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Inputs in distress: Geoeconomic fragmentation and firms' sourcing

by Ludovic Panon, Laura Lebastard, Michele Mancini, Alessandro Borin, Peonare Caka, Gianmarco Cariola, Dennis Essers, Elena Gentili, Andrea Linarello, Tullia Padellini, Francisco Requena and Jacopo Timini

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Abstract

We study how disruptions to the supply of foreign critical inputs (FCIs) − that is, inputs primarily sourced from extra-EU countries with highly concentrated supply, advanced technology products, or which are key to the green transition − might affect value added at different levels of aggregation. Using firm-level customs and balance sheet data for Belgium, France, Italy, Slovenia and Spain, our framework allows us to assess how much geoeconomic fragmentation might affect European economies differently. Our baseline calibration suggests that a 50 % reduction in imports of FCIs from China and other countries with similar geopolitical orientations would result in sizable losses of value added with significant heterogeneity across firms, sectors, regions and countries, driven by the heterogeneous exposure of firms. Our findings show that the short-term costs of supply disruptions of FCIs can be substantial, especially if firms cannot easily switch away from these inputs.

Keywords: Geoeconomic fragmentation, global value chains, global sourcing, international trade, imported inputs.

JEL Codes: F10, F14, F50, F60.

Authors:

Ludovic Panon, Directorate General Economics, Statistics and Research, Bank of Italy.
Email: ludovic.panon@bancaditalia.it
Laura Lebastard, Euro Area External Sector Division, Directorate General Economics, European Central Bank.
Email: laura.lebastard@ecb.europa.eu
Michele Mancini, Directorate General Economics, Statistics and Research, Bank of Italy.
Email: michele.mancini@bancaditalia.it
Alessandro Borin, Directorate General Economics, Statistics and Research, Bank of Italy.
Email: alessandro.borin@bancaditalia.it
Peonare Caka, Analysis and Research Department, Bank of Slovenia.
Email: peonare.caka@bsi.si
Gianmarco Cariola, Regional Economic Research Unit, Bologna Branch, Bank of Italy.
Email: gianmarco.cariola@bancaditalia.it
Dennis Essers, Economics and Research Department, National Bank of Belgium.
Email: dennis.essers@nbb.be
Elena Gentili, Regional Economic Research Unit, Bologna Branch, Bank of Italy.
Email: elena.gentili@bancaditalia.it
Andrea Linarello, Directorate General Economics, Statistics and Research, Bank of Italy.
Email: andrea.linarello@bancaditalia.it
Tullia Padellini, Directorate General Economics, Statistics and Research, Bank of Italy.
Email: tullia.padellini@bancaditalia.it
Francisco Requena, University of Valencia.
Email: francisco.requena@uv.es
Jacopo Timini, Directorate General Economics, Statistics and Research, Bank of Spain.
Email: jacopo.timini@bde.es

Non-technical summary

Global disruptions, such as the COVID-19 pandemic and the Russian war in Ukraine and, more recently, threats to global integration and multilateralism, have highlighted the euro area's reliance on and vulnerability to foreign input sourcing. This paper studies the potential impact on GDP of cuts to imports of specific products from China and other countries with a similar geopolitical orientation. We use firm-level production and trade data for five European countries − Belgium, France, Italy, Slovenia and Spain.

We begin by identifying "foreign critical inputs" (FCIs): inputs with highly concentrated extra-EU imports, primarily sourced from outside the EU and that are difficult to substitute, or which are key to the green transition. We propose a simple firm-level sourcing framework, to enable quantitative estimates of the impact on value added of supply disruptions of FCIs, at different levels of aggregation. Our findings suggests that a 50% reduction in imports of FCIs from China-aligned countries would result in losses of value added in the manufacturing sector ranging from 2 % for Belgium to 3.1 % for Italy. Thus, our findings show that the short-term costs of supply disruptions of FCIs could be substantial, especially if firms cannot easily switch away from these inputs.

This paper highlights substantial variation in the impact of FCI supply disruptions across firms, sectors, regions and countries, driven by firms' heterogeneous exposure. Our analysis adds to the growing strand of work on understanding why changes to the organisation of global value chains might affect firms and economies differently.

Our model is a parsimonious partial equilibrium model that captures only direct exposure and does not account for the possibility that the factors of production may adjust.

By providing a firm-level analysis for different European countries, we demonstrate the potential of cross-country collaborations. In this sense, the present paper is a first step towards achieving "an alliance to map global supply networks", combining different data sources for different countries.

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1 Introduction

Decades of increasing economic integration have led to the unprecedented expansion of global value chains (GVC) —that is, international interconnected production process networks. However, in such a globalised economy, recent events, such as the COVID-19 pandemic and the Russian invasion of Ukraine, show that the impact of foreign shocks on domestic production can be substantial. In light of these events, many countries are trying to reduce their vulnerability to foreign input sourcing by diversifying their supply chains —that is, by increasing the number of suppliers of those goods and services deemed "critical" or "strategic" for domestic production —and by bringing production closer to home, both geographically and geopolitically.[1] Policies that undermine integration, sometimes described as "geoeconomic fragmentation" (Aiyar et al., 2023), can lead to economic losses and inflationary pressures. Therefore, the mapping of strategic vulnerabilities and quantification of the impact of supply disruptions to key inputs are central to building resilience.

In this paper, we use firm-level production and trade data for five European countries: Belgium, France, Italy, Slovenia and Spain (henceforth BFISS), to shed quantitative light on the effect of *firm-level exposure* to foreign supply risks on manufacturing value added.[2] Our micro-level data allow us to calibrate a tractable, but parsimonious model of supply disruptions that considers firm-level exposure to such disruptions, induced by the selected countries reducing their exports of critical inputs. We employ the model to simulate the economic impact of a sudden reduction in imports from China and other countries with a similar geopolitical orientation (hereafter, China-aligned countries) of "foreign critical inputs" (FCIs). We define FCIs as inputs containing high concentrations of material sourced mostly from outside the EU and which are difficult to substitute or are advanced technologies that are vital for the green transition. Our micro data for five EU countries allows us to retrieve economic impact at different levels of aggregation —firm, sectoral, regional and aggregate —with an arguably relatively high degree

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[1]Governments are offering incentives for firms to diversify and/or re-shore/friend-shore their activities, through measures such as tax breaks, subsidies and concessional loans to support new investments, or the imposition of export restrictions. On the former measures, see, for instance, the US "CHIPS and Science Act" and the "Inflation Reduction Act", the Chinese "Dual Circulation Strategy", India's "Make in India" programme, and the EU's "InvestEU", "REPowerEU" and the "Green Deal Industrial Plan". On the case of export restrictions, for instance, see China's imposition of export restrictions on minerals used in semiconductor and electric vehicle production following the restrictions on semiconductor sales imposed by the US, Japan and the Netherlands. See the *Financial Times* article, "China imposes export curbs on chipmaking metals", 3 July 2023.

[2]Given its key role in production, we focus on the manufacturing sector. However, we also provide results for the whole economy.

of external validity.

We start by showing that EU firms report strong dependence on critical inputs from China.[3] We rely on the results of a European Central Bank (ECB) survey and a national survey administered by the Bank of Italy,[4] which focused on firm sourcing of critical inputs from China. The responses show that 41% of leading European firms are exposed to China through imports of critical inputs and among these firms, 90% estimated that these critical inputs were difficult to substitute.

Based on this evidence and to try to provide a more complete mapping of foreign dependence beyond China, we identify FCIs at the HS6 product level.[5] We leveraged our detailed customs data to map vulnerabilities at the firm level. This resulted in a list of 667 FCIs defined at the HS6 level.[6] Matching our list of FCIs to balance-sheet data from the universe of Belgian, French, Italian, Slovenian and Spanish firms, we propose five stylised facts about importers of FCIs: 1) the share of exposed firms is higher amongst the large firm group; 2) importers of FCIs account for a sizable share of the economy; 3) diversification of FCI sources is limited and large importers are *less* vulnerable; 4) FCIs account for a modest share of total firm purchases; and 5) importers of FCIs are larger and more productive than other firms, even within narrowly defined industries. These stylised facts suggest use of a framework that takes account of heterogeneous firm-level exposure to geoeconomic fragmentation.

Our framework combines firm labour, capital and intermediates, in a Cobb-Douglas production function, to produce an output good. Note in particular, that the intermediates are produced using FCIs and non-FCIs in a constant-elasticity of substitution (CES) fashion.[7] Our baseline scenario consists of halving the supply of FCIs from China-aligned countries.[8] The advantage of granular data is that this aggregate shock can be combined with firms' hetero-

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[3]The definition of critical inputs in the survey differs from that used in the rest of the paper. See the next section for more details.

[4]The European Central Bank survey targeted the largest European firms; the Bank of Italy survey also included small firms.

[5]Our methodology builds on the method proposed by the (European Commission, 2021), which typically identifies vulnerable inputs according to three criteria: inputs with highly concentrated extra-EU imports, primarily sourced from extra-EU countries, and that are difficult to substitute. We build on the list provided by Arjona et al. (2023), but also include inputs whose intrinsic characteristics render them prone to supply disruptions. We prefer the term critical rather than vulnerable, since the description critical encompasses a wider range of high-tech products and products crucial for the green transition. See Section 3 for more detail.

[6]China is a major supplier of FCIs (accounting for 30% of overall EU FCI imports from extra-EU countries).

[7]Bachmann et al. (2022) take a similar country level approach to analyse the potential impact of a Russian oil embargo on German value added.

[8]We build on den Besten et al. (2023) and Capital Economics (2023) to assign countries into blocs based on four different measures of geopolitical alignment. See Section 3 for more details.

geneous exposure to FCIs (i.e., firms' FCI share imported from China-aligned countries) to generate idiosyncratic shocks. These shift-share shocks are then fed into our model to assess how geoeconomic fragmentation may affect firms, sectors, regions and countries. Since our model features a CES nest, the impact of firm-level supply disruptions arising from decoupling is governed by the elasticity of substitution between FCIs and non-FCIs. We propose a range of estimates that are contingent on this parameter,[9] to account for uncertainty surrounding its precise value. Other parameter values needed to calibrate the model, such as sectoral share of expenditure on capital and labour and firm share of expenditure on FCIs, have direct counterparts in our microdata. Since, in our model, factors of production other than FCIs are held constant and the elasticity of substitution between intermediate inputs is assumed to be low, we consider this framework particularly appropriate to study the *short-run* effects related to fragmentation scenarios (Peter and Ruane, 2023).

We find that the impact of geoeconomic fragmentation is heterogeneous across firms and countries. On average, larger firms experience *lower* value-added losses, consistent with Fact 3, which states that these firms are also relatively *less* exposed to FCI disruptions. Aggregating these firm-level effects using value-added weights, we find that, when FCIs and non-FCIs are perfect complements, in the baseline shock scenario, our countries could experience drops in manufacturing value added ranging between 2% for Belgium to 3.1% for Italy and Slovenia.[10] We show, also, that large firms, given their larger weight in the economy, are those that are driving the aggregate change (Gabaix, 2011). Indeed, exposed firms in the top quartile of the value-added distribution account for about 75% of the manufacturing value-added drop in all five countries. We ran a battery of robustness checks which show that our results remain sizable when considering alternative values for the aggregate supply shock, an alternative list of critical inputs, China as the only country source of risk, and the whole economy.

Finally, we show that relying on industry-level rather than firm-level data may bias the impact of geoeconomic fragmentation if the assumed elasticity of substitution value is sufficiently low. The bias stemming from use of more aggregated data arises for two reasons. First, use of macro data results in *mismeasurement* of exposure to FCI disruptions and masks the heterogeneity in firm-level exposure. Second, the *distribution of the value-added weights* contributes to

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[9]As detailed below, we constrain this elasticity to be smaller than 0.2, which is consistent with recent evidence (Barrot and Sauvagnat, 2016; Atalay, 2017; Boehm et al., 2019).

[10]Also, we show that the effects of geoeconomic fragmentation are more muted if the elasticity of substitution is higher and that they vary substantially across sectors and regions.

pinning down the size of the bias. Indeed, the aggregate impact obtained from using a value-added weighted average of firm-level effects yields different results from the impact obtained using sectoral data. This is because the weighting scheme may dilute firm-level changes in value added and underlines the importance of using micro data to monitor exposure to supply shocks on critical inputs.

We would emphasise that our model is tractable, in that it can be calibrated easily using micro data to account for actual firm exposure to critical inputs and to study how different decoupling scenarios might affect the economy at different levels of aggregation, over the short run. However, it is also a parsimonious partial equilibrium model in that it captures only direct exposure and does not account for the possibility that the factors of production might adjust. For this reason, we consider that our paper complements those studies that rely on general equilibrium trade models.

Finally, by providing firm-level analysis for different European countries, we show the potential of cross-country collaboration. Thus, our paper can be considered a first step towards the forging of "an alliance to map global supply networks", combining different data sources for different countries, proposed by Pichler et al. (2023).

Related literature. Our paper contributes to two literature streams. First, it is related to research that uses information at the firm level (survey-based or micro data for a single country) to assess firm exposure to potential sources of geoeconomic fragmentation and measures to mitigate it (Jaravel and Méjean, 2021; Di Stefano et al., 2022; de Lucio et al., 2023; Attinasi et al., 2023b; Baur and Flach, 2023; Crosignani et al., 2024). We add to this literature by going beyond the mapping of dependencies and vulnerabilities and providing a quantitative analysis of the impact of supply disruptions on critical inputs, at the firm, sectoral, regional and aggregate levels.

We also add to work that quantifies the potential economic impacts of different geoeconomic fragmentation scenarios, using general equilibrium (multi-country, multi-sector) trade models.[11,12] Other recent studies, such as Berthou et al. (2024), map GVC vulnerabilities us-

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[11]This literature typically relies on models à la Caliendo and Parro (2015), Allen et al. (2020), Antràs and Chor (2022), or Baqaee and Farhi (2024), to calculate the economic consequences of an increase in trade barriers along geopolitical lines. Examples of such applications include Eppinger et al. (2021), Góes and Bekker (2022), Javorcik et al. (2024), Attinasi et al. (2023a), Borin et al. (2023), Campos et al. (2023), Felbermayr et al. (2023), and Hakobyan et al. (2023).

[12]Other studies use different frameworks, such as large macroeconomic models (the METRO model in OECD (2020) and the World Bank ENVISAGE model in Chepeliev et al. (2022)), Hypothetical Extraction Method (HEM)

ing input-output tables and trade data from Comtrade, and quantify the output losses arising from supply disruptions to direct imports of vulnerable products. Our contribution is aimed precisely at identifying exposure to disruptions to the supply of HS6 products at the *firm* level, using micro data. This allows us to propose stylised facts related to importers of foreign critical inputs and demonstrate potential bias in results that arises from use of more aggregated data. The inclusion in our analysis of five different EU countries ensures a relatively high degree of external validity.

