteristic of a supplying industry rather than a precise measure of industry concentration in a specific country.

In order to analyse the role of policies in promoting adaptation to shocks, the dataset is complemented with country-specific information on government fiscal support, management and worker skills, as well as digital infrastructure. Government fiscal support is measured as the increase in the underlying fiscal deficit in 2020 (i.e. the increase in the fiscal deficit relative to 2019 that was unrelated to the business cycle) from the OECD Economic Outlook database.[13] Management skills are obtained from the publicly available vintage of the World Management Survey covering firms in manufacturing from 2004-14. Worker skills are measured as the average literacy score from the Programme for the International Assessment of Adult Competencies (PIAAC), mainly collected in 2012. The quality of digital infrastructure is proxied by fixed broadband subscriptions per 100 inhabitants in 2021 supplied by the OECD’s Broadband Portal.

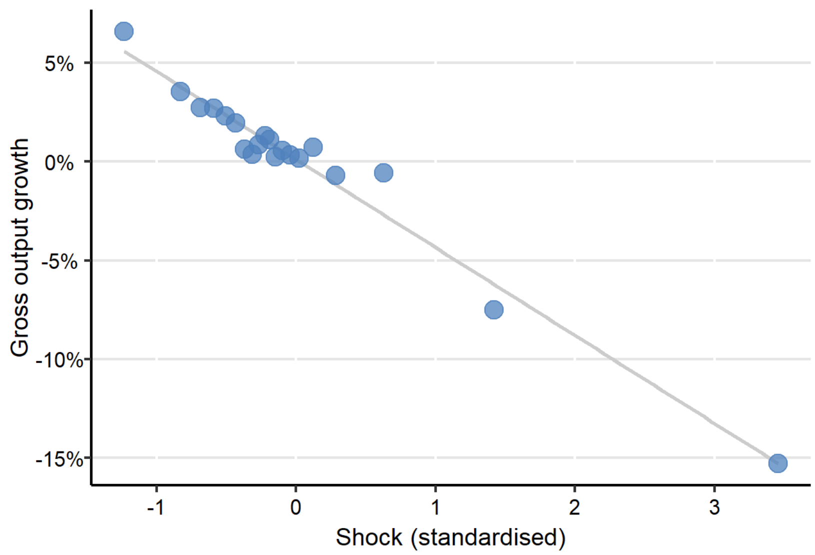
4 Results

Upstream value chain shocks: Descriptive results

Industry-level output growth and value chain shocks are negatively correlated (Figure 2). The bivariate correlations between output growth and upstream value chain shocks is negative, suggesting that foreign input reliance indeed acts as a mechanism through which shocks abroad are transmitted to domestic output. Despite the upstream shocks being plausibly exogenous to domestic output, the correlation cannot be interpreted in a causal sense, the reason being that upstream shocks may be correlated with domestic and downstream shocks.[14] In this sense, the negative correlation between domestic output growth and the upstream shock may partly be picking up the effect of the domestic and downstream shocks.

Figure 2. Output growth is negatively correlated with negative upstream value chain shocks

Mean output growth by upstream shock quantile, binned scatterplot, 2020-21



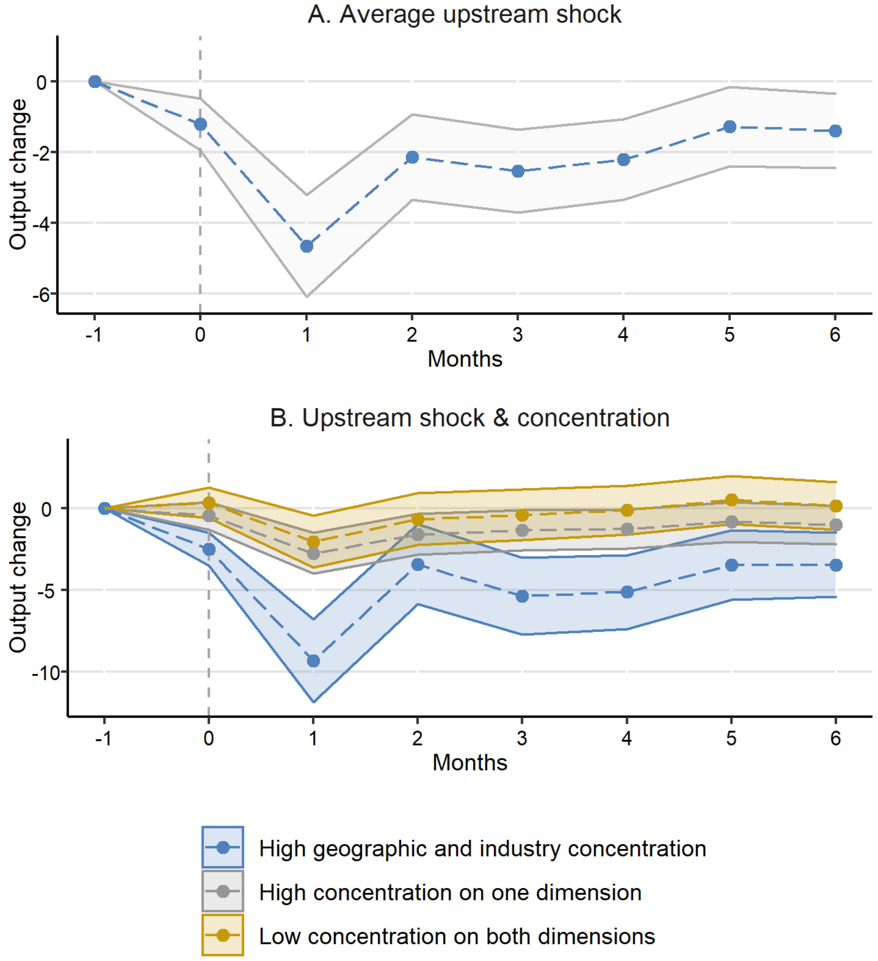
Note: The shocks are first standardised (de-meaned and divided by the standard deviation over the sample period) and then grouped into 20 equal-sized bins along the distribution of shocks. The binned scatterplot represents the mean contemporaneous change in gross output in the relevant countries and industries against the mean value of the standardised shock in each bin.
Source: OECD, ICIO database.

Upstream value chain shocks: Regression results

Using Equation 1 to estimate the effect of upstream GVC shocks on output suggests that a one-standard deviation shock reduces output during the quarter by around 2.7% (Figure 3 and Table A A.2).[15] To put this effect into context, across countries and industries, the average upstream shocks between February and April 2020 – the period during which mobility restrictions were tightened most severely – was on the order of two standard deviations. The effect of the shock is fairly persistent, with the negative response of output remaining statistically and economically significant after 6 months. This suggests that while businesses were partly able to adapt to pandemic-induced disruptions, production only fully recovered once mobility restrictions abroad were lifted.

Figure 3. Output response to upstream GVC shocks

Response of output to a one-standard deviation negative upstream GVC shock, %, Equation 1, 2020-21



Note: Based on Equation 1. The dots represent the response of output to a one-standard deviation GVC shock in period 0, with the shaded area representing the 90% confidence interval. Continuous concentration indicators are mapped into dummy indicators to distinguish between high concentration (above median) and low concentration (bellow median) of suppliers/buyers.
Source: OECD, ICIO database.

The average impact of upstream GVC shock appears to be driven by highly concentrated suppliers and buyers (Figure 3, Panels C and D; Figure A A.3). The negative response of domestic output to an adverse upstream shock is largest when supply is both geographically and industrially concentrated. This is consistent with the expectation that high geographic concentration of supplying countries and high within-industry concentration of supplying firms reduces possibilities for buying firms to source inputs from alternative suppliers. Conversely, when supply is neither geographically nor industrially concentrated, the effect of an upstream shock is not statistically significant. Industries concentrated only along one dimension (geography or industry) are slightly more affected than the low concentration group even though the difference between the two groups is not always statistically significant (Figure A A.5). Overall, these results suggest that geographic and industry concentration are crucial determinants of the impact of GVC shocks on domestic production.