The rest of the paper is organised as follows. In Section 2, we report survey-based evidence on firm exposure to foreign risks. Section 3 explains how we identify foreign critical inputs and introduces our stylised facts. Section 4 describes our framework and Section 5 presents the results for the impact of geoeconomic fragmentation. Section 6 concludes.

2 Exposure to foreign risk: evidence from survey data

In this section, we rely on data collected by the ECB in summer 2023, via a survey of large European firms.[13] The survey asked about global supply chains (see Attinasi et al., 2023b for a summary of the results) in order, among other things, to shed light on firms' exposure to critical inputs sourced from abroad and to provide a first assessment of the associated economic risks. The survey included questions about how European firms assessed their exposure to critical inputs sourced from non-EU countries, including China, and their strategies to increase supply chain resilience.[14,15]

Our findings are consistent with a recent joint Eurosystem study. In 2023, the Banca d'Italia, Banco de España and Deutsche Bundesbank included in their respective firm surveys, a set of coordinated questions aimed at obtaining a better understand the level of exposure of European economies to the sourcing of critical inputs from China. This additional evidence is

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models (Wu et al., 2021; Giammetti et al., 2022), or computable general equilibrium (CGE) models (Lim et al., 2021).

[13]The survey was sent to companies with which the ECB maintains regular contact as part of its information gathering on current business trends, under the umbrella of the Corporate Telephone Survey (CTS). A total of 66 responses was received, which, compared to the total number of firms, is a relatively small sample. However, the aggregate value added of these firms is equivalent to around 5% of euro area GDP.

[14]In the survey, "critical" inputs are defined as goods without which a significant part of the business activity could not be completed, would suffer significant delays, or would significantly decrease the quality of the good or service produced by the firm. This definition contrasts with that used in all the following sections.

[15]For comparison, Appendix Figure A1, for our FCIs, highlights the most exposed manufacturing sectors in terms of value added and employment, using customs and balance sheet data for Belgium, France, Italy, Slovenia and Spain.

Figure 1: Critical Inputs from China among Large Euro Area Firms
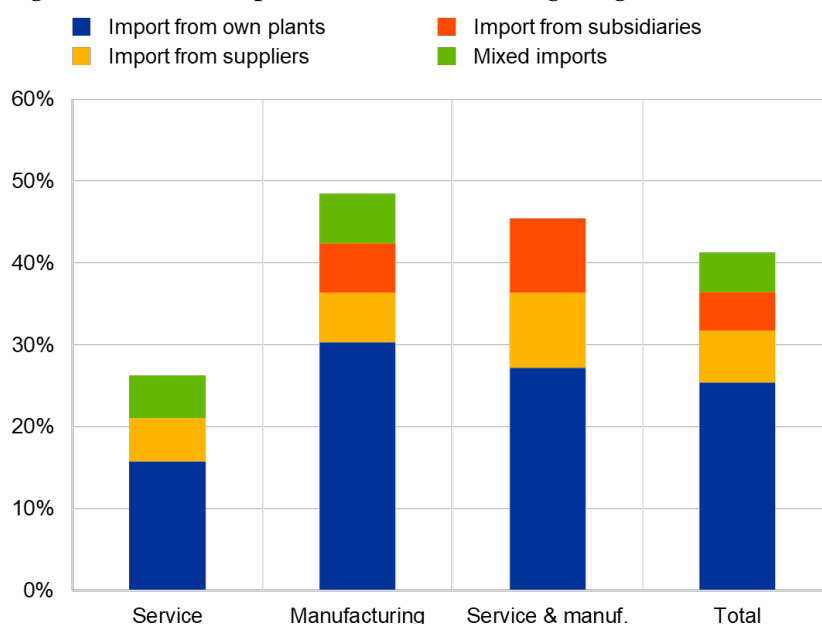
reported in Balteanu et al. (2024).[16]

Exposure to critical inputs is high. About 40% of these large European firms rely on inputs from China that they deem critical for their activity (see Figure 1). Intra-group imports are the main channel of exposure (60%), which is not surprising, since the firms surveyed were multinationals. This result is to be contrasted with other national surveys administered to a larger sample of firms that includes small firms, for which intra-firm trade is more modest.[17] Perhaps not surprising, given the importance of China in manufacturing, the share of firms importing critical inputs from China is much higher in manufacturing than in services (48% and 26% respectively).[18]

Substitutability of critical inputs is low. The CTS also asked firms how difficult it would be to replace their critical inputs from China since it is not possible to directly infer this impor-

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[16]Additional results provided in Appendix D are based only on the Bank of Italy survey. Other results can be found in Balteanu et al. (2024).

[17]The Survey of Industrial and Service Firms (hereafter INVIND) includes 4,000 Italian firms. Appendix Figure A2 mirrors the results in Figure 1 for Italy. We found that around 20% of Italian manufacturing firms report imports of critical inputs from China.

[18]The average share of manufacturing firms importing critical inputs from China is 20% and 35% for Spain and Germany, respectively (Balteanu et al., 2024).

Figure 2: Substitutability of Critical Inputs from China
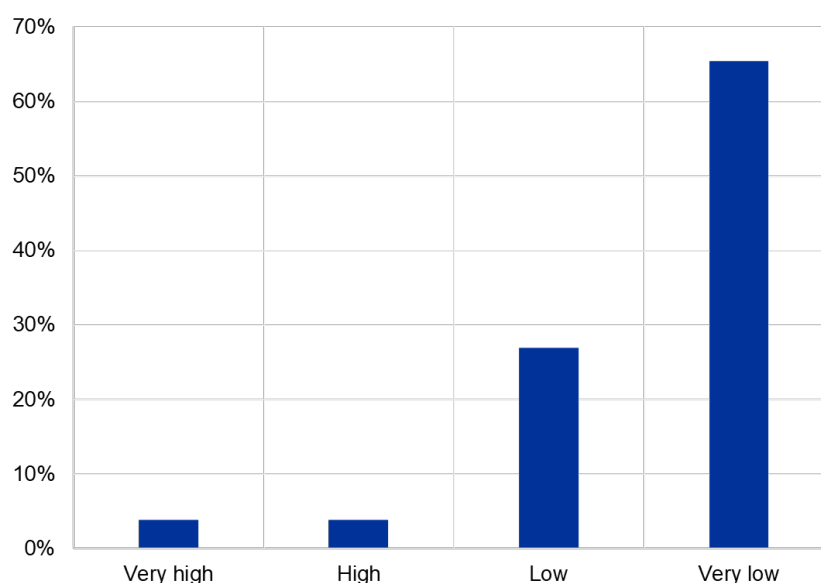
tant information from the granular trade data. Figure 2 shows that the degree of substitution associated with sourcing critical inputs from China is either low or very low for almost 90% of manufacturing firms. The corresponding number is also high (70%) in surveys that include a larger number of companies.[19]

Potential impact of growing tensions with China. Balteanu et al. (2024) report that an escalation of tensions increasing the barriers to trade between China and the West would negatively impact a large share of European companies. Around 40% of Italian and Spanish manufacturing companies indicate that increased tension could have a negative effect on their activities. This share is much higher for German firms (75%), which reflects their higher exposure to China. One of the main channels of disruption to business activity would be loss of access to Chinese inputs.

Taken together, in the midst of growing geopolitical tensions, sourcing from China is a key source of vulnerability for EU firms.

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[19]See Appendix Figure A3 for the corresponding findings based on Italian survey data.

3 Identifying foreign critical inputs

In this section, we detail the data and methodology used to identify foreign critical inputs and then propose a set of stylised facts related to firms importing FCIs.

3.1 Data

The data used for our analysis refer to 2019, the last year before the onset of the COVID-19 pandemic, and come from three different datasets: i) customs data; ii) balance sheet data; and iii) international trade data.

3.1.1 Customs data

Customs data are available at the importing country-firm-product-year level. European firms are required to report all transactions with extra-EU counterparts, indicating the date, quantity and value of the transaction, specific product traded and the country of origin or destination. Intra-EU trade flows that exceed a country-specific threshold, must include the same information. Product codes are defined at the 8-digit 2019 Combined Nomenclature (CN) level, the European counterpart of the Harmonized System (HS). Unique firm tax identifiers are reported in customs data, which allows us to merge our customs data with other firm-level datasets.

3.1.2 Balance sheet data

The balance sheet data provide indicators for the universe of the focal country's firms (with some country-specific exceptions) and include value added, turnover and intermediate inputs. These data also include information on firms' main sector of economic activity (NACE3).

3.1.3 Country sources and specificities

Belgium. Belgian customs data according to the "national concept" (which exclude cross-border movements of goods in Belgium between non-resident businesses) are from the National Bank of Belgium's International Trade Dataset. Balance sheet data for non-financial corporations are from the annual accounts provided by the Central Balance Sheet Office of the National Bank of Belgium. We use VAT declarations, collected by the Belgian tax authority (Federal Public Service Finance), to complement data on turnover and intermediate inputs for

those Belgian firms that, for reporting threshold reasons, do not report this information in their annual accounts. For number of employees and labour costs, we rely on social security data from the *Rijksdienst voor Sociale Zekerheid / Office national de securité sociale*. Information on location (region) of firm headquarters is from the Crossroads Bank for Enterprises.

France.   French customs data, *Statistiques du Commerce Extérieur*, are provided by the *Direction générale des douanes et droits indirects*. Balance sheet data are from the French National Institute of Statistics and Economic Studies (INSEE).

Italy.   Italian customs data are from ISTAT's international trade statistics and are based on microdata from the Italian Customs and Monopolies Agency. Balance sheet data are from the Cerved Group and exclude companies operating in the financial and real estate sectors and companies with no revenues or assets. We complement these data with information from Infocamere, which is the Official Business Register of the Italian Chambers of Commerce and also includes demographic information for non-limited liability companies. Finally, Italian sectoral data are from ISTAT's Frame SBS database.[20]

Slovenia.   Slovenian customs data are from the Bank of Slovenia Financial Statistics Department and the Statistical Office of the Republic of Slovenia. Balance sheet data come from the Agency of the Republic of Slovenia for Public Legal Records and Related Services (AJPES), which includes all firms registered in Slovenia which are obliged to report their annual balance sheet and financial statement data. The financial statement data are complemented by data from the Business Registry of the Republic of Slovenia and provide information on regions and sectors of economic activity.

Spain.   The Spanish data come from three different sources. Customs data are from the Spanish Tax Agency Customs and Excise Department; balance sheet data are from the Bureau Van Dijk SABI (*Sistema de Análisis de Balances Ibéricos*) database, which provides detailed financial and accounting information for Spanish firms that filed their accounts with the Business Registry. Unfortunately, it is not possible to link customs data and SABI data directly, due to the absence of a common firm identifier. We overcome this limitation with information from a

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[20]These data complement administrative data on business units with survey and balance sheet data and are one of the major sources of national accounts statistics.

third source, the Directory of Spanish Exporting and Importing Firms (*Directorio*), which is published by the Spanish Chamber of Commerce. The *Directorio* contains both customs and tax identifiers, for a sample of firms that accounted for almost 90% of Spain's total imports in 2019.

3.2 Methodology

Inputs are classified as FCI if they match at least one of the two, conceptually different, criteria. First, inputs susceptible to supply disruptions in a fragmenting global economy are categorised based on their *intrinsic characteristics*. This category encompasses high-tech products and items crucial for the green transition (IRC Trade Expert Network, 2024), which major economies are actively striving for to secure and enhance resilience and which could be used by geopolitical rivals to exert pressure (i.e., weaponisation of supply). Second, we identify *foreign dependencies* based on European Commission efforts (European Commission, 2021; Arjona et al., 2023).

More specifically, we consider FCIs as: *i*) inputs included by the US Census in the list of Advanced Technology Products;[21] *ii*) inputs and raw materials, such as lithium, nickel and photovoltaic cells, crucial for the green transition (IRC Trade Expert Network, 2024);[22] *iii*) inputs for which the "EU experiences an important level of foreign dependencies" according to the European Commission (Arjona et al., 2023).[23]

In our baseline scenario, we combine items *i*, *ii* and *iii*. In the robustness checks, we define FCIs based only on their intrinsic characteristics, that is, items *i* and *ii* above. Our baseline list of FCIs includes 667 HS6 product codes, such as Electronic integrated circuits (HS code 854239) and Insulin and its salts (HS code 293712).

3.3 Allocation of countries into blocs

To assess from which countries importing FCIs is riskier for our sample of EU countries, we build on approaches based on United Nations voting patterns, to assess geopolitical alignment

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[21]The US Census considers Advanced Technology Products as items used in the production processes of applications in the following fields: biotechnology, life sciences, opto-electronics, information and communications, electronics, flexible manufacturing, advanced materials, aerospace, weapons and nuclear technologies. These items are mostly in the 29, 30, 84, 85, 88, and 90 chapters of the HS classification.

[22]Compared to the original list of raw materials essential for the green transition, compiled by the OECD (Kowalski and Legendre, 2023), we restrict the sample by including only those which extra-EU sourcing countries are highly concentrated, i.e., Herfindahl-Hirschman index above 0.4.

[23]Compared to the official European Commission list, we restrict the sample only to inputs and capital goods and exclude final products.

—as those recently used in the literature (Campos et al., 2023; Javorcik et al., 2024; Gopinath et al., 2024). Specifically, we build on the geopolitical index proposed by den Besten et al. (2023). This index was constructed by combining four measures of political alignment among countries over the past decade. They include frequency of sanctions, military import disparities, China's official lending and voting on specific UN resolutions. The final index varies between zero and 1, indicating the degree of geopolitical alignment with China and Russia (closer to 1) compared to the US (closer to 0). Countries with an index below 0.25 are assigned to the US-aligned bloc; those with an index above 0.75 are assigned to the China-aligned bloc. The remaining countries are categorised as Neutral. Our country allocations include a larger sample of countries than considered by den Besten et al. (2023), who only include 63 economies. We rely on the allocation provided by Capital Economics (2023), which is also based on political and economic alignment, as both measures are conceptually similar.[24] Appendix B shows that the China-aligned bloc includes China, Russia and Pakistan.[25]

Foreign critical inputs for the EU. We investigate the main sourcing countries of FCIs for the EU as a whole, using BACI data (Gaulier and Zignago, 2010). Figure 3 shows that it is very concentrated. China accounts for 30% of extra-EU imports of FCIs and, thus, is ranked the most important extra-EU supplier of FCIs to the EU. The US accounts for 18% and the UK 7%. These three countries together account for roughly 55% of imports of FCIs from extra-EU countries, with Ukraine and Russia accounting for 2.5% each.[26]

3.4 Stylised facts

Our firm-level framework is constructed using micro data for the BFISS countries, which provide five stylised facts on the characteristics of firms importing FCIs. Our five datasets combined include 34,074 importers of FCIs in the manufacturing sector (20,325 from China-aligned countries), accounting for 9% of the total manufacturing firms.

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[24]We consider US-aligned economies to be those described as US allies in Capital Economics (2023) and consider China-aligned economies as those described as China allies. Other economies are considered to be Neutral. In the overlapping sample, the first two classifications are highly correlated since only three (out of 63) countries are assigned to different blocs. Click here to access the Capital Economics (2023) list.

[25]China-aligned countries account for about 30% of global GDP in purchasing power parity.

[26]At the extensive margin, China is also the main exporter of FCIs for about 30% of these goods (200 out of 667 FCIs); the US is the most important supplier of 145 FCIs; followed by Switzerland with 48 FCIs (Appendix Figure A4).

Figure 3: Extra-EU Import Share of FCIs by Country and Partner Alignment
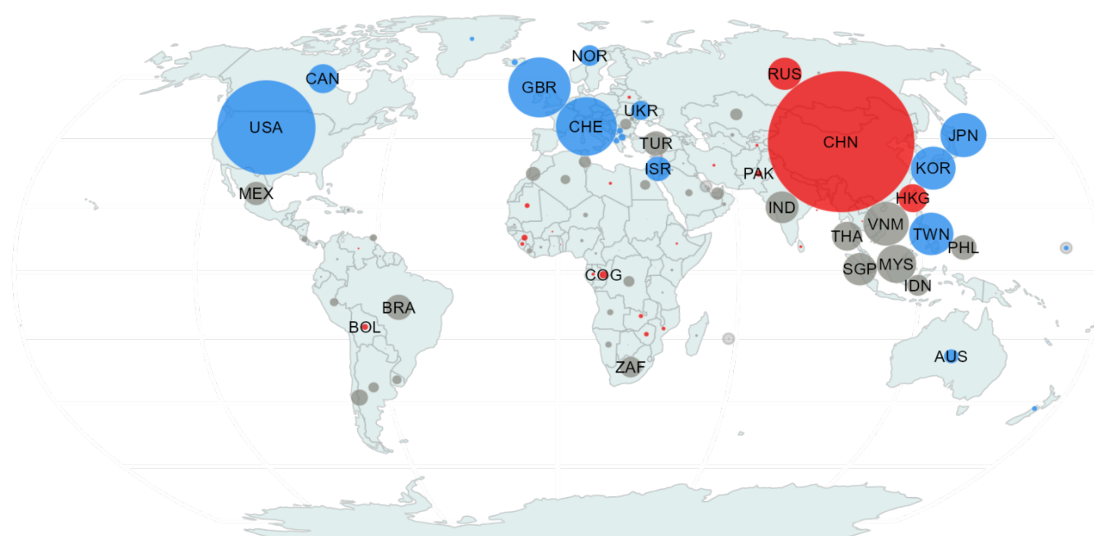
Notes: The size of the circles represents the share of each extra-EU country's exports of FCIs in EU imports of FCIs from all extra-EU countries. International trade data are from the CEPII BACI dataset, which provides data on bilateral trade flows for 200 countries, at the HS6 product level —see Gaulier and Zignago (2010). See Appendix B for the complete list of US-aligned (blue circles), China-aligned (red circles) and neutral (grey circles) countries.

3.4.1 Exposure to foreign critical input disruptions

Which firms are exposed to FCI disruptions? Across all manufacturing firms, the largest organisations are likely to be the most exposed to a cut in imports of FCIs from China aligned countries. For instance, 37% of Spanish firms and 61% of Slovenian firms in the top 1% of the corresponding value-added distribution import FCIs from China aligned countries (Figure 4). The share of exposed firms decreases monotonically for all countries, along the firm size distribution. As a consequence, large exposed firms account for 70% to 96% of total *exposed* value added (Appendix Figure A5).

Over-representation of the largest firms in exposed firms is due to the fact, first, that almost all large firms are importers (86% in Spain to 100% in Slovenia)[27] and second, that large *importers* and second, that large importers are more exposed than small importers as a share of the relevant population (42% in Spain to 61% in Slovenia for firms in the top 1% of the value-added distribution).[28]

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[27]See Appendix Figure A6.
[28]See Appendix Figure A7.

Figure 4: Share of Exposed Firms by Firm Size
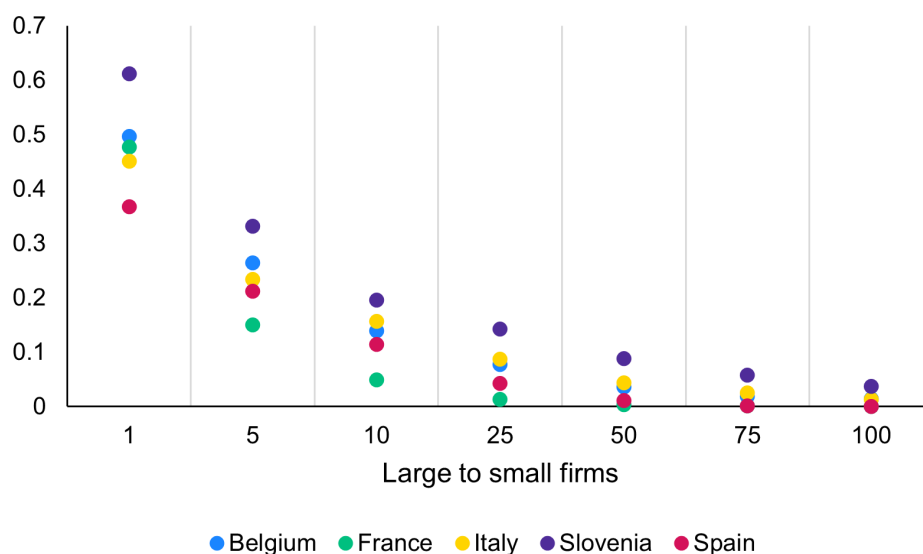
Notes: The x-axis represents percentiles, e.g. 1 represents the 1% largest firms in value added, 5 represents the 1% to 5% largest firms, etc. Exposed firms are firms importing FCI from China-aligned countries. The share is computed by dividing the number of exposed firms by the total number of firms (importers and non-importers).

Fact 1: *The share of exposed firms is much higher for large firms and large exposed firms account for the lion's share of total exposed value added. This is driven by two factors: (1) almost all large firms are importers; (2) large importers are more exposed than small ones as a share of the relevant population.*

We have seen that the share of exposed firms is higher for large firms. But how large are importers of FCIs? Appendix Figure A8 shows that firms importing FCIs account for 70% of *total BFISS* manufacturing value added. Firms importing FCIs from China aligned countries account, specifically, for 55% of total BFISS manufacturing value added.[29]

Fact 2: *Firms importing FCIs account for a sizeable share of the economy.*

3.4.2 Sourcing strategy

Deeper examination of firms' sourcing strategies shows that the average number of FCIs is 6, compared to 23 non-FCIs. Appendix Table A2 shows that the number of FCIs purchased has

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[29]As shown in the previous subsection, China is the main source of FCIs. The value added that depends on FCIs imported from China corresponds to 26% of total BFISS value added and reaches 35% in the manufacturing sector.

Figure 5: Import Share of FCIs from China-aligned Countries by Firm Size (Conditional on Exposure)
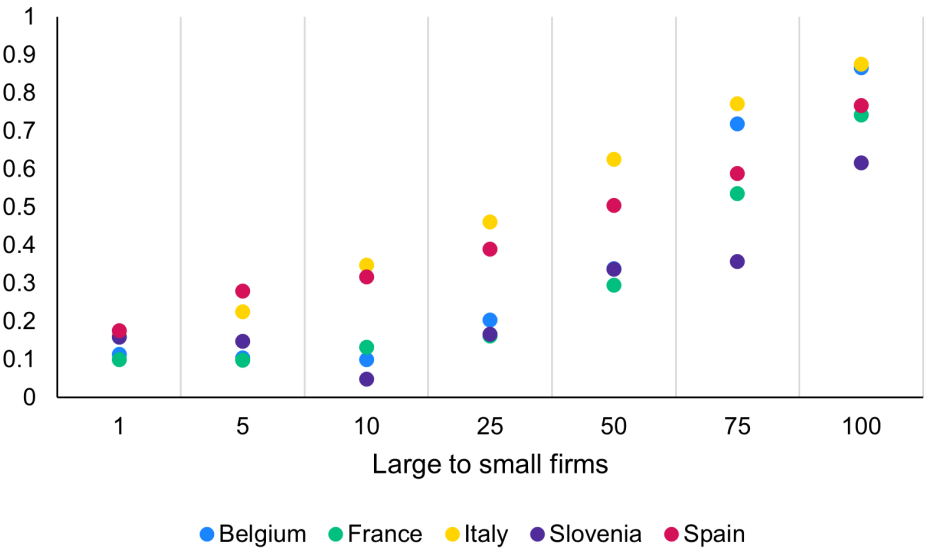
a right-skewed distribution, and reaches a maximum of 241 FCIs for France.[30] The median number of sourcing countries for each firm-FCI pair is 1, while around 10% of firms purchase the same FCI from at least two or three different countries. These figures are similar to those observed for non-FCIs.

We then compute the import share of FCIs sourced from China-aligned countries. Figure 5 shows that smaller firms tend to be more exposed to China aligned countries for their FCI imports, with the risk lower for larger firms.[31]

Fact 3: *Diversification of sources is limited for FCIs and large importers are relatively less vulnerable.*

3.4.3 Expenditure shares of foreign critical inputs

To understand the importance to firms of FCIs, we compute the share of imports of FCIs in total firm goods and services purchases. These statistics are described in Table 1 (for the whole economy, see Appendix Table A4). On average, FCIs account for about 6% of total firm pur-

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[30]See Appendix Table A3 for the whole economy.

[31]Figure 5 defines firm size based on value added. Appendix Figure A9 provides the results for firm size measured by number of employees.

Table 1: Summary Statistics for FCI Importers

		Mean	p10	p50	p90	SD	Obs.
Belgium	FCIs, share of firms' total purchases	4.9	0.0	0.7	13.3	11.4	2,748
	FCIs from low-risk countries, share of firm's total purchases	4.3	0.0	0.6	10.9	10.7	2,422
	FCIs from high-risk countries, share of firm's total purchases	3.2	0.0	0.3	8.0	8.7	975
France	FCIs, share of firms' total purchases	5.9	0.0	1.0	17.0	12.9	8,366
	FCIs from low-risk countries, share of firm's total purchases	5.3	0.0	0.8	14.8	12.3	7,657
	FCIs from high-risk countries, share of firm's total purchases	2.8	0.0	0.2	6.6	8.2	3,224
Italy	FCIs, share of firms' total purchases	4.6	0.0	0.8	12.8	10.4	15,238
	FCIs from low-risk countries, share of firm's total purchases	3.9	0.0	0.5	10.4	9.6	12,346
	FCIs from high-risk countries, share of firm's total purchases	3.4	0.0	0.6	9.3	7.7	6,604
Slovenia	FCIs, share of firms' total purchases	6.3	0.1	1.3	18.3	13.2	3,570
	FCIs from low-risk countries, share of firm's total purchases	5.7	0.1	1.2	15.4	12.3	3,490
	FCIs from high-risk countries, share of firm's total purchases	4.1	0.0	0.4	10.6	10.7	642
Spain	FCIs, share of firms' total purchases	8.6	0.1	1.6	24.4	17.4	4,030
	FCIs from low-risk countries, share of firm's total purchases	7.6	0.1	1.3	21.0	16.3	3,594
	FCIs from high-risk countries, share of firm's total purchases	5.0	0.0	1.0	12.5	11.7	1,476
All	FCIs, share of firms' total purchases	6.0	0.0	1.1	17.2	13.1	6,790
	FCIs from low-risk countries, share of firm's total purchases	5.3	0.0	0.9	14.5	12.2	5,902
	FCIs from high-risk countries, share of firm's total purchases	3.7	0.0	0.5	9.4	9.4	2,584

Notes: Table 1 presents summary statistics for manufacturing firms importing FCIs in 2019. See Appendix Table A4 for the whole economy. The variables are expressed in percentage points. The category "all" refers to a simple average across countries. Total purchases refer to expenditure on intermediate goods and services. With the exception of Spain, all the countries use the population of importing firms; in the case of Spain, the sample corresponds to the importers included in the Directorio. Differences between Spain and the other countries are explained by the fact that the Directorio excludes most small importing firms.

chases (see last panel), with some heterogeneity across countries. The median of this ratio is 1.1% and the 90th percentile is 17%.[32]

However, the risks of supply disruptions are higher for countries with weaker ties to the EU and different political stances on major issues. For example, for European countries, diplomatic ties with Switzerland and the US are stronger than ties with China or Russia for instance. To account for this, we distinguish between "China-aligned" and "US-aligned" countries. Table 1 shows that the share of FCIs from China-aligned and US-aligned countries is 4% and 5% respectively, on average.[33]

Fact 4: *On average, FCIs account for a modest share of total firm purchases. The ratio of imports of FCIs to total expenditure on intermediate inputs is relatively constant along the firm size distribution.*

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[32]Despite some variation, the share of FCI in total inputs is fairly stable along the firm size distribution (Appendix Figure A10).

[33]The firm numbers reported rows 2 and 3 in each country panel do not necessarily add up to the numbers in the first row, since some firms may import from both US- and China-aligned countries.