Policy analysis

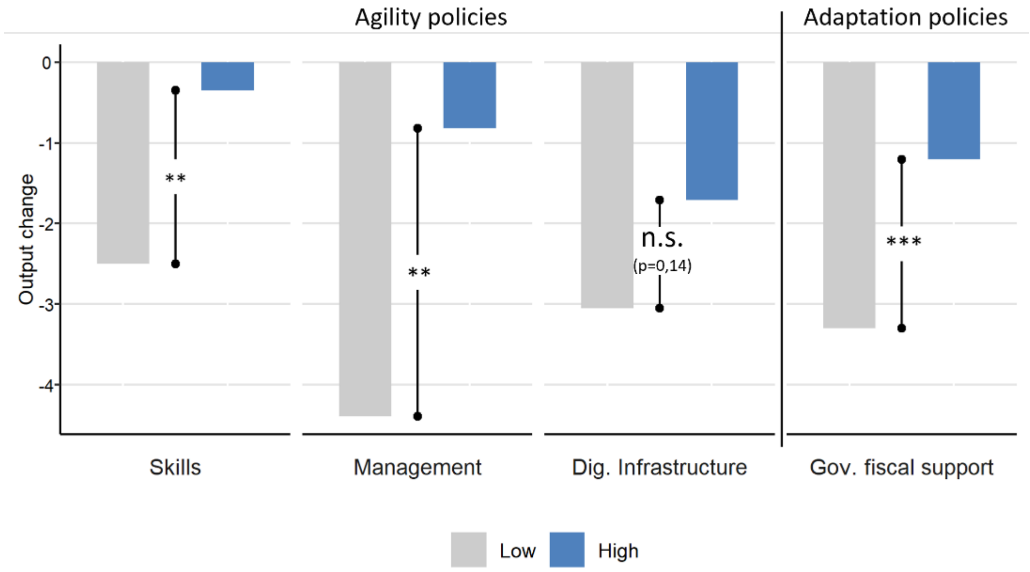
Supporting a rapid rebound

The above empirical framework can be used to analyse how public policies promote a rapid rebound in the event that the risk of a value chain shock materialises (Equation 3). This analysis suggests that government fiscal support, management quality, worker skills and digital infrastructure are positively related to a rapid rebound following an upstream supply shock (Figure 4 and Figure A A.4).

Policies that are adopted ex-ante before a shock materialises (agility policies), such as the promotion of management and worker skills as well as enhancing digital infrastructure, appear to have facilitated a rapid rebound during the COVID-19 crisis (Figure 4) Higher-skilled managers may be better able to re-tool production, have a better knowledge of the company's supplier network beyond its immediate suppliers (e.g. by using advanced digital tools), or may have a more prudent inventory management strategy. High worker skills smooth restructuring of production processes according to demand developments, as higher-skilled workers generally also tend to have more transferrable skills. The estimated difference between countries with high and low rollout of digital infrastructure would be consistent with better digital infrastructure facilitating adaptation but is statistically insignificant at the 10% level. In any case, it may partly reflect the specificity of the COVID-19 crisis, as the availability of broadband internet access allowed the wide adoption of telework.

Figure 4. A range of policies dampen negative effects on output of negative upstream GVC shocks

Average output response in the 3 months following a one-standard deviation adverse upstream GVC shock, %, 2020-21



Note: Based on Equation 3. Continuous variables are transformed into binary ones to distinguish between high (top quartile) and low (bottom three quartiles) and low values of the indicators. The vertical whiskers denote differences between high and low policy scores, with stars denoting statistical significance (*** p<0.01, ** p<0.05, * p<0.1). The statistical significance of the difference is established by bootstrap (200 repetitions). The results by month can be found in Table A A.4.
Source: OECD, ICIO database.

Fiscal support is among the key ex-post measures that governments can take after a GVC shock materialises (adaptation policies). For instance, in 2020, most OECD countries provided fiscal support, including through tax relief, grants and guaranteed loans and short-time work schemes. These discretionary fiscal measures – measured by the change in the underlying fiscal deficit – allowed firms hit by supply chain disruptions to surmount temporary liquidity squeezes and rapidly ramp-up production as the disruptions eased (Figure 4)

Mitigating the risk of disruptions from abroad

The above empirical framework can also be used to analyse how public policies can mitigate the risk of disruptions from abroad by influencing the sourcing of foreign intermediate inputs. Analysing the role of policies in mitigating the risk from foreign sourcing involves generating shock scenarios under various GVC configurations.

One scenario of particular policy interest involves comparing shocks under the actual configuration of GVC with perfect supplier diversification. In practice, this scenario involves re-distributing trade dependencies across countries according to shares in GVC trade without modifying overall value chain integration and calculating the predicted value of various shock scenarios from Equation 3.

For instance, suppose that country A has three trade partners, with partner B supplying 80% of country A's foreign intermediate inputs and countries C and D supplying 10% each. Then, if country B accounts for 50% of GVC trade and countries C and D for 25% each, the perfect diversification scenario involves reducing country A's dependence on country B (by 30 percentage points) and increasing its dependence on countries C and D (by 15 percentage points).[16] An illustration of such diversification is the recent rebalancing of natural gas supply in European countries, which was heavily tilted towards Russia before the war in Ukraine but has converged towards shares in global natural gas trade.

Diversification of suppliers in GVCs is estimated to significantly dampen the effects of an upstream supply shock from China. As shown in Schwellnus et al. (forthcoming[4]), China is a major choke point in GVC. Under current GVC dependencies, a tightening of mobility restrictions of 20 points on the Oxford stringency indicator in China (corresponding roughly to the tightening observed between early-March and early-April 2022) is simulated to reduce output in selected downstream industries to up to 4% (Figure 5).[17]

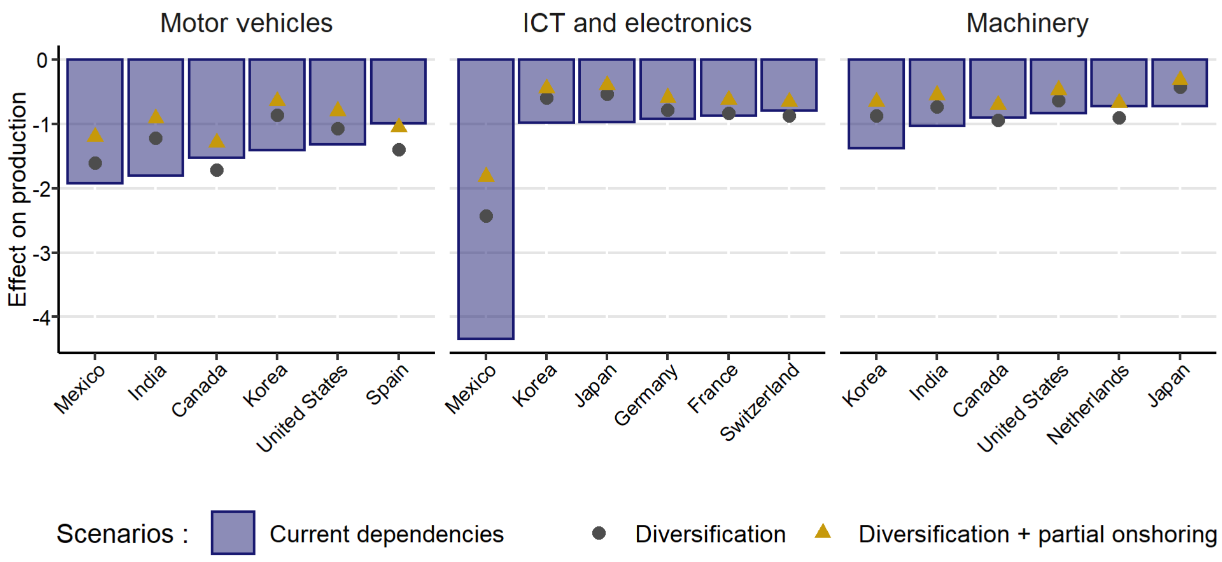
Diversification of trade dependencies would have particularly large shielding effects on domestic output in many Asian countries and Mexico, reflecting their high ongoing reliance on Chinese upstream suppliers. By contrast, in the specific case of the simulated China shock, diversification would be much less beneficial, or even costly, for Canada and European countries, because current dependencies are lower than under the diversification benchmark.