Table 2: FCI Premia

Import FCI	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All firms				Extra-EU importers			
	log Employment	log Turnover	log Wages	log Labor Prod.	log Employment	log Turnover	log Wages	log Labor Prod.
Belgium	2.031***	2.465***	0.383***	0.310***	1.319***	1.495***	0.180***	0.167***
	(0.0347)	(0.0382)	(0.0116)	(0.0158)	(0.0465)	(0.0502)	(0.0143)	(0.0221)
Obs.	12,343	12,343	12,343	12,343	4,071	4,071	4,071	4,071
France	2.399***	2.858***	0.215***	0.242***	1.467***	1.593***	0.0823***	0.0993***
	(0.0195)	(0.0210)	(0.00641)	(0.00819)	(0.0309)	(0.0319)	(0.0114)	(0.0146)
Obs.	92,353	92,353	92,353	92,353	10,722	10,722	10,722	10,722
Italy	1.558***	2.123***	0.305***	0.363***	0.930***	1.137***	0.147***	0.174***
	(0.0123)	(0.0136)	(0.00299)	(0.00556)	(0.0148)	(0.0161)	(0.00362)	(0.00696)
Obs.	107,773	107,773	107,773	107,773	30,642	30,642	30,642	30,642
Slovenia	1.255***	1.637***	0.150***	0.275***	1.168***	1.325***	0.123***	0.148***
	(0.0383)	(0.0425)	(0.00926)	(0.0186)	(0.0852)	(0.0951)	(0.0171)	(0.0369)
Obs.	6,125	6,125	6,125	6,125	2,280	2,280	2,280	2,280
Spain	1.280***	1.681***	0.139***	0.336***	0.927***	1.125***	0.0896***	0.198***
	(0.0271)	(0.0312)	(0.00643)	(0.0115)	(0.0325)	(0.0368)	(0.00773)	(0.0144)
Obs.	10,161	10,161	10,161	10,161	6,060	6,060	6,060	6,060
3-digit industry FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Table 2 reports the estimates of eq. (1). Standard errors clustered at firm level. * significant at 10%, ** significant at 5%, *** significant at 1%. Manufacturing firms only, see Appendix Table A5 for the whole economy. With the exception of Spain, all countries use the population of importing firms; for Spain, the sample corresponds to the importers included in the Directorio. Differences between Spain and the other countries are explained by the fact that the Directorio excludes most small importers.

3.4.4 Foreign critical inputs and size premia

To assess whether there are significant differences between importers and non-importers of FCIs, we estimate the following regression:

$$\log y_i = \gamma + \beta \text{Foreign Critical}_i + \delta_s + \varepsilon_i \qquad (1)$$

where i is a firm, y_i is employment, turnover, wages or labour productivity, measured as the ratio of value added to number of employees, and Foreign Critical$_i$ is a dummy variable that is equal to 1 if firm i imports FCIs. We include three-digit (NACE3) sector fixed effects δ_s to control for differences in demand or supply that might explain size differences across firms and also the fact that firms in specific industries may need FCIs for their production process.

Table 2 presents the results for the manufacturing sector.[34] Columns 1 to 4 show that importers of FCIs are larger and more productive than non-importers of FCIs. Columns 1 to 4 show also that importers of FCIs have between 250% to 1,000% more employees, 410% to 1,640% higher turnover, pay 15% to 47% higher wages and have 27% to 44% higher labour productivity than non-importers of FCIs. However, it might be that these premia mostly reflect

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[34]See Appendix Table A5 for the whole economy.

differences in the sizes of importers and non-importers (Bernard et al., 2007). To address this concern, Columns 5 to 8 present size differences among FCI importers from extra-EU countries which, arguably, are larger than other types of importers since the fixed costs of sourcing from outside the EU are likely to be higher. While the point estimates are smaller, they remain highly significant and size differences remain important. For example, Column 8 shows that importers of FCIs are 10% to 22% more productive than non-importers of FCIs, conditional on sourcing from an extra-EU partner

Fact 5: *Firms importing FCIs are relatively larger and more productive, even within narrowly defined industries.*

Taken together, Facts 1-5 indicate that importers of FCIs are relatively large and that the degree of exposure to disruptions to imports from China-aligned countries varies across firms. This motivates the use of a framework that takes account of heterogeneous exposure to geoeconomic fragmentation.

4 Shortages in supply of foreign critical inputs

We adopt a stress-test approach to evaluate the effects on value added of a disruption in the availability of FCIs. We start by describing our framework and then discuss its advantages and limitations.

4.1 Model

4.1.1 Environment

Each firm i produces output Y with a Cobb-Douglas technology, by combining labour (L), capital (K) and intermediates goods and services (M):

$$Y_i = A_i K_i^{\alpha_s} L_i^{\beta_s} M_i^{1-\alpha_s-\beta_s},\tag{2}$$

where α_s and β_s are industry-specific shares of expenditure in labour and capital and $1 - \alpha_s - \beta_s$ is the share of expenditure on intermediate goods and services.

In turn, intermediate goods and services are combined using a firm-specific CES aggregator:[35]

$$M_i = \left[\gamma_i^{\frac{1}{\sigma}} E_i^{\frac{\sigma-1}{\sigma}} + (1 - \gamma_i)^{\frac{1}{\sigma}} X_i^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{3}$$

where γ_i is the firm's share of expenditure on FCIs E, and X is a bundle of non-foreign critical intermediate goods and services. σ is the elasticity of substitution between FCIs and other intermediates. As usual, with this type of production function, when $\sigma = 0$ (the Leontief case), FCIs and non-FCIs are perfect complements, and if $\sigma = 1$ the function becomes Cobb-Douglas.

4.1.2 Foreign critical input disruption and value added

We assume that a firm-specific shock ε_i reduces the availability of FCIs E. Normalising its original endowment to 1, expenditures on FCIs after the shock are given by $E_i = 1 - \varepsilon_i$. After some derivations, detailed in Appendix A, we obtain:

$$\Delta\mathrm{va}_i = (1 - \alpha_s - \beta_s) \left[\frac{\left(\gamma_i^{\frac{1}{\sigma}} (1 - \varepsilon_i)^{\frac{\sigma-1}{\sigma}} + (1 - \gamma_i)^{\frac{1}{\sigma}} \left(\frac{1-\gamma_i}{\gamma_i} \right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}}{\left(\gamma_i^{\frac{1}{\sigma}} + (1 - \gamma_i)^{\frac{1}{\sigma}} \left(\frac{1-\gamma_i}{\gamma_i} \right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}} - 1 \right]. \tag{4}$$

The change in value added $\Delta\mathrm{va}_i$ depends on the firm-specific shock ε_i, the elasticity of substitution σ, the sectoral parameter $1 - \alpha_s - \beta_s$ and the firm-specific parameter γ_i.

Aggregation. To derive the effect of disruptions to the supply of FCIs at the sectoral, regional and aggregate levels, we calculate the average value-added change as follows:

$$\Delta\mathrm{va} = \sum_i \Delta\mathrm{va}_i \times \omega_i^{va}, \tag{5}$$

where ω_i^{va} is firm i's value-added share in the relevant sample (sector, region, aggregate). In other words, the aggregate change in value added is given by a value-added weighted average of the change in firm-level value added. Importantly, these value-added weights are computed over the entire sample of firms, that includes both firms exposed to the shock and non-exposed firms. We return to this point when we discuss the importance of relying on micro data.

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[35]This formulation echoes Bachmann et al. (2022)'s country-level study of the effect of cutting energy imports from Russia.

4.2 Calibration

We calibrate our model as follows. We recover the γ_i parameters by combining customs data at the firm-product level, with balance sheet data for 2019 for BFISS. More specifically, we compute the ratio of the import value of FCIs to expenditure on intermediates.[36] The sectoral shares $1 - \alpha_s - \beta_s$ are the ratio of expenditure on intermediates to turnover. To minimise the importance of outliers that could be driven by differences in how turnover is defined in different country databases, we rely on OECD data (Horvát and Webb, 2020). However, the Cobb-Douglas parameters are allowed to vary at the country-industry level, with industries defined at the 3-digit (NACE3) level.

In our baseline scenario, we assume that geoeconomic fragmentation will disrupt imports of FCIs sourced from China-aligned countries. Using our customs data, we can compute the share of FCIs sourced from China-aligned countries in total FCI imports (China-aligned share$_i$) and allow this share to change depending on the parameter δ. Therefore, the firm-level shock is:

$$\varepsilon_i = \text{China-aligned share}_i \times \delta \tag{6}$$

In other words, we reduce firm-level endowments of FCIs by a share that is proportional to their imports from China-aligned countries. Our baseline value for δ is 0.5 —a 50% reduction —but we provide robustness checks using alternative values.

A number of remarks are in order. First, firms that do not import FCIs from China-aligned countries —China-aligned share$_i$ = 0 and thus ε_i = 0 —will not experience any change in value added (Δva_i = 0). Second, all else being equal, value added decreases more with a higher degree of exposure to disruptions to the supply of FCIs from China-aligned countries ($\frac{\partial \text{va}_i}{\partial \varepsilon_i} < 0$). Third, δ not only captures different degrees of disruptions but also the ease of substitution between FCIs from China-aligned countries and FCIs from US-aligned/neutral countries.[37]

Finally, given the central role of σ and to reflect the uncertainty about its value, we allow this parameter to vary between 0 and 0.2. However, since our focus is on the *short-run* effects of decoupling, the elasticity of substitution between intermediates is arguably closer to zero

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[36]The import value of FCIs is derived by aggregating the value of imports of all HS6 FCIs at the firm level.

[37]For instance, $\delta = 0.5$ could result from either a 100% drop in the supply of critical inputs, partially mitigated by substituting 50% of this supply from elsewhere, or from a 50% drop in the supply of critical inputs with no substitution.

(Barrot and Sauvagnat, 2016; Atalay, 2017; Boehm et al., 2019).[38,39]

4.3 Discussion

Despite some limitations related to the prices and factors of production other than FCIs being held constant and the assumption that not-directly exposed firms are not affected by indirect importing (Dhyne et al., 2021),[40] we believe that, for the following reasons, our framework is useful. First, the model can be calibrated easily using micro data which typically tend to be available to researchers. Second, considering alternative decoupling scenarios or using alternative elasticity values is computationally fast since value-added losses can be readily recovered from eq. (4). Third, our framework sheds light on the role of firm-level exposure to aggregate geoeconomic shocks in the supply of granular *inputs*.

Overall, our framework aims to assess how shocks affecting different sets of *inputs* may affect firms, sectors, regions and the economy differently, depending on the *firm*'s underlying exposure. The limitations and advantages of our model suggest that it could complement recent work that relies on Baqaee and Farhi (2024)'s framework (see Section 1).

5 Results

We detail our results in this section. To facilitate the exposition, we provide robustness checks where relevant.

5.1 Heterogeneous effects across firms

Figure 6 depicts the firm-level distribution of value-added changes for a Leontief production function. The distribution has a fat left tail. Our five BFISS countries display similarly shaped bi-modal distributions, although Italy has a larger group of firms that are highly affected by the cut.[41]

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[38]Peter and Ruane (2023) find consistent values for the elasticity of substitution between intermediates higher than 1. However, theirs are long-run estimates, focused on the period of India's trade liberalisation.

[39]See footnote 58 in Appendix A for the change in value added in the Leontief case.

[40]Not accounting for indirect exposure may lead to underestimation of the impact of geoeconomic fragmentation. At the same time, firms may also adjust their sourcing strategies (either domestic or/and international), to help mitigate the losses arising from exposure to foreign risk. This margin of adjustment may take time to manifest and may depend on the degree of substitutability of different producers and/or types of inputs. The empirical question of which effect dominates, persists and suggests fruitful directions for future research.

[41]Appendix Figure A11a shows that, when the elasticity of substitution is high ($\sigma = 0.2$), the mass flattens out and is more concentrated around zero. Appendix Figure A11 depicts some additional robustness checks based on

Figure 6: Distribution of Changes in Value Added (in %)
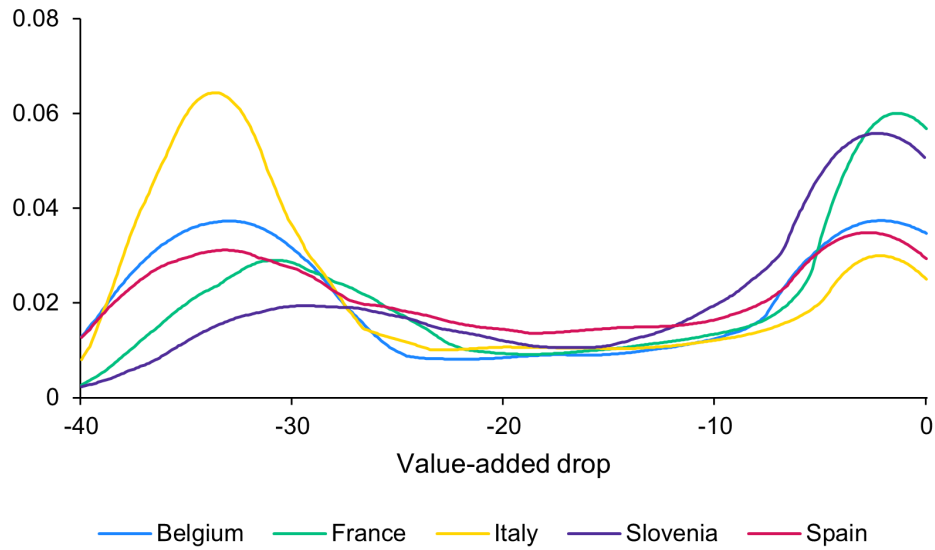
Notes: Figure 6 depicts the distribution of changes to value added (in %) resulting from a 50% cut in FCIs from China-aligned countries when $\sigma = 0$. Only manufacturing firms are included.

Figure 7: Value-added Changes (in %) among Exposed Firms by Size
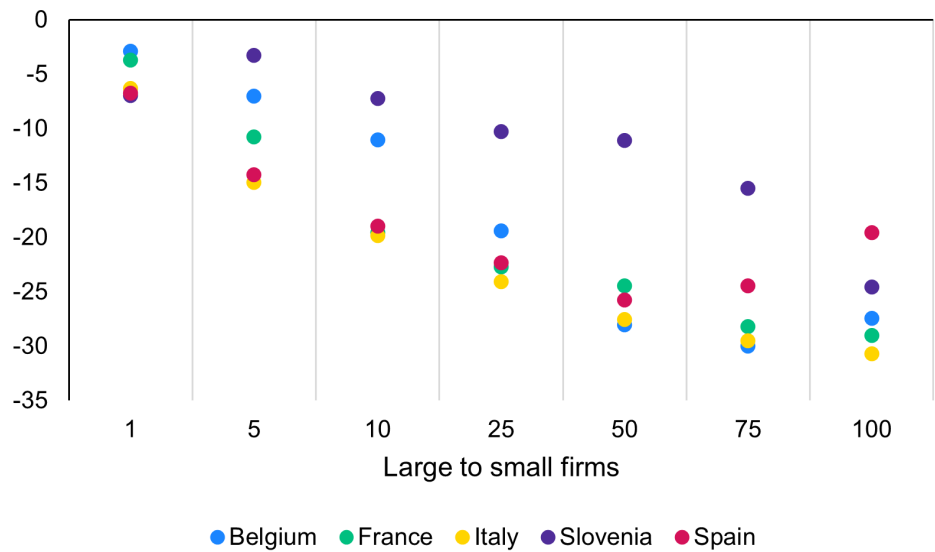
Notes: Figure 7 depicts the value-added changes distribution (in %) across different types of firms. The scenario considered is a 50% cut in FCIs from China-aligned countries when $\sigma = 0$. The x-axis represents percentiles, e.g. 1 is the 1% largest firms in value added, 5 is the 1% to 5% largest, etc. Only firms importing critical inputs from China-aligned countries are considered.

Which firms lose more and why? It seems that the largest firms are relatively less affected

a restricted set of FCIs; where only imports of Chinese critical inputs are cut and where we consider the whole economy instead of only the manufacturing sector.

by a cut in supply of FCIs (Figure 7). In fact, the loss in value added for the largest firms ranges from 3% for Belgium to 7% for Slovenia. Conversely, conditional on importing FCIs from China-aligned countries, the impact is relatively larger for smaller firms, ranging from about -20% for Spain to -30% for Italy. Although firm-level changes in value added are shaped also by technology parameters (see eq. (4)), the results depicted in Figure 6 and Figure 7 are consistent with the import share of FCIs from China-aligned countries being higher for smaller importers (Fact 3) with the result that these firms are relatively more affected in our geoeconomic fragmentation scenario.

Overall, *heterogeneous exposure* to FCIs sourced from China-aligned countries leads to heterogeneous patterns of value-added losses across importing firms and countries.

5.2 Aggregate effects

We aggregate our firm-level results using eq. (5) and plot the aggregate value-added change as a function of the elasticity of substitution between FCIs and other intermediates (Figure 8). If $\sigma = 0$, halving the supply of FCIs from China-aligned countries would result in a drop in manufacturing value added of up to 2.0% for Belgium, 2.5% for France, 2.9% for Spain and 3.1% for both Italy and Slovenia. The smaller aggregate impact, compared to Figure 6, recalls the finding that firms might have Leontief technologies, but the aggregate production function exhibits a different shape (Houthakker, 1955; Jones, 2005). If we assume higher values for σ, the aggregate value-added loss converges towards 0: since FCIs can be more easily substituted with other inputs, firms experience smaller value-added losses, which, in turn, reduces the effect on aggregate value added.

We test the robustness of these results in different ways. In the case that FCIs cannot be substituted, a larger 75% cut in the supply of FCIs from China-aligned countries ($\delta = 0.75$) is associated with a drop in manufacturing value added ranging from 3% for Belgium to more than 4.5% for Italy and Slovenia (Appendix Figure A12a). A smaller drop of 25% ($\delta = 0.25$) would lead to a 1% to 1.5% drop in value added (Appendix Figure A12b), depending on the country considered. We also used an alternative, restricted, list of critical inputs (Appendix Figure A11b and Figure A12c), to show that our results remain similar (a 2.4% rather than a 2.7% average drop when $\sigma = 0$). Also, halving the supply of FCIs from China implies a value-added decrease that is relatively close to that derived from a reduction in the supply of

Figure 8: Aggregate Value-Added Change (in %) across Countries
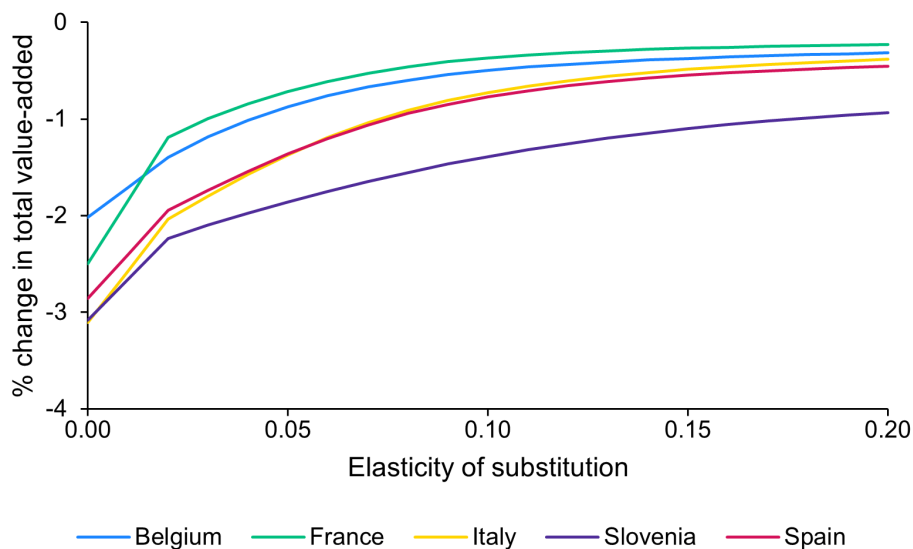
Notes: Includes only manufacturing firms.

FCIs from all China-aligned economies (2.3% drop on average).[42] This can be explained by the central role of China as the supplier of these inputs (see Section 3). Finally, the shock's impact is reduced if we consider the whole economy rather than just the manufacturing sector and implies an average 1.5% drop in value added.[43]

Which firms are driving this change in aggregate value added? Given our reliance on a weighted average in eq. (5) and the results depicted in Figure 7 and Figure 8, we expect large firms to drive the aggregate change. This would support the well-known finding for aggregate productivity in Hulten (1978), recently revived by Gabaix (2011).[44,45] The decomposition in Figure 9 confirms this intuition if $\sigma = 0$. The drop (the height of the bars corresponds to the numbers in Figure 8) is due mainly to exposed firms in the highest quartile of the value-added distribution: 25% of exposed firms are responsible for 75% or more of the decrease, in all countries.[46] The results for the top 1% display more heterogeneity; they drive around 15%

[42]See Appendix Figure A11c and Figure A12d

[43]See Appendix Figure A11d and Figure A12e.

[44]Hulten (1978) showed that, in efficient economies and based on a first-order approximation, the impact on aggregate productivity of a change in firm total factor productivity is given by the share of the focal firm's sales as a fraction of GDP —its Domar weight. See Baqaee and Farhi (2020) for a recent important contribution focusing on inefficient economies with input-output linkages.

[45]Homogeneous drops in value added across firms of similar size could also be driving the results. However, arguably, this explanation would be harder to reconcile with our fat-tailed firm size distribution (Appendix Figure A8). We return to this point in discussion of how specialisation might be relevant at the regional level.

[46]As a robustness test, in Appendix Figure A13 the results are based on number of employees to proxy for firm size.

Figure 9: Decomposition of Value-added Change (in %) by Exposed Firm Size
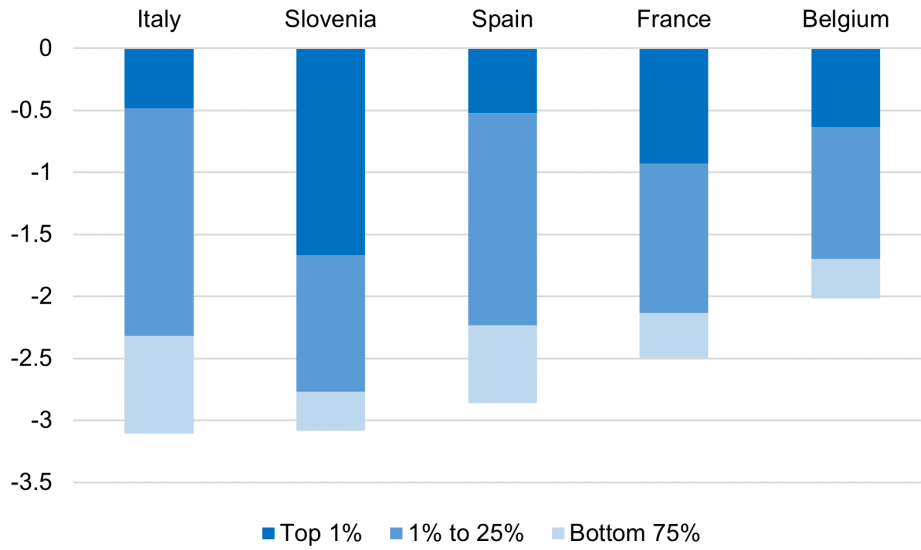
Notes: Firm size measured as value added. Percentile calculations include only exposed firms operating in the manufacturing sector.

of the drop in Italy and Spain, one-third of the drop in France and Belgium and more than half of the drop in Slovenia. This last result is perhaps due to the presence of large multinationals which is arguably more salient in France, Belgium and Slovenia.[47,48]

5.3 Regional and sectoral effects

The impact of our geoeconomic fragmentation scenario also varies substantially across different manufacturing sectors and geographic regions.

5.3.1 Regional effects

Figure 10 shows the impact of a 50% cut in manufacturing value added by region (defined at the NUTS2 level or NUTS3 for Slovenia).[49,50] The high heterogeneity across regions within countries is driven by two factors: specialisation and concentration. Regions specialised in sectors heavily reliant on FCIs, imported from extra-EU countries, may be affected the most. For

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[47]See, among others, Di Giovanni et al. (2017) for the effect of multinationals and international linkages in driving cross-border co-movements.

[48]For confidentiality reasons, we cannot disclose the names of the firms driving our results.

[49]We present results for the Leontief case where $\sigma = 0$, for the sake of simplicity. Results for alternative values of σ are available upon request.

[50]Appendix Figure A14 depicts the impact for the whole economy across regions.

Figure 10: Aggregate Value-added Change (in %) across Regions
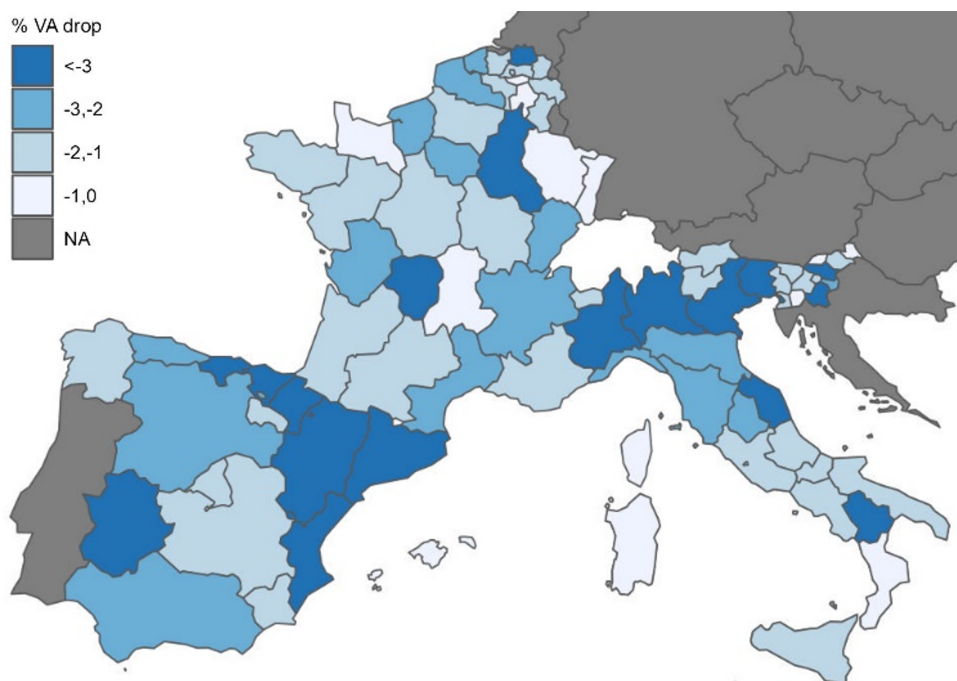
Notes: Figure 10 reports the change in value added (in %) across regions, from a 50% drop in supply of FCIs from China-aligned countries ($\sigma = 0$). Only manufacturing sectors are considered.

instance, the Italian Marche region is relatively more specialised than other regions in the production of electrical equipment, which is a particularly exposed and affected industry. Also, the concentration in some regions of top producers works to drive this heterogeneity: the presence of large exposed firms implies that their effect on their region's value added is more substantial,[51] which is consistent with the aggregate effects described above.

5.3.2 Sectoral effects

There is also substantial heterogeneity across manufacturing industries. Figure 11, which focuses on the five sectors experiencing the largest decrease, shows that the impact of the shock in the Leontief case would exceed 6.5%, on average, for the electrical equipment sector, and would be higher than 4%, on average, for the chemical products and machinery and equipment industries. These effects are considerably higher than the results obtained for the entire manufacturing sector (2.7% on average),[52] reflecting the higher share of FCIs from China-aligned

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[51] Again, for reasons of confidentiality we cannot disclose the names or locations of the firms driving the impact in some of our regions.

[52] Appendix Figure A15 depicts the decomposition along the 5 sectors making the biggest average contribution to the drop, namely chemicals, electrical equipment, machinery and equipment, and motor vehicles.

Figure 11: Aggregate Value-added Change (in %) across Sectors
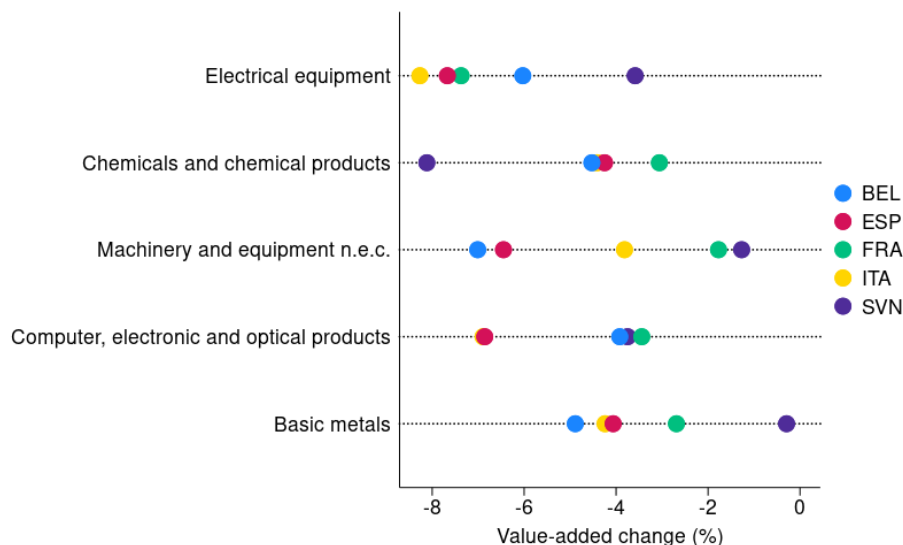
Notes: Figure 11 reports the change in value added (in %) across the most exposed sectors, from a 50% drop in supply of FCIs from China-aligned countries ($\sigma = 0$). The yellow circle denoting Italy is hidden by the blue and red circles (Belgium and Spain) for the chemicals industry and is hidden by the red circle (Spain) in the case of the computer industry. The figure includes manufacturing sectors with the highest median value-added reductions across countries.

countries used by these industries.[53] Moreover, our results point to substantial heterogeneity *across* countries *within* certain sectors, reflecting different sub-sector compositions and firm-specific sourcing patterns that differ across countries. For instance, Belgium and Spain experience larger value-added drops within the machinery and equipment industry than the other three countries.