Another scenario of policy interest is the partial onshoring of production (De Backer et al., 2016[19]). These policies can be simulated by re-assigning production abroad to domestic producers. Concretely, the partial onshoring scenario assumes that 25% of current foreign intermediate input needs are onshored (on top of diversification).

Compared with the diversification scenario, the partial onshoring of production has only limited additional benefits in terms of shielding domestic production from the upstream GVC shock from China (Figure 5). The reason is that onshoring production from a low starting point – either because of previous diversification or low initial dependence on China – only shields a small part of domestic production from the simulated China shock. For instance, in countries and industries with initially high dependence on inputs from China, such as the Mexican ICT industry or the Korean machinery industry, diversification reduces dependence on China substantially, so that the subsequent onshoring of production has only little additional benefits. Onshoring without previous diversification (e.g. because diversification is infeasible) would have larger shielding effects but would also be more costly since a larger share of input production would have to be onshored.

Figure 5. A supply shock from China would have sizeable effects on downstream industries

Simulated effect of an increase in Chinese mobility restrictions on output of selected downstream industries



Note: The bars report the simulated effect of an increase of 20 points in the Oxford stringency indicator for China in the quarter of the shock based on Equation 3. In each industry, the 5 displayed countries are the countries that are most affected by the shock (constraining the sample to the 15 largest importers and exporters). The diversification scenario is obtained by rebalancing the total reliance of each buying industry on supplying countries according to supplying countries' shares in GVC trade. The diversification + partial onshoring scenario is obtained by additionally reducing total foreign reliance by 25%.
Source: OECD, ICIO database.

In sum, even though the diversification and partial onshoring scenarios are highly stylised and focus on a specific shock, they nonetheless highlight two key points. First, geographical diversification of value chains can have large beneficial effects in terms of shielding domestic output from GVC shocks. Second, additionally onshoring production may have only small additional benefits and must be balanced with potentially large costs in terms of economic efficiency. Box 1 analyses the role of technological innovation as a risk management strategy that may complement diversification and partial onshoring. For instance, innovation in battery technology may reduce reliance on imports of critical minerals from geographically highly concentrated suppliers (Schwellnus et al., forthcoming[4]).

Box 1. Technological innovation can complement diversification

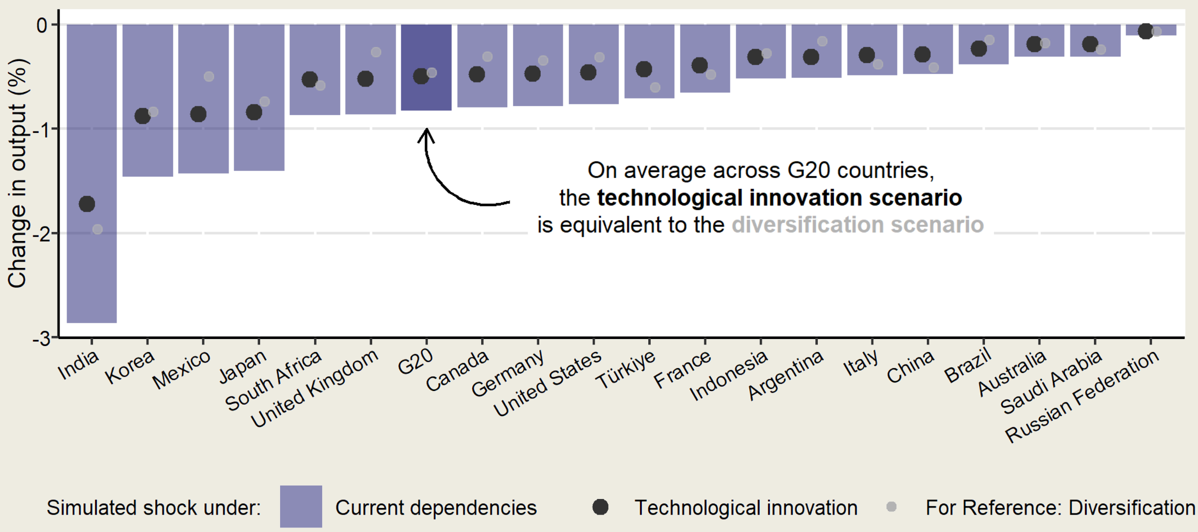
Over the past 50 years, the fossil fuel intensity of GDP has decreased substantially in many OECD countries, resulting in reduced reliance on fossil fuel-supplying countries. This box simulates the extent to which a further reduction in technological reliance on fossil fuels would dampen the effect of a negative shock to fossil fuel supply.

The simulated shock consists of a reduction of 20% in fossil fuel supply from the three main foreign suppliers. For each country, the magnitude of the effect depends on the initial level of foreign fossil fuel reliance and the concentration of suppliers. Countries with high reliance on foreign fossil fuels (e.g. India) are among the most affected by the shock. Moreover, at a given level of foreign fossil fuel supply, countries with diversified supply (e.g. China) are comparatively less affected than countries with highly concentrated supply (e.g. Germany).

On average, across G20 countries, reducing technological reliance on fossil fuels by 40% through technological innovation has the same effects as diversification. To put the simulated 40% reduction in technological fossil fuel reliance into perspective, the energy intensity of GDP (the share of primary energy consumption in GDP) of G7 countries declined by 35% over the period 1995-2019 (Our World in Data, 2022[20]). Gains are comparatively larger for countries with low initial concentration of fossil fuel supply (e.g. France, Italy and Türkiye), where gains from further diversification would be limited.

Figure 6. A 40% reduction in technological dependency is broadly equivalent to diversification

Output response to a 20% reduction in primary energy supply from 3 main suppliers, %



Note: The chart presents the effect of a reduction of 20% in the supply of the top 3 suppliers of fossil fuels (energy mining) on the 5 most reliant industries (air transport, electricity, motor vehicles, machinery, electrical machinery). The mobility shock equivalent to a 20% reduction of production in the mining non energy sector is computed using the coefficient of Equation 1. The bar represents the weighted average of the effect across the 5 industries, with the weights being each industry's gross output. The diversification scenario is obtained by rebalancing each country and industry's total fossil fuel reliance according to the share in global fossil fuel trade. The technological innovation scenario corresponds to a reduction of technological fossil fuel reliance of 40%.
Source: OECD, ICIO database.

5 Policy implications

A key factor shaping the appropriate policy response to GVC risk is geographical concentration of supply and demand. The empirical results in this paper suggest that the impact of GVC shocks on domestic production is generally less pronounced, or even insignificant, when geographical concentration of suppliers is low (Figure 3 and Figure A.3). In this case, GVC shocks are of limited policy concern since inputs can be sourced from alternative suppliers in case a supplying industry in a specific country is disrupted. By contrast, if supply or demand are highly geographically concentrated, disruptions abroad may have large adverse effects on domestic production.

Another crucial determinant of the appropriate policy response to GVC risk is the strategic importance of the relevant value chain. From an economic perspective, a strategically important value chain provides an essential input to a wide range of domestic downstream industries (e.g. some raw materials) or provides significant technological spillovers to the wider economy (e.g. semiconductors) (Ding and Dafoe, 2021[21]). The economic perspective is generally not only based on current considerations but also forward-looking (e.g. importance of a value chain for the green transition). From a non-economic perspective, strategic importance also encompasses considerations such as the importance of a value chain for national defence, public health and food security.