5.4 Importance of micro data

How important is use of micro data for assessing the impact of disruptions to the supply of FCIs? To answer this question, we investigated how reliance on more aggregate rather than firm-level data affects our quantitative results.[54] Appendix Figure 12a is equivalent to Figure 8, but is based on sector-level data. Appendix Figure 12b shows that using macro rather than more granular data can bias the simulated impact of geoeconomic fragmentation.[55] Specifically,

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[53]Appendix Figure A16 show non-manufacturing sectors for comparison. The results are on average smaller than for manufacturing owing to the lower exposure of firms active in those sectors to FCIs sourced from China-aligned countries.

[54]To construct sectoral level data, we used our firm-level data to aggregate all relevant variables (imports, value added, etc.) at the 3-digit level (NACE3).

[55]We reran our procedure using the sectoral level data and computed the difference in manufacturing value-added losses compared to those derived from our baseline firm-level data (difference between the values displayed

when the production function features complementarity between FCIs and other intermediate inputs, use of macro data leads to the effect on value added being overstated for Belgium, Italy, Spain and Slovenia, but not France,: the size of the bias ranges from 2.3 percentage points for Italy to -0.3 percentage points for France. The bias might also be negative, that is, use of macro data might understate the effect of disruptions to supply of FCIs, for different levels of σ and would converge towards 0 as the elasticity of substitution increases.[56]

Figure 12: Firm-Level vs Sector-Level Aggregation
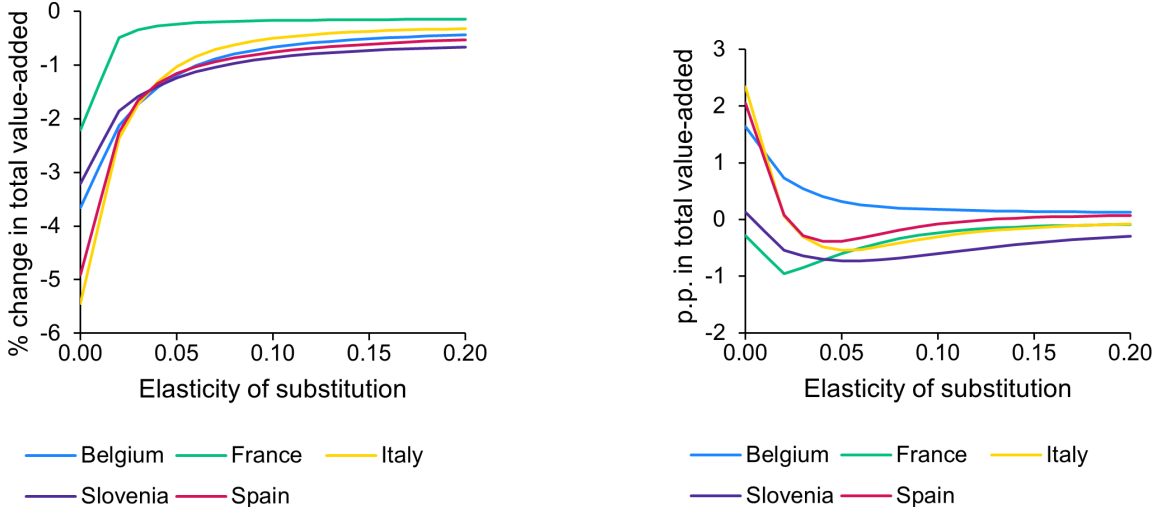
(a) Value-Added Change with Sector-Level Data

(b) Aggregation Bias

Notes: Figure 12a and Figure 12b report the change in value added (in %) for a 50% cut in supply of FCIs, and the resulting percentage point bias. The sector-level data are at the NACE3 level. Figure 12a is equivalent to Figure 8, but using sector-level instead of firm-level data. Figure 12b depicts the difference between Figure 8 and Figure 12a.

Why does use of macro data bias the results and why does the bias differ across countries? Because *exposure* to imports of FCIs from China-aligned countries is computed at the *sector-wide* level, which masks substantial heterogeneity in exposure across firms, use of macro data yields different results. In fact, since we estimate the overall change in value added by aggregating firm-level changes in value added, which changes depend on *firm exposure* to supply disruptions (see eq. (5)), there are two factors that can drive the direction of the bias. First, as discussed above in reference to Hulten (1978)'s theorem, all else being equal, the distribution of value-added weights shapes the aggregate impact. If those firms that exhibit large value-added changes because of their underlying exposure also have very large sample weights, the

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in Appendix Figure 12a and Figure 8).

[56]As explained in Section 5.2, the factors of production are more easily substitutable at higher values of σ so that, all else being equal, disruptions to the supply of FCIs become less costly in terms of value added.

aggregate impact when using *micro* data may be larger. Second, conditional on the distribution of value-added weights, then, even if *firm-level* exposure and, thus, value-added changes are *unaffected*, exposure at the sectoral level may be different —from eq. (4).[57] In this case, the aggregate impact when using *macro* data may be different. Appendix C provides an analytical example that further illustrates these two channels in.

Overall, use of granular data is essential to recovering *exposure* to disruptions in the supply of FCIs and the *relative size* of firms and, thus, to estimating the impact of geoeconomic fragmentation, especially if the production function exhibits complementarity between FCIs and other intermediates. The size of the bias is driven by the distributions of value-added weights and FCI imports, which both vary across countries.

6 Conclusion

In this paper, we identify foreign critical inputs (FCIs) and exploit micro data of five European countries to assess the effects of potential disruptions to supplies of FCIs from China-aligned countries. We propose a parsimonious firm-level sourcing framework and estimate the size of the impact of supply disruptions to FCIs on value added at different levels of aggregation. This paper is a first attempt to understand the impact of firm-level exposure to aggregate geoeconomic shocks affecting the supply of key inputs that is focused on several countries. Our work adds to the growing stream of work on why changes in the organisation of GVCs might affect firms and economies differently. We hope that our paper provides one explanation to such a question.

We find that firms, sectors, regions and countries would be significantly impacted by such a supply shock, with substantial heterogeneity across units stemming from heterogeneous import exposure. For instance, manufacturing value-added losses for a 50% reduction in imports of FCIs from China-aligned countries, would range from 2% to 3.1%.

Finally, we argue that micro data are crucial not only for mapping strategic dependencies (Méjean and Rousseaux, 2024) but also for quantifying their importance in the case a shock materialises. In this context, to design more effective industrial policy and policies aimed at

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[57]For instance, for a subset of firms, it would be possible to adjust both their imports of FCIs from China-aligned countries and their total imports of FCIs, using the same scaling factor, so that their exposure —ratio of the former to the latter —would not change. However, at the aggregate level, sector-level exposure, defined as the ratio of the *sum* of imports of FCIs from China-aligned countries to the *sum* of total imports of FCIs, would change because this scaling factor would affect both the numerator and the denominator, in different proportions.

diversifying away from China-aligned countries, we endorse the call of Pichler et al. (2023) and stress the importance of collecting micro data and making it available for research purposes.

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Appendices

A Derivations

The CES aggregator combining intermediate goods and services given by

$$M_i = \left[\gamma_i^{\frac{1}{\sigma}} E_i^{\frac{\sigma-1}{\sigma}} + (1-\gamma_i)^{\frac{1}{\sigma}} X_i^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

gives us the following cost-minimisation problem:

$$\min_{E_i, X_i} p_E E_i + P_X X_i$$

$$\text{s.t.} \quad \left[\gamma_i^{\frac{1}{\sigma}} E_i^{\frac{\sigma-1}{\sigma}} + (1-\gamma_i)^{\frac{1}{\sigma}} X_i^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \geq M_i$$

The first-order conditions yield:

$$p_E = \lambda \gamma_i^{\frac{1}{\sigma}} E_i^{\frac{-1}{\sigma}} M_i^{\frac{1}{\sigma}} \tag{7}$$

and

$$p_X = \lambda (1-\gamma_i)^{\frac{1}{\sigma}} X_i^{\frac{-1}{\sigma}} M_i^{\frac{1}{\sigma}} \tag{8}$$

where λ is the associated Lagrange multiplier. Taking the ratio of the two first-order conditions, we obtain:

$$\frac{p_E}{p_X} = \left(\frac{\gamma_i}{1-\gamma_i} \right)^{\frac{1}{\sigma}} \left(\frac{E_i}{X_i} \right)^{\frac{-1}{\sigma}} \tag{9}$$

Solving for FCIs yields:

$$X_i = \left(\frac{p_E}{p_X} \right)^{\sigma} \frac{1-\gamma_i}{\gamma_i} E_i \tag{10}$$

We take a partial equilibrium perspective in which relative prices and supply of non-FCIs E_i are normalised to 1 The supply of FCIs is then pinned down by the share of expenditure γ_i.

Plugging this term back into the CES aggregator and including the fact that E_i is normalised to 1 prior to the shock, yields:

$$M_i = \left[\gamma_i^{\frac{1}{\sigma}} + (1-\gamma_i)^{\frac{1}{\sigma}} \left(\frac{1-\gamma_i}{\gamma_i} \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

Given that expenditure on FCIs is given by $(1 - \varepsilon_i)$ after the shock, the change in M is:[58]

$$\frac{\Delta M_i}{M_i} = \frac{\left[\gamma_i^{\frac{1}{\sigma}} (1 - \varepsilon_i)^{\frac{\sigma-1}{\sigma}} + (1 - \gamma_i)^{\frac{1}{\sigma}} \left(\frac{1-\gamma_i}{\gamma_i}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}}{\left[\gamma_i^{\frac{1}{\sigma}} + (1 - \gamma_i)^{\frac{1}{\sigma}} \left(\frac{1-\gamma_i}{\gamma_i}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}} - 1 \tag{11}$$

We assume that K and L are fixed in the short-run. Proxying Δm by $\frac{\Delta M}{M}$, allows the log change in production to be recovered from eq. (2):

$$\Delta y_i = (1 - \alpha_s - \beta_s)\Delta m_i \tag{12}$$

Using the Cobb-Douglas production function specified in eq. (2), shares of expenditure on goods and services are defined by the Cobb-Douglas exponents, i.e., $p_M M_i / p_Y Y_i = (1 - \alpha_s - \beta_s)$. Then, value added can be expressed as $\text{VA}_i = p_Y Y_i - p_M M_i = p_Y Y_i - (1 - \alpha_s - \beta_s)p_Y Y_i$. Normalising the price of the output good to unity, we obtain:

$$\Delta va_i = \Delta y_i \tag{13}$$

Combining eq. (11), eq. (12), and eq. (13) yields the firm-level impact of a reduction in FCIs on value added given by eq. (4) in the main text.

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[58]When $\sigma = 0$, $\frac{\Delta M_i}{M_i} = -\varepsilon_i$. Conversely, when $\sigma = 1$, $\frac{\Delta M_i}{M_i} = \frac{\frac{1-\gamma}{\gamma}^{1-\gamma_i} (1-\varepsilon_i)^{\gamma_i}}{\frac{1-\gamma}{\gamma}^{1-\gamma_i}} - 1$.

B List of countries and ISO codes

List of US-aligned countries: Aruba (ABW), Anguilla (AIA), Albania (ALB), Netherlands Antilles (ANT), American Samoa (ASM), French Southern and Antarctic Territories (ATF), Australia (AUS), Austria (AUT), Belgium (BEL), Bonaire (BES), Bulgaria (BGR), Bosnia Herzegovina (BIH), Saint Barthélemy (BLM), Belize (BLZ), Bermuda (BMU), Canada (CAN), Cocos Islands (CCK), Switzerland (CHE), Cook Islands (COK), Curaçao (CUW), Christmas Islands (CXR), Cayman Islands (CYM), Cyprus (CYP), Czechia (CZE), Germany (DEU), Denmark (DNK), Spain (ESP), Estonia (EST), Finland (FIN), Falkland Islands (Malvinas) (FLK), France (FRA), United Kingdom (GBR), Gibraltar (GIB), Greece (GRC), Greenland (GRL), Guatemala (GTM), Guam (GUM), Croatia (HRV), Haiti (HTI), Hungary (HUN), British Indian Ocean Territory (IOT), Ireland (IRL), Iceland (ISL), Israel (ISR), Italy (ITA), Japan (JPN), Rep. of Korea (KOR), Liechtenstein (LIE), Lithuania (LTU), Luxembourg (LUX), Latvia (LVA), Monaco (MCO), Marshall Islands (MHL), North Macedonia (MKD), Malta (MLT), Montenegro (MNE), Northern Mariana Islands (MNP), Montserrat (MSR), New Caledonia (NCL), Norfolk Islands (NFK), Niue (NIU), Netherlands (NLD), Norway (NOR), Nauru (NRU), New Zealand (NZL), Pitcairn (PCN), Palau (PLW), Poland (POL), Portugal (PRT), French Polynesia (PYF), Romania (ROU), Saint Helena (SHN), San Marino (SMR), Saint Pierre and Miquelon (SPM), Slovakia (SVK), Slovenia (SVN), Sweden (SWE), Saint Maarten (SXM), Turks and Caicos Islands (TCA), Tokelau (TKL), Taiwan (TWN), Ukraine (UKR), United States of America (USA), British Virgin Islands (VGB), Wallis and Futuna Islands (WLF).

List of China-aligned countries: Burundi (BDI), Benin (BEN), Burkina Faso (BFA), Bangladesh (BGD), Belarus (BLR), Bolivia (BOL), Central African Rep. (CAF), China (CHN), Rep. of Congo (COG), Comoros (COM), Djibouti (DJI), Dominica (DMA), Eritrea (ERI), Ethiopia (ETH), Gabon (GAB), Guinea (GIN), Gambia (GMB), Guinea-Bissau (GNB), Equatorial Guinea (GNQ), China, Hong Kong SAR (HKG), Iran (IRN), Kyrgyzstan (KGZ), Lao People's Dem. Rep. (LAO), Lebanon (LBN), Libya (LBY), Sri Lanka (LKA), China, Macao SAR (MAC), Mali (MLI), Mozambique (MOZ), Mauritania (MRT), Nepal (NPL), Pakistan (PAK), Papua New Guinea (PNG), Dem. People's Rep. of Korea (PRK), State of Palestine (PSE), Russian Federation (RUS), Sudan (SDN), Solomon Islands (SLB), Sierra Leone (SLE), Somalia (SOM), South Sudan (SSD), Sao Tome and Principe (STP), Suriname (SUR), Togo (TGO), Tajikistan (TJK), Tonga (TON),

Uganda (UGA), Venezuela (VEN), Yemen (YEM), Zambia (ZMB), Zimbabwe (ZWE).