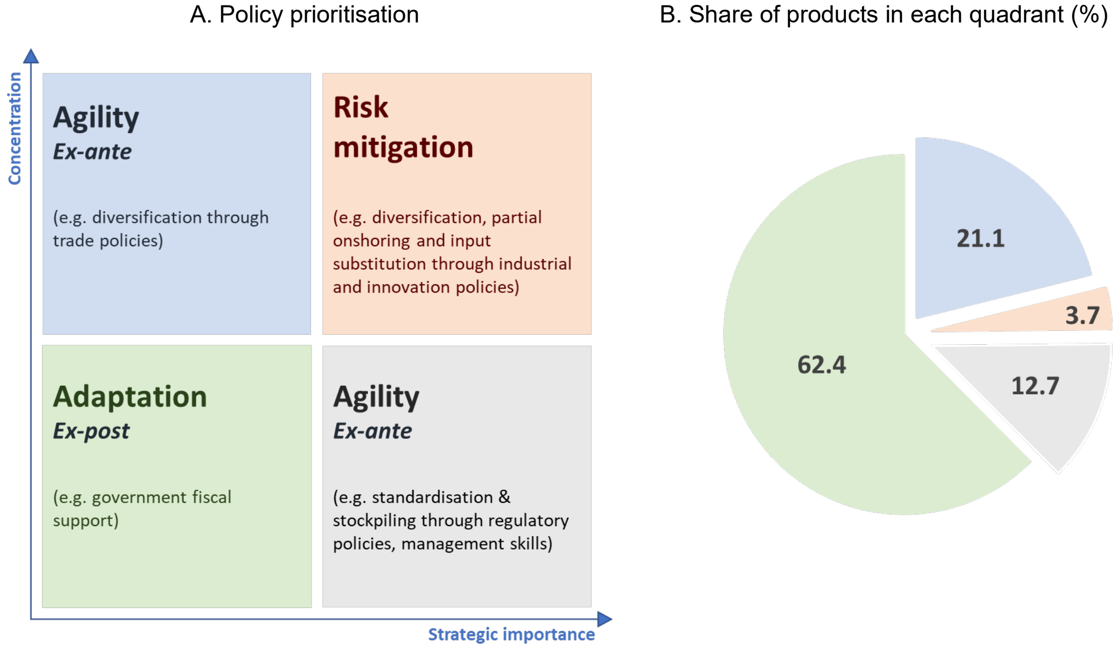
Highly-concentrated and strategically-important value chains

Concerns about GVC risk are most pronounced in highly-concentrated and strategically-important value chains (Figure 7, Panel A, top-right quadrant). For instance, given that semiconductor production is highly concentrated in a small number of key players and semiconductors are a critical input into a broad range of other industries (including national defence), a disruption of the value chain would have large adverse macroeconomic consequences (Haramboure et al., forthcoming[22]). In such value chains, the benefits of risk mitigation strategies to limit foreign exposures, such as diversification of input suppliers (including through near- and partial onshoring of production) and technological innovation to substitute specific inputs may, in some cases, justify large up-front investments and/or higher production costs.

Diversification of suppliers and partial onshoring of production is being pursued through a wide range of policies, including industrial and innovation policies. For instance, significant supply-side support is being rolled out to the semiconductor industry in several OECD economies. The US and European Union Chips Acts provide significant funding for semiconductor manufacturing, supply chain and R&D investments. A demand-side example is recent US climate legislation that provides tax credits for buyers of electric vehicles if the battery incorporates raw materials that have been extracted, processed or recycled in the United States or selected trade partners.

Technological innovation to reduce reliance on specific inputs that are currently sourced from geographically concentrated suppliers can complement diversification and onshoring strategies. This is particularly the case in value chains where diversification and onshoring is costly or infeasible, such as a number of critical raw materials, including oil and gas. For instance, many countries are actively pursuing policies to reduce the reliance on fossil fuels by supporting the rollout of existing renewable energy technologies and promoting green energy innovation. The Dutch decarbonisation strategy, for instance, supports the uptake of existing low-carbon technologies (e.g. renewable electricity) and the development of radically new technologies (e.g. hydrogen) through subsidy programmes and corporate tax incentives (Anderson et al., 2021[23]).

Figure 7. Policy prioritisation



Note: Concentration is defined based on a Herfindahl-Hirschman Index (HHI) of geographic supplier concentration, where any product with a HHI of above 2500 is considered to be highly concentrated. Strategic products include minerals; fuels and mineral oils; precious metals; pharmaceutical products; railway and parts thereof, such as traffic signalling equipment; vehicles other than railway; medical, surgical, dental or veterinary equipment and instruments; and semiconductors as well as machines solely for the manufacturing of semiconductors and integrated circuits. Sample: OECD imports from all countries in 2020 excluding agriculture and fishing.
Source: COMTRADE, OECD computations.

The potential benefits of risk mitigation policies need to be balanced with potential costs. More domestic and shorter supply chains may shield countries from shocks abroad, but the onshoring or near-shoring of production may make countries more vulnerable to domestic and regional shocks (Javorcik, 2020[24]). Moreover, risk mitigation policies may involve substantial upfront costs and higher operating costs. For instance, setting up a cutting-edge semiconductor production plant requires upfront investments in the range of USD 12-20 billion (The White House, 2021[25]), and, in many countries, the lack of an ecosystem of specialised suppliers and highly-skilled workers may drive up operating costs relative to the status quo (Criscuolo et al., 2022[26]). In order to avoid costly subsidy wars, duplication and uncoordinated capacity expansion, international coordination and information exchange is a minimum requirement for public policies. For instance, the EU-US Technology Council has been set up to coordinate approaches to key trade and technology issues.

Non-strategic or geographically non-concentrated value chains

In non-strategic or geographically non-concentrated value chains, agility and adaptation policies are likely to be sufficient to ensure resilience. On top of promoting management and worker skills to deal with unexpected supply and demand disruptions, this could include:

- In strategic value chains where suppliers are geographically diversified (Figure 7, Panel A, bottom-right quadrant), which includes, for instance, a range of medical, pharmaceutical and ICT products, policies could promote agility, for instance through the standardisation and the holding of adequate inventories. This could be promoted through the international coordination of regulatory policies (e.g. by mandating technical standards for some ICT products) or by strengthening domestic regulatory policies (e.g. by mandating hospitals to hold adequate inventories of essential medical equipment and pharmaceuticals). Switzerland, for instance, mandates the holding of minimum inventories in some sectors.
- In non-strategic value chains with few suppliers (Figure 7, Panel A, top-left quadrant), which includes, for instance, parts of the textiles and apparel value chain, public policies could promote greater diversification through trade policies providing better market access to small suppliers.
- In non-strategic value chains with many suppliers (Figure 7, Panel A, bottom-left quadrant), which includes, for instance, large parts of materials for construction (e.g. stone, cement or plaster), the focus should be on ex-post adaptation measures through fiscal support in case of exceptionally large disruptions. This may include grants and loan guarantees for businesses, and job retention support for workers.

Overall assessment

The vast majority of value chains are non-strategic and non-concentrated, with only a small fraction being strategically important and highly concentrated (Figure 7, Panel B). Based on a common threshold of geographic supplier concentration (Herfindahl-Hirschman Index above 2500) and an ad-hoc definition of strategic value chains, about 62% of value chains are neither dependent on concentrated suppliers nor strategically important. Only about 4% are strategically important and highly concentrated. Even though these proportions are only illustrative due to the ad-hoc definitions of geographic concentration and strategic importance, they nonetheless imply that risk mitigation policies are relevant only for a small fraction of GVCs.[18]

In sum, in most value chains, ex-ante and ex-post adaptation measures are likely to be sufficient to deal with GVC disruptions. Moreover, even in highly concentrated and strategically important value chains, the potential benefits of risk mitigation policies need to be balanced with potential costs. The key challenge for public policies will thus be to preserve the benefits of global sourcing for the overwhelming majority of value chains, while limiting costs when resorting to risk mitigation strategies in strategically-important and highly-concentrated ones.

6 Conclusions

The key insights from the empirical analysis in this paper are threefold. First, the new indicators of exposure to GVC risk developed by Baldwin and Freeman (2021[6]) and described in Schwellnus et al. (forthcoming[4]) are accurate predictors of the impact of shocks to foreign suppliers and buyers on domestic production. Second, the adverse effects of GVC supply shocks are largest when foreign suppliers are highly geographically concentrated and operating in industries with a small number of dominant players. Third, public policies can dampen the effect of GVC shocks on domestic production, both by promoting rapid adaptation to shocks and by mitigating the risk of disruptions.

The appropriate policy mix to address GVC risk depends on the degree of concentration of the relevant value chain and its strategic importance. Risk in the small minority of value chains where suppliers are highly concentrated and that are of vital strategic importance – such as a number of critical raw materials, essential medical equipment, pharmaceuticals and semiconductors – may require mitigation policies. However, the potential benefits of diversification of supply, partial onshoring of production and technological substitution of specific inputs need to be balanced against potential costs. For the vast majority of value chains, where suppliers are highly geographically diversified or strategic importance is limited, policies to facilitate a rapid rebound may be sufficient to enhance GVC resilience while preserving the benefits of global sourcing.

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Endnotes

[1] Of course, industry and firm-level risk exposure can be related if the entire industry relies on single supplier of intermediate goods.

[2] For instance, Taiwan Semiconductor Manufacturing Company is dependent on a single Dutch supplier for its lithography systems, which is, in turn, dependent on a single supplier in Germany for its optical engine (Shih, 2020[32]).

[3] Risk mitigation strategies are often referred to as robustness strategies (Baldwin and Freeman, 2021[6]; Brunnermeier, 2021[5]; Miroudot, 2020[31]).

[4] Since pandemic-related supply disruptions abroad may be correlated with domestic and foreign demand disruptions, the model controls for domestic and foreign demand disruptions as proposed by Acemoglu, Akcigit and Kerr (2016[29]).

[5] $\boldsymbol{\varphi^k}$ is a (row) vector of estimated coefficients. Specifically, $\boldsymbol{\varphi^k dyn_{c,j,t}} = \sum_{f=1}^{k}(\varphi^{u,f}\mathrm{up}_{c,j,t+f} + \varphi^{d,f}\mathrm{do}_{c,j,t+f} + \varphi^{x,f}\mathrm{x}_{c,j,t+f}) + \sum_{l=1}^{L}(\varphi^{u,l}\mathrm{up}_{c,j,t-l} + \varphi^{d,l}\mathrm{do}_{c,j,t-l} + \varphi^{x,l}\mathrm{x}_{c,j,t-l})$. The leads control for shocks between *t* and *t+k* whose omission could bias the estimates of a shock at *t* itself if changes in the policy shock are autocorrelated (Teulings and Zubanov, 2014[33]). The lags control for shocks before *t* and are included for the same reason.

[6] Even though monthly output data is available up to the first quarter of 2022 for most countries, the sample is restricted to 2020m1-2021m9 in order to ensure that an identical sample is used regardless of the number of included leads (up to 6).

[7] In order to minimise collinearity issues, concentration and public policy indicators are interacted separately rather than simultaneously with the upstream and downstream shocks.

[8] In particular it covers NACE sectors B, C, D (D353 and E excluded), F, H, I, J, L, M (M701, M72, M75 excluded) and N. In the rare cases where output is provided at a more disaggregated level by Eurostat than in the OECD TiVA database (e.g. in professional scientific and technical activities), nominal gross output is used as weight to aggregate output growth to the level available in the OECD ICIO database.

[9] Data for Korea, Mexico and the United States are only available at a quarterly frequency. For these countries, both production data and the Oxford mobility stringency index are interpolated. The interpolation of the stringency index is necessary to avoid introducing attenuation bias by interpolating the dependent variable in Equation 1.

[10] For further details on the individual components of the index or the weighting, please refer to Hale et al. (2021[15]).

[11] For the purpose of this paper, teleworkability within industries is assumed to be constant throughout the observation period.

[12] The initial data, based on Orbis, is available at a finer level of aggregation than the ICIO industry classification. The data is aggregated to the ICIO level of aggregation using turnover as weights.

[13] Increases in the underlying fiscal deficit reflect discretionary fiscal measures such as tax cuts and the expansion of job retention schemes (short-time work and/or employment subsidies).

[14] In fact, the correlation between domestic shocks and downstream shocks is 0.73, and between domestic shocks and upstream shocks 0.66

[15] The quarterly decline is computed as the average decline over the 3-months period following the shock (months 0 to 2).

[16] The rationale for not distributing intermediate trade dependencies uniformly across countries is that it would be highly implausible to assume that all countries can produce the same amount of intermediate inputs in all industries (e.g. raw materials). Distributing intermediate trade dependencies according to shares in global gross output rather than shares in intermediate trade would fail to account for the fact that only a part of intermediate good output is available for trade since an important part is used in domestic production.

[17] In a number of countries, these industries account for a significant share of GDP (e.g. motor vehicles in Canada, Korea, Mexico and the United States).

[18] Numbers are similar when proportions are based on the value of trade rather than the number of products (Figure A A.5)

Annex A. Supplementary technical material

A1. Technical details on the construction of the explanatory variables

The foreign supply disruption variable $disruption_{j'c't}$ in Equation 2 is defined as:

$$disruption_{j'c't} \equiv \sum_{c'=1}^{N} \sum\nolimits_{j'}^{J} \left(presence_{j'} \times \Delta mobilrestr_{c't}\right) \qquad \text{Equation 4}$$

where subscripts c, j, and t denote, respectively, country, industry and time; $presence_j$ is an industry-level measure of required physical presence; and $\Delta mobilrestr_{ct}$ is a measure of mobility restrictions.

The control variables $x_{c,j,t}$ in Equation 1 include downstream demand shocks and domestic demand and supply shocks. Downstream demand shocks are defined as follows:

$$do_{c,j,t} \equiv \sum_{c'=1}^{N} \sum\nolimits_{j'}^{J} \left(FMRI_{cjc'j',0} \times disruption_{j'c't}\right) + \sum_{c'=1}^{N} \left(FMRF_{cjc',0} \times \Delta mobilrestr_{c't}\right) \qquad \text{Equation 5}$$

where $FMRI$ is a measure of reliance on foreign intermediate demand of country-industry *cj* on foreign country-industry *c'j'* at (pre-estimation) period 0; and $FMRF$ is a measure of reliance on foreign final demand. The first term on the right-hand side of Equation 5 measures the downstream intermediate demand shock, which depends on required physical presence of downstream industries. The second term on the right-hand side measures the downstream final demand shock, which is independent of required physical presence since it does not depend on the level of production in downstream industries but on overall business and consumer demand.

Domestic demand and supply shocks are defined as follows:

$$dom_{c,j,t} \equiv disruption_{jct} + \sum\nolimits_{j'\neq j}^{J} \left(DIR_{cjj',0} \times disruption_{j'ct}\right) \qquad \text{Equation 6}$$

$$+ \sum\nolimits_{j'\neq j}^{J} \left(DMRI_{cjj',0} \times disruption_{j'ct}\right) + \left(DMRF_{cj,0} \times \Delta mobilrestr_{c't}\right)$$

where DIR_{cj} is the strength of reliance on upstream domestic inputs; $DMRI$ is a measure of reliance on downstream domestic intermediate demand; and $DMRF$ is a measure of reliance on domestic final demand. The first term on the right-hand side of Equation 6 measures the direct domestic supply shock; the second and third terms the indirect upstream supply and downstream demand shocks through input-output linkages, and the fourth term direct domestic demand shocks.