List of neutral countries: Afghanistan (AFG), Angola (AGO), Andorra (AND), United Arab Emirates (ARE), Argentina (ARG), Armenia (ARM), Antigua and Barbuda (ATG), Azerbaijan (AZE), Bahrain (BHR), Bahamas (BHS), Brazil (BRA), Barbados (BRB), Brunei Darussalam (BRN), Bhutan (BTN), Botswana (BWA), Chile (CHL), Côte d'Ivoire (CIV), Cameroon (CMR), Dem. Rep. of the Congo (COD), Colombia (COL), Cabo Verde (CPV), Costa Rica (CRI), Cuba (CUB), Dominican Rep. (DOM), Algeria (DZA), Ecuador (ECU), Egypt (EGY), Fiji (FJI), FS Micronesia (FSM), Georgia (GEO), Ghana (GHA), Grenada (GRD), Guyana (GUY), Honduras (HND), Indonesia (IDN), India (IND), Iraq (IRQ), Jamaica (JAM), Jordan (JOR), Kazakhstan (KAZ), Kenya (KEN), Cambodia (KHM), Kiribati (KIR), Saint Kitts and Nevis (KNA), Kuwait (KWT), Liberia (LBR), Saint Lucia (LCA), Lesotho (LSO), Morocco (MAR), Moldova (MDA), Madagascar (MDG), Maldives (MDV), Mexico (MEX), Myanmar (MMR), Mongolia (MNG), Mauritius (MUS), Malawi (MWI), Malaysia (MYS), Namibia (NAM), Niger (NER), Nigeria (NGA), Nicaragua (NIC), Oman (OMN), Panama (PAN), Peru (PER), Philippines (PHL), Paraguay (PRY), Qatar (QAT), Rwanda (RWA), Saudi Arabia (SAU), Senegal (SEN), Singapore (SGP), El Salvador (SLV), Serbia (SRB), Swaziland (SWZ), Seychelles (SYC), Syria (SYR), Chad (TCD), Thailand (THA), Turkmenistan (TKM), Timor-Leste (TLS), Trinidad and Tobago (TTO), Tunisia (TUN), Turkey (TUR), Tuvalu (TUV), Tanzania (TZA), Uruguay (URY), Uzbekistan (UZB), Saint Vincent and the Grenadines (VCT), Vietnam (VNM), Vanuatu (VUT), Samoa (WSM), South Africa (ZAF).

C   Aggregation bias

Table A1: Illustration of Aggregation Bias ($\sigma = 0$)

Firm	FCI Risky Imports (1)	FCI Imports (2)	China-aligned share (3)	Value added (4)	Δva (5)
Panel A. Baseline bias					
1	0	0		100	
2	5	400	0.0125	400	−0.625%
3	30	200	0.15	200	−7.5%
4	100	500	0.20	500	−10%
Firm-level data					−5.6%
Sectoral data	135	1100	0.12		−6.1%
Bias (p.p)					−0.5
Panel B. Alternative value-added weights					
4	100	500	0.20	700	−10%
Firm-level data					−6.3%
Sectoral data	135	1100	0.12		−6.1%
Bias (p.p)					0.2
Panel C. Alternative import values					
4	50	250	0.20	500	−10%
Firm-level data					−5.6%
Sectoral data	85	850	0.1		−5%
Bias (p.p)					0.6

Notes: Table A1 presents the direction of the bias from using sectoral-level data. Panel A reports the baseline bias given the values reported in columns 1 to 5 for firms 1,2,3,4 and 5. Panels B and C report only the new values for firm 4 —the values used for the first 3 firms do not change.

C.1   Set-up

We show that use of sectoral rather than firm-level data can bias the results (see Table A1). We focus on four fictitious firms and made-up values for imports and value added, based on an assumption, without loss of generality, that value added is proportional to imports. We assume, also, that firm 1 does not import.

For simplicity, we assume that the aggregate shock is equal to 50% ($\delta = 0.5$) and that production is Leontief ($\sigma = 0$), and we normalise the Cobb-Douglas shares to unity ($1 - \alpha_s - \beta_s = 1$). Table A1 Columns 1 and 2 report respective firm-level imports of FCIs from China-aligned countries, and all countries. Column 3 is the ratio of the Column 1 to Column 2 values. Column 4 is each firm's value added. Column 5 reports the change in value added, which is obtained by multiplying the values in Column 3 by the aggregate shock δ (see footnote 58 in Appendix A: Δva = −China-aligned share $* 0.5$).

C.2 Baseline bias

As reported in the text, the change in aggregate value added presented in Column 5 using micro data is obtained as follows:

$$\Delta\text{va} = \sum_i \Delta\text{va}_i \times \omega_i^{va}.$$

Thus, in the firm-level data case, the change in value added is obtained by taking the value-added weighted average of the change in value added where the sample includes both exposed and *non-exposed* firms, that is, firms that do not import FCIs from China-aligned countries. In Table A1 Panel A, the change in value added using firm-level data is obtained by computing $-0.625\% \times 400/1200 + -7.5\% \times 200/1200 + -10\% \times 500/1200 = -5.6\%$.

The change in value added obtained using sector-level data is different because exposure (Column 3) is computed over the entire sector directly. In this case, the change in aggregate value added is obtained simply by multiplying the share of FCI imports at risk (from the sum of both imports of FCIs from China-aligned countries and total FCI imports across firms) by the aggregate shock ($0.1227 \times -0.5 = -6.1\%$). In this case, use of sectoral-level data leads to over-estimation of the impact of geoeconomic fragmentation. Indeed, exposure to imports of FCIs from China-aligned countries is higher when using more aggregate data because important changes in firm-level value added are diluted by the *weighting*.

C.3 Alternative value-added weights

In Table A1 Panel B, we changed the value added produced by firm 4 and, thus, the distribution of value-added weights. In this case, the weight associated to firm 4 is larger (going from 0.42 to 0.58). While the impact calculated using sectoral data does not change (-6.1%), when calculated using micro data, it changes from -5.6% to -6.3%. This is because firm 4, which experiences a larger change in value added (-10%), is assigned a larger weight. In this case, using macro data could result in *underestimation* of the impact of geoeconomic fragmentation.

C.4 Alternative import values

In Table A1 Panel C, the import values for firm 4 are changed. Specifically, we halve the import values reported in Columns 1 and 2, which means that, when using micro data, the values in

Columns 3-5 do not change. However, using macro data, the estimated impact of geoeconomic fragmentation is lower: the change is -5% instead of -6.1%. This is because the exposure based on macro data is underestimated, but exposure at the micro level is unaffected.
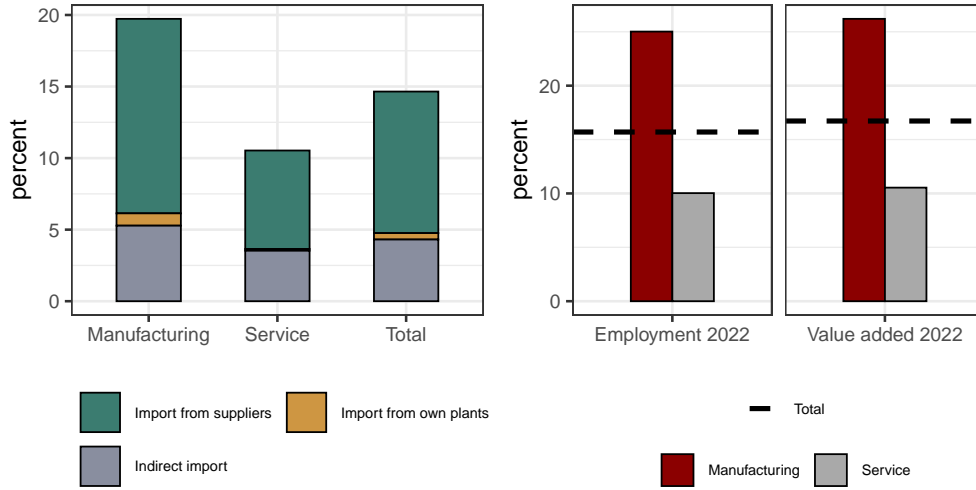
D   Additional figures

Figure A1: Exposure to China through FCIs by Sector (Share of Sectoral Employment and Value Added)
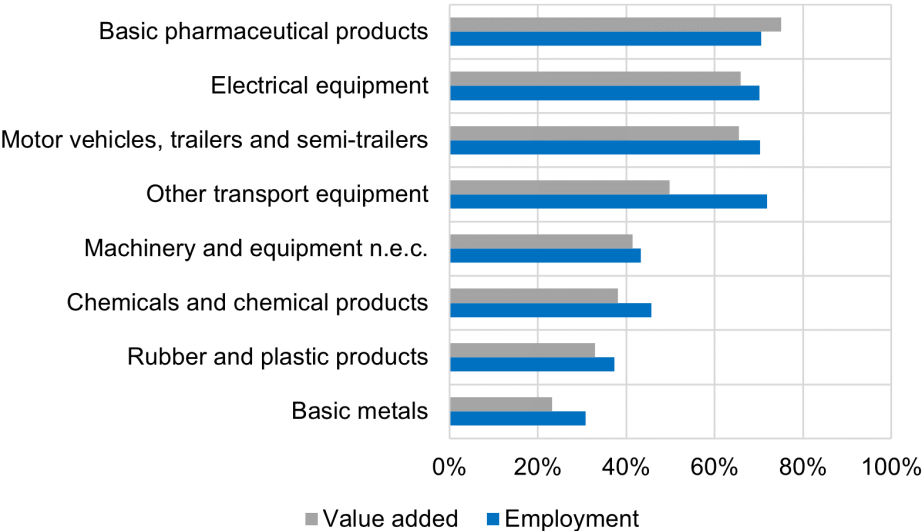

 Notes: Firms are considered exposed if they imported at least one FCI from China in 2019. The values for value added and employment are aggregated for the five BFISS countries.

## Figure A2: Critical Inputs from China among Italian Firms

Source: Own elaboration using INVIND data. **Notes:** Left panel: Firms sourcing critical inputs from China (share of total firms). In this survey, critical inputs are defined as those where shortages would lead to a reduction in the quality of the good or service produced or whose absence would mean that a significant part of the production process could not be completed or would be substantially delayed. Right panel: Exposure to China (share of total employment and value added).

Figure A3: Substitutability of Critical Inputs from China for Italy
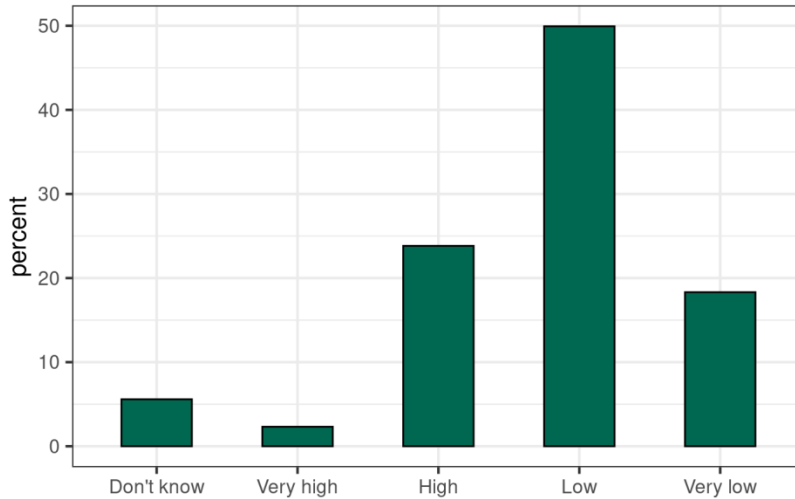

Source: Own elaboration using INVIND data. **Notes:** The bars represent the extent to which critical inputs sourced from China (share of manufacturing firms sourcing critical inputs from China) could be substituted. In this survey, critical inputs are defined as those where shortages would lead to a reduction in the quality of the good or service produced or whose absence would mean that a significant part of the production process could not be completed or would be substantially delayed.

## Figure A4: Number of FCIs by Country
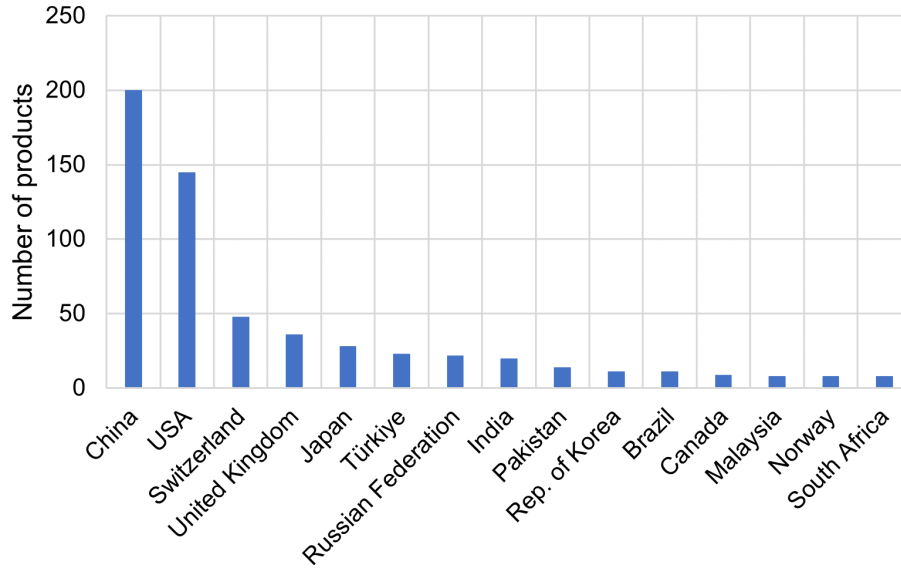
Notes: The bars represent the number of FCIs. The x-axis represents the main exporter of each FCI to the EU using CEPII BACI data, which include information on bilateral trade flows for 200 countries at the HS6 product level —see Gaulier and Zignago (2010).