Note that *FIR*, *FMRI*, *FMRF*, DIR, $DMRI$, $DMRF$ are constructed using the pre-estimation sample period, and mobility shocks are overwhelmingly determined by the severity of the pandemic, so that *up*, *do* and *dom* can plausibly be viewed as exogenous to domestic output developments. Pandemic-related mobility restrictions – which underlie the exogenous shocks defined in Equation 4 to Equation 6 typically disrupt the entire shipment of a good rather than only the value added by the mobility-restricting country. Consequently, the preferred definitions of FIR and FMR are based on gross trade and gross output and as defined in Haramboure et al (forthcoming[22]). Importantly, *FIR* and *FMR* account for both direct and indirect trade between partner countries by making use of the OECD ICIO data. For instance, the ratio of Chinese output to US gross output accounts for both direct gross imports from China and indirect imports that are routed through other US trading partners. Equation 4 to Equation 6 also implicitly account for the length of the supply chain, as gross output increases each time a good crosses the border: In other words, the gross output-based FIR and FMR account for the fact that the entire shipment may be held up at any point of the value chain (Haramboure et al., forthcoming[22]).

A2. Data for estimation of Equation 1

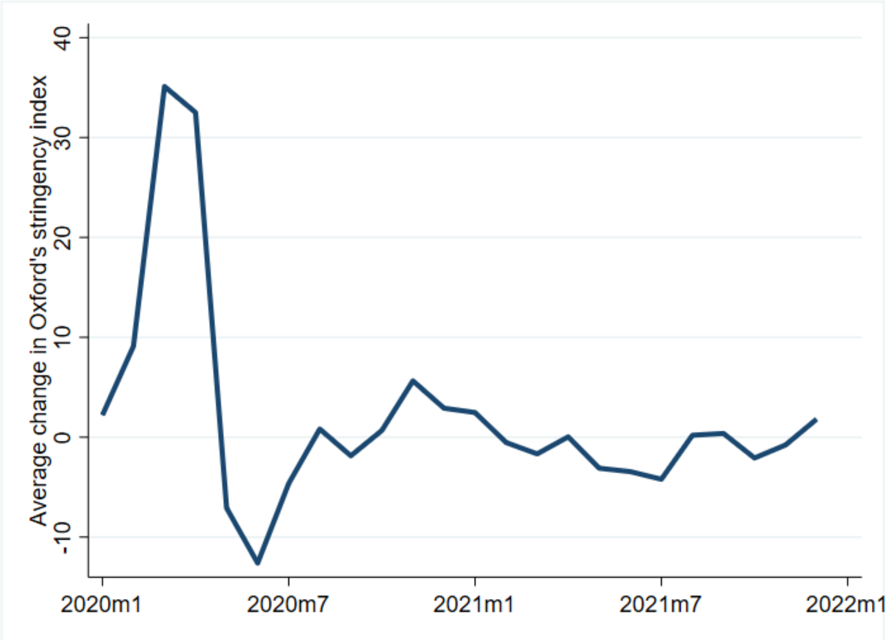
Table A A.1. List of countries and industries covered in the regression analysis

Countries	ISIC Rev.4	
AUT	05-06	Mining, energy
BEL	07-08	Mining, non-energy
BGR	09	Mining, services
CAN	10-12	Food products
CHE	13-15	Textile and apparel
CYP	16	Wood
CZE	17-18	Paper and printing
DEU	19	Coke and petroleum
DNK	20	Chemicals
ESP	21	Pharmaceuticals
EST	22	Rubber and plastics
FIN	23	Non-metal minerals
FRA	24	Basic metals
GBR	25	Fabricated metals
GRC	26	ICT and electronics
HRV	27	Electrical machinery
HUN	28	Machinery
IRL	29	Motor vehicles
ITA	30	Other transport
KOR	31-33	Other manufacturing
LTU	35	Electricity
LUX	36-39	Other utility
LVA	41-43	Construction
MEX	45-47	Wholesale and retail
MLT	49	Land transport
NLD	50	Water transport
NOR	51	Air transport
POL	52	Warehousing
PRT	53	Postal
ROU	55-56	Hotel and restaurants
SVK	58-60	Publishing, broadcasting
SVN	61	Telecoms
SWE	62-63	IT services
TUR	68	Real estate
USA	69-75	Professional, scientific and technical
	77-82	Admin support

Note: Not all industries are covered by each of the listed countries above.

Figure A A.1. Mobility restrictions

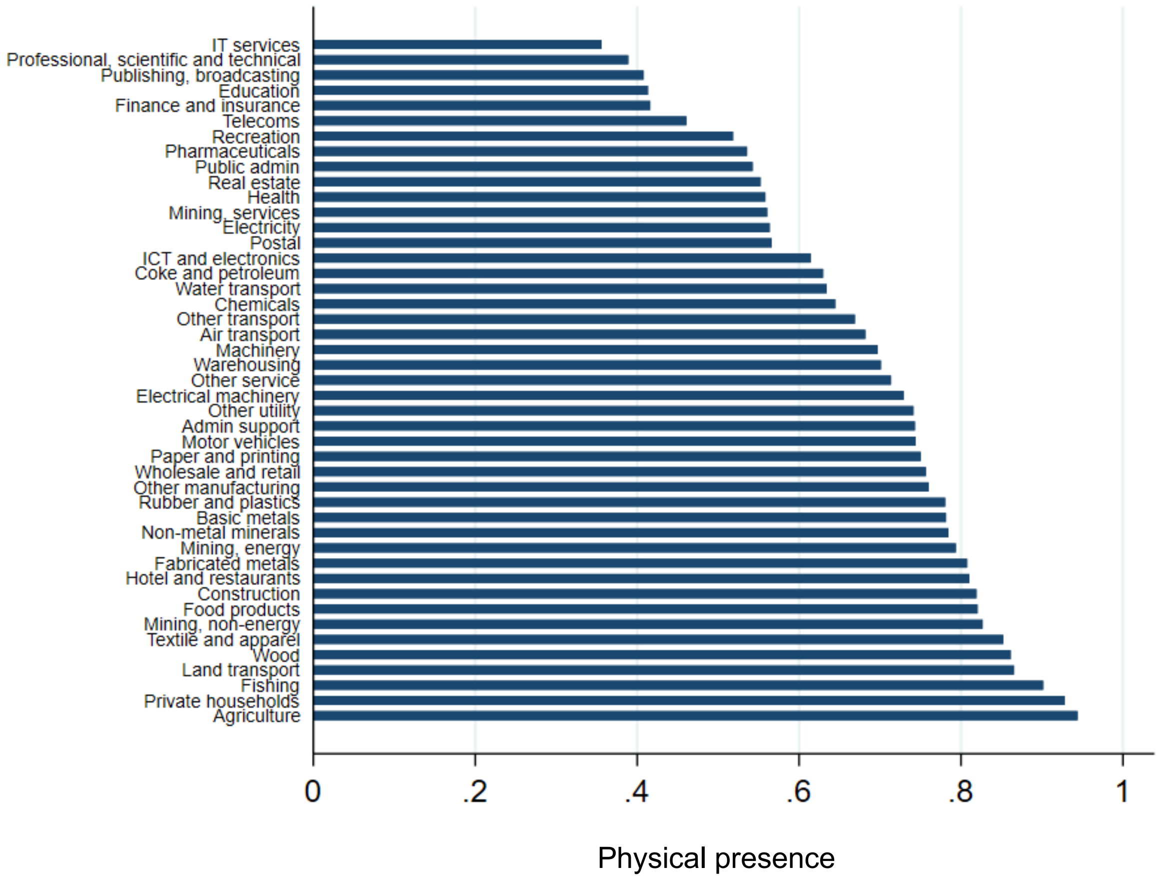
Change in monthly stringency index, average across countries in TiVA, January 2020 - December 2021



Note: Country-specific mobility restrictions are proxied by the Oxford COVID-19 Government Response Tracker constructed by Hale et al. (2021[15]). The overall stringency index ranges from zero to 100 and measures the extent of school, workplace and public transport closures, restrictions to public events, gatherings and internal movements, requirements to stay at home, controls of international travel and public information campaigns.
Source: OECD calculation based on Hale et al. (2021[15]).

Figure A A.2. Required physical presence of workers

1 minus share of teleworkable jobs, average across EU28 countries, by ISIC Rev.4 industry division, 2019

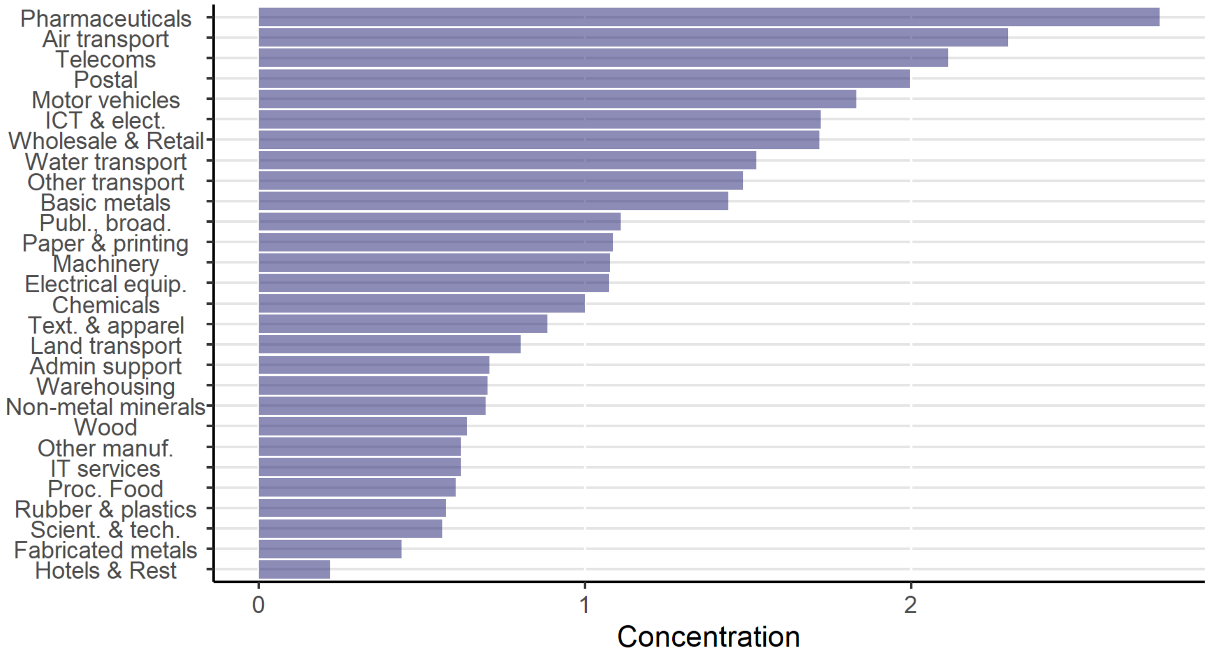


Note: Required physical presence is measured as 1 minus the share of teleworkable jobs in an industry, where the share of teleworkable jobs is constructed based on Dingel and Neiman (2020[16]). Their approach distinguishes teleworkable from non-teleworkable occupations based on whether an occupation can be fully carried out from home using US O*NET classifications.
Source: OECD based on EU LFS data.

Job characteristics, such as the ability to perform tasks remotely (Dingel and Neiman, 2020[16]) and person-to-person contact intensity (Famiglietti, Leibovici and Santacreu, 2020[27]), played a significant role in industries' exposure to disruptions during COVID-19. However, not all industries were hit equally hard by social distancing policies aimed at reducing the risk of contagion especially in contact-intensive places, such as restaurants and beauty salons. While these non-essential contact-intensive industries did in fact experience much larger job losses (Famiglietti, Leibovici and Santacreu, 2020[27]), some traditionally contact intensive jobs managed to move the person-to-person contact side of their business online. For instance, lawyers were able to transition to telework and carry out client meetings online. In other words, it was not the contact intensity but the fact that their physical presence was not required to carry out their day-to-day business that helped mitigating COVID-19 induced disruptions. This important difference is also acknowledged in the literature (e.g. Pizzinelli and Shibata (2022[28])).

Figure A A.3. Sales concentration by industry

Sum of sales of the top-4 firms over the total industrial production by industry, 2016-2018, ratio to the median industry concentration

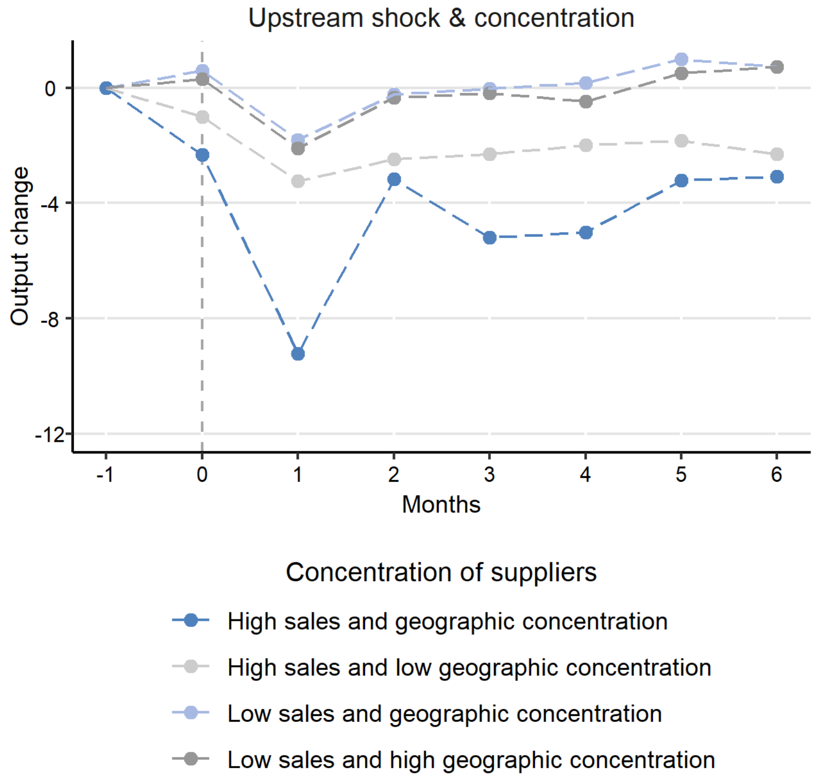


Note: The chart plots the sales concentration defined as the sum of sales of the top-4 firms over the total industrial production normalised by the sales concentration of the median industry (Chemicals). The data is available for 14 countries between 2016 and 2018. The concentration plotted is a simple average by industry across years and countries. The initial data is aggregated using turnover as weights to reach a similar level of aggregation as the ICIO industry classification.
Source: OECD calculation based on Orbis, based on ongoing work on industry concentration at the OECD

A3. Additional heterogeneity analysis

Figure A A.4. Output response to upstream GVC shock

Response of output to a one-standard deviation upstream GVC shock, based on Equation 1, 2020-21



Note: The dots represent the response of output to a one-standard deviation GVC shock in period 0. Continuous concentration indicator are transformed in dummy indicators to distinguish between high concentration (above median) and low concentration (bellow median) of suppliers/buyers
Source: OECD, ICIO database.

A4. Regression results

Table A A.2. Domestic, upstream and downstream value chain shocks

Effect of a one-standard deviation shock on the change in (log) output, 2020-21

	Impact	1 month	2 months	3 months	4 months	5 months	6 months
Domestic shock	-0.009***	-0.016***	-0.010***	-0.008***	-0.009***	-0.004	-0.006**
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Upstream shock	-0.012***	-0.046***	-0.021***	-0.025***	-0.022***	-0.013*	-0.014**
	(0.005)	(0.009)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
Downstream shock	-0.001	-0.007	-0.006	-0.022***	-0.018***	-0.021***	-0.020***
	(0.003)	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
Country FE	yes	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes
R-squared	0.157	0.223	0.245	0.239	0.215	0.200	0.208
Observations	16,016	16,016	16,016	16,016	16,016	16,016	16,016

Note: The regression model controls for up to 6 leads (depending on the horizon) and one lag for each of the shocks (domestic, upstream and downstream). Coefficients of those and of the constant are not reported. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Source: OECD, ICIO database.

Table A A.3. Upstream value chain shocks & concentration

Effect of a one-standard deviation shock on the change in (log) output, January 2020 to September 2021

	Impact	1 month	2 months	3 months	4 months	5 months	6 months
	Concentration and upstream shock						
Domestic shock	-0.004	0.007	0.009	0.005	0.009	0.020**	0.002
	(0.007)	(0.011)	(0.010)	(0.010)	(0.010)	(0.009)	(0.010)
Upstream shock	0.003	-0.020**	-0.006	-0.004	-0.001	0.005	0.001
	(0.006)	(0.010)	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)
Downstream shock	-0.005	-0.011	-0.006	-0.024***	-0.017**	-0.017**	-0.017**
	(0.004)	(0.007)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)
Up * OneHighOneLow	-0.008**	-0.007	-0.009	-0.009	-0.012	-0.013*	-0.012
	(0.004)	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
Up * Both High	-0.028***	-0.073***	-0.028**	-0.050***	-0.050***	-0.040***	-0.036***
	(0.005)	(0.012)	(0.013)	(0.012)	(0.012)	(0.011)	(0.011)
Observations	15,967	15,967	15,967	15,967	15,967	15,967	15,967
R-squared	0.255	0.323	0.330	0.315	0.270	0.244	0.233
Country FE	yes	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes

Note: The table presents the result of the interaction between the upstream chock and a dummy equal to 1 if both the geographical concentration of the suppliers and the sales concentration of the suppliers is high (Both High) and the interaction with a dummy equal to 1 if only one of the two dimensions of concentration is high (OneHighOneLow). The regression models controls for up to 6 leads (depending on the horizon) and one lag for each of the shocks (domestic, upstream and downstream). Coefficients of those and of the constant are not reported. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Source: OECD, ICIO database.

Table A A.4. Adaptation channels and upstream value chain shocks

Effect of a one-standard deviation shock on the change in (log) output, January 2020 to September 2021

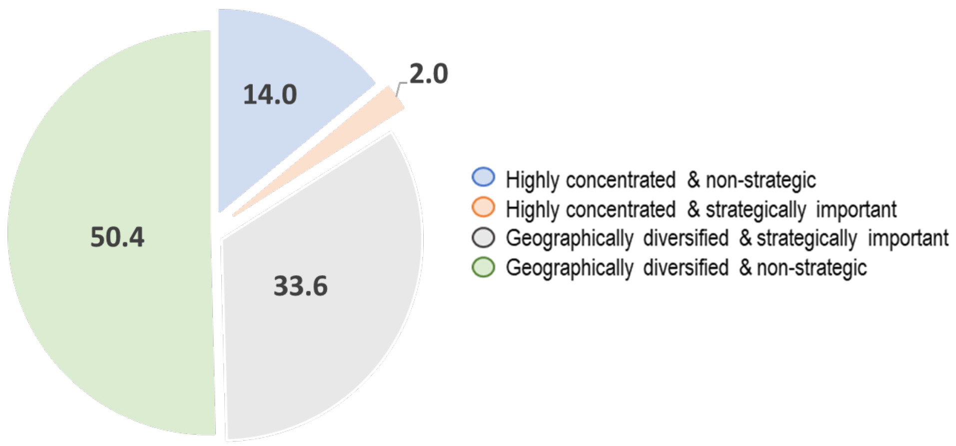
	Impact	1 month	2 months	3 months	4 months	5 months	6 months
				Management			
Domestic shock	-0.010**	-0.024***	-0.014***	-0.014***	-0.014***	-0.013***	-0.013***
	(0.004)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
Upstream shock	-0.018*	-0.076***	-0.037**	-0.045***	-0.036**	-0.027*	-0.021
	(0.010)	(0.019)	(0.015)	(0.016)	(0.016)	(0.016)	(0.013)
Downstream shock	-0.014**	-0.021*	-0.014	-0.032***	-0.031***	-0.025**	-0.025***
	(0.006)	(0.012)	(0.012)	(0.011)	(0.010)	(0.010)	(0.010)
Up. interaction	0.026***	0.056**	0.026	0.037*	0.031	0.025	0.017
	(0.009)	(0.023)	(0.023)	(0.022)	(0.022)	(0.021)	(0.019)
Observations	6,894	6,894	6,894	6,894	6,894	6,894	6,894
R-squared	0.263	0.341	0.362	0.354	0.314	0.302	0.310
				Skills			
Domestic shock	-0.010***	-0.021***	-0.014***	-0.010***	-0.012***	-0.007**	-0.008**
	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Upstream shock	-0.009*	-0.043***	-0.023***	-0.026***	-0.018**	-0.016*	-0.018**
	(0.005)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
Downstream shock	-0.004	-0.008	-0.002	-0.023***	-0.019***	-0.020***	-0.020***
	(0.004)	(0.008)	(0.009)	(0.008)	(0.007)	(0.007)	(0.007)
Up. interaction	0.016***	0.032**	0.017	0.033**	0.016	0.012	0.032***
	(0.005)	(0.012)	(0.014)	(0.014)	(0.013)	(0.012)	(0.012)
Observations	11,512	11,512	11,512	11,512	11,512	11,512	11,512
R-squared	0.143	0.203	0.226	0.220	0.203	0.192	0.209
				Digital infrastructure			
Domestic shock	-0.010***	-0.018***	-0.011***	-0.008**	-0.010***	-0.005*	-0.006**
	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Upstream shock	-0.014***	-0.051***	-0.026***	-0.028***	-0.024***	-0.018**	-0.016**
	(0.005)	(0.010)	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)
Downstream shock	0.000	-0.002	-0.005	-0.019***	-0.017***	-0.018***	-0.018***
	(0.004)	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
Up. interaction	0.009**	0.014	0.017	0.015	0.008	0.016	0.012
	(0.005)	(0.012)	(0.012)	(0.012)	(0.011)	(0.010)	(0.010)
Observations	14,478	14,478	14,478	14,478	14,478	14,478	14,478
R-squared	0.156	0.222	0.246	0.240	0.217	0.203	0.213

	Government fiscal support						
Domestic shock	-0.011***	-0.020***	-0.012***	-0.010***	-0.010***	-0.005*	-0.006**
	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Upstream shock	-0.018***	-0.057***	-0.024***	-0.031***	-0.029***	-0.015**	-0.019**
	(0.005)	(0.010)	(0.009)	(0.009)	(0.008)	(0.008)	(0.007)
Downstream shock	-0.000	-0.004	-0.006	-0.020***	-0.016***	-0.020***	-0.018***
	(0.004)	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
Up. interaction	0.015***	0.034***	0.013	0.020**	0.024**	0.007	0.013
	(0.004)	(0.009)	(0.010)	(0.010)	(0.010)	(0.010)	(0.009)
Observations	15,094	15,094	15,094	15,094	15,094	15,094	15,094
R-squared	0.156	0.224	0.245	0.237	0.213	0.199	0.206
Country FE	yes	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes

Note: The table presents the coefficients of four separate regression models, one for each policy measure interacted with the upstream shock. Each of the four regression models controls for up to 6 leads (depending on the horizon) and one lag for each of the shocks (domestic, upstream and downstream). Coefficients of those and of the constant are not reported. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Source: OECD, ICIO database.

A5. Policy prioritisation

Figure A A.5. Value of trade in each quadrant (%)



Note: Concentration is defined based on a Herfindahl-Hirschman Index (HHI) of geographic supplier concentration, where any product with a HHI of above 2500 is considered to be highly concentrated. Strategic products include minerals; fuels and mineral oils; precious metals; pharmaceutical products; railway and parts thereof, such as traffic signalling equipment; vehicles other than railway; medical, surgical, dental or veterinary equipment and instruments; and semiconductors as well as machines solely for the manufacturing of semiconductors and integrated circuits. Sample: OECD imports from all countries in 2020 excluding agriculture and fishing.
Source: COMTRADE, OECD computations.