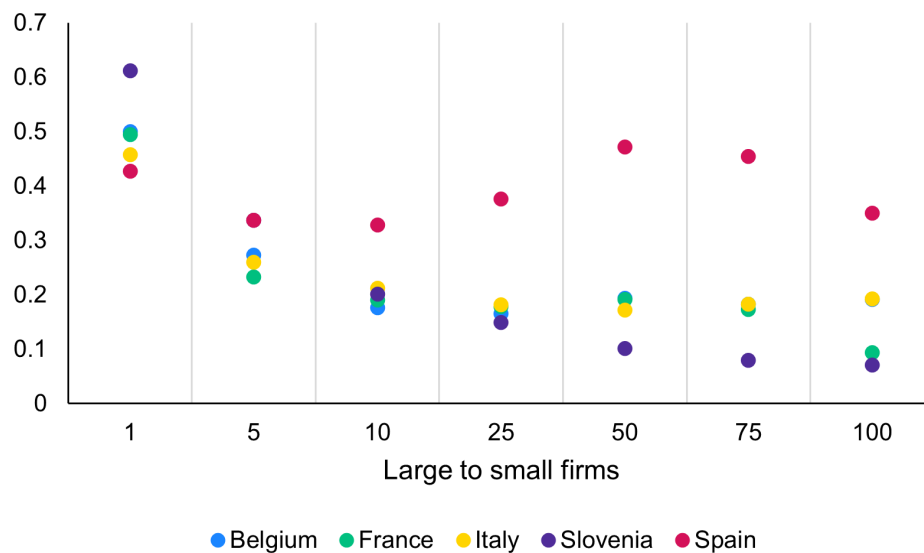## Figure A5: Share of Value added by Exposed Firm Size
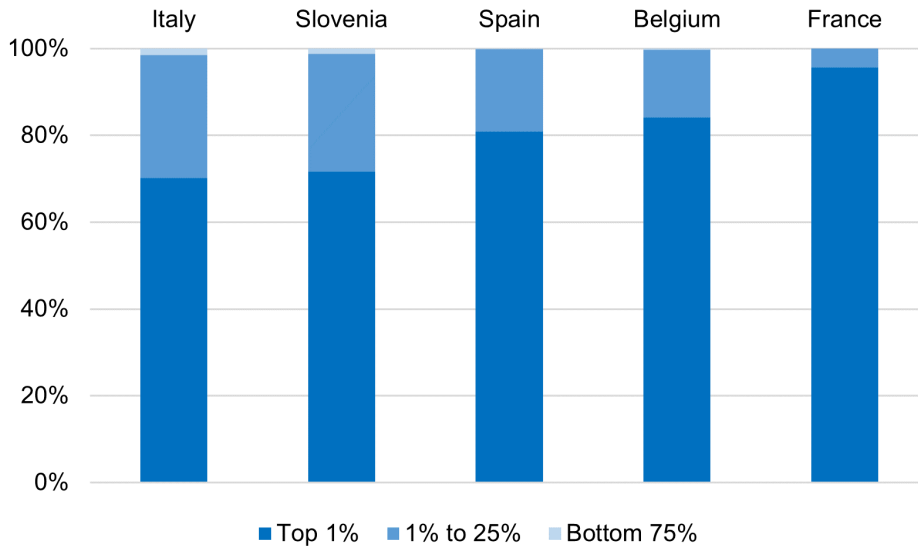
Notes: Value added percentiles. Only firms importing FCIs from China-aligned countries are considered. INSEE groups legal entities belonging to the same firm ("Profilage d'un groupe de sociétés"), which explains why the largest French firms have higher shares of value added compared to the firms in other countries.

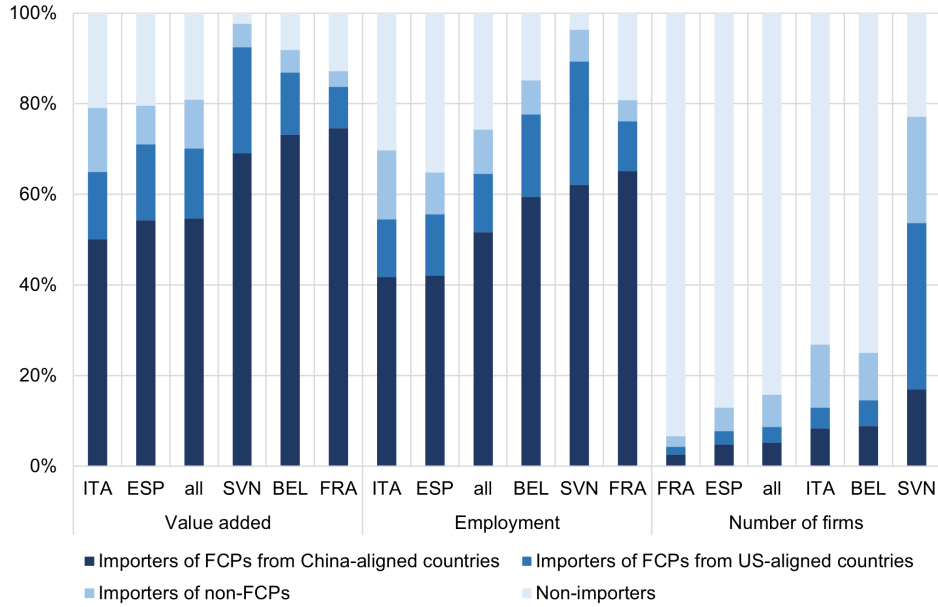## Figure A6: Share of Importing Firms by Firm Size
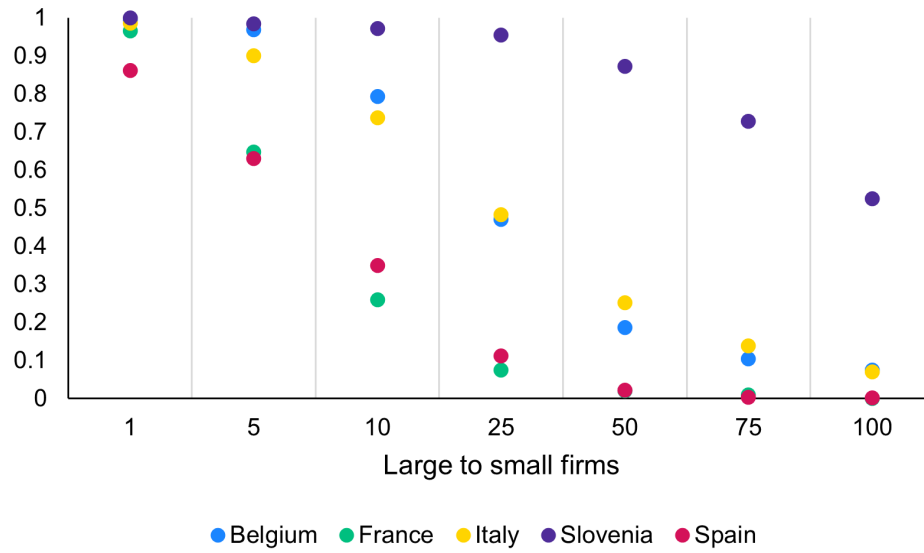
Notes: The x-axis shows percentiles, e.g. 1 is the 1% largest firms for value added, 5 is the 1% to 5% largest, etc. The share is computed over the total number of firms.

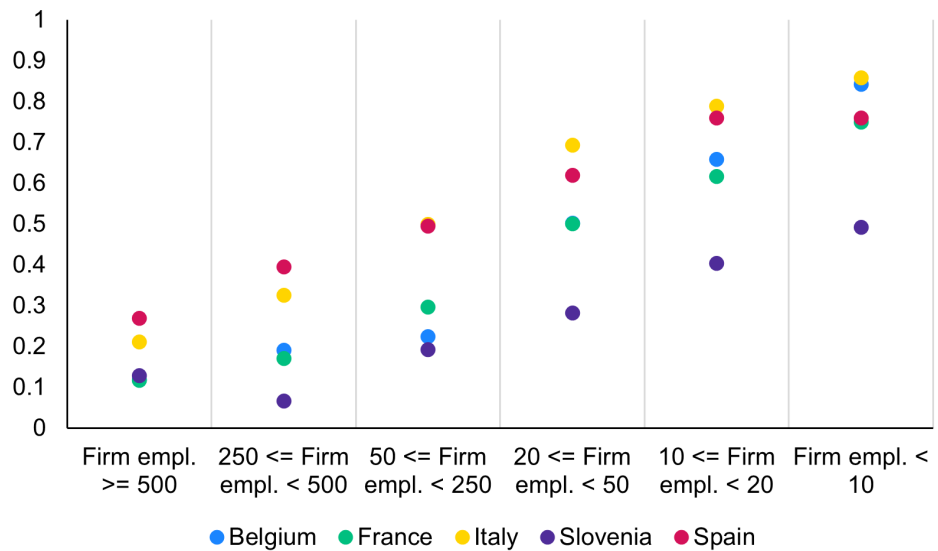## Figure A7: Share of Exposed Firms among Importers by Firm Size

Notes: The x-axis shows percentiles, e.g. 1 is the 1% largest firms for value added, 5 is the 1% to 5% largest, etc. Exposed firms are those firms that import FCIs from China-aligned countries.

Figure A8: Share of Value added, Employment and Number of Firms by Status

Notes: Includes only manufacturing firms.

Figure A9: Import Share of FCIs from China-aligned Countries by Firm Employment Size

Notes: Firm size measured as number of full-time equivalent employees. Includes only manufacturing firms and only firms importing FCIs from China-aligned countries.

Figure A10: Share of Foreign Critical Inputs over Total Inputs
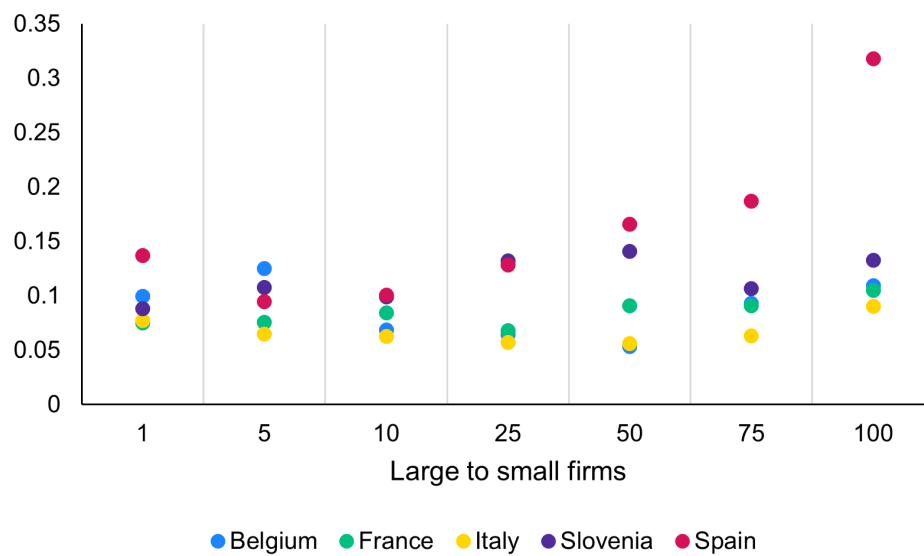
Notes: The x-axis shows percentiles, e.g. 1 is the 1% largest firms for value added, 5 is the 1% to 5% largest, etc. Includes only firms importing FCIs from China-aligned and non-China-aligned countries. Import-to-inputs ratios above 1 are winsorised.

Figure A11: Distribution of Value-added Change (in %) – Variations of Figure 6
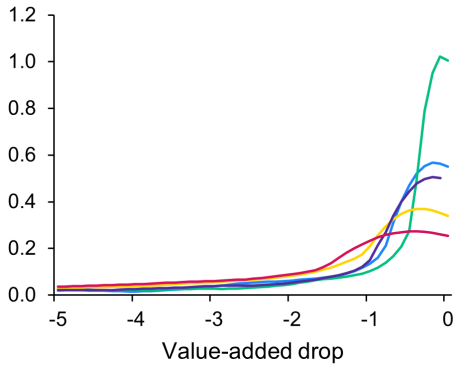
(a) $\sigma = 0.2$ instead of $\sigma = 0$

(b) Restricted FCIs list
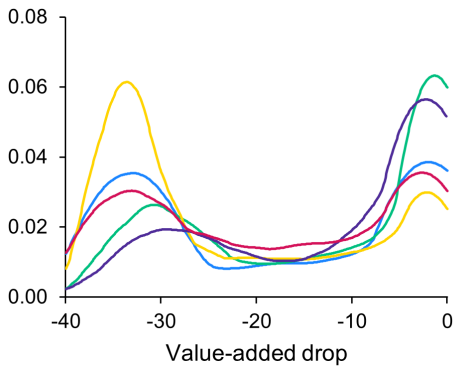
(c) Cut from China only
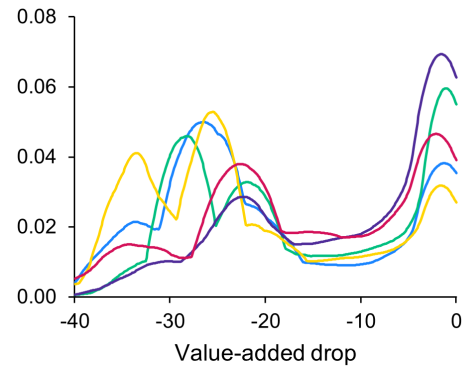
(d) Whole economy

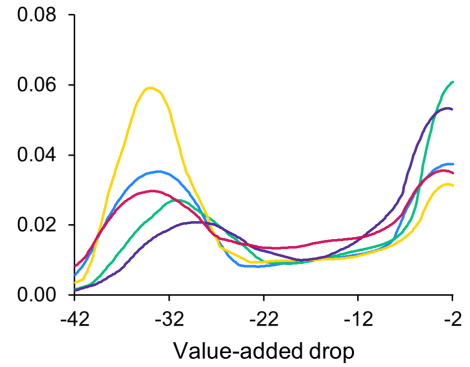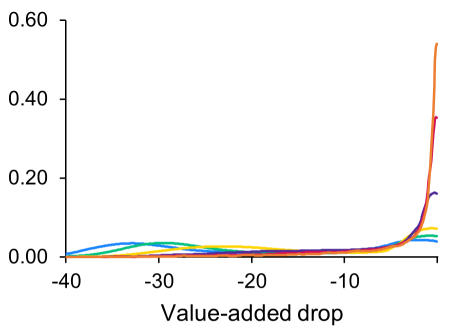(e) Country average (large scale)
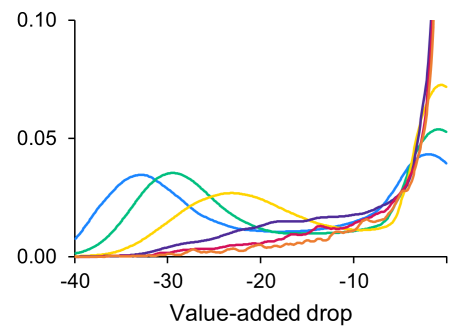
(f) Country average (zoom)

Notes: Figure A11 depicts the distribution of changes in value added (in %) for a 50% cut in FCIs. The restricted list includes inputs that are advanced technology products, products crucial for the green transition and highly concentrated raw materials, at the global level. The country average is a simple average; the results are very similar if we use a weighted average.

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Figure A12: Aggregate Value-added Change (in %) – Variations of Figure 8

(a) 75% cut

(b) 25% cut

(c) Restricted FCIs list

(d) Cut from China only

(e) Whole economy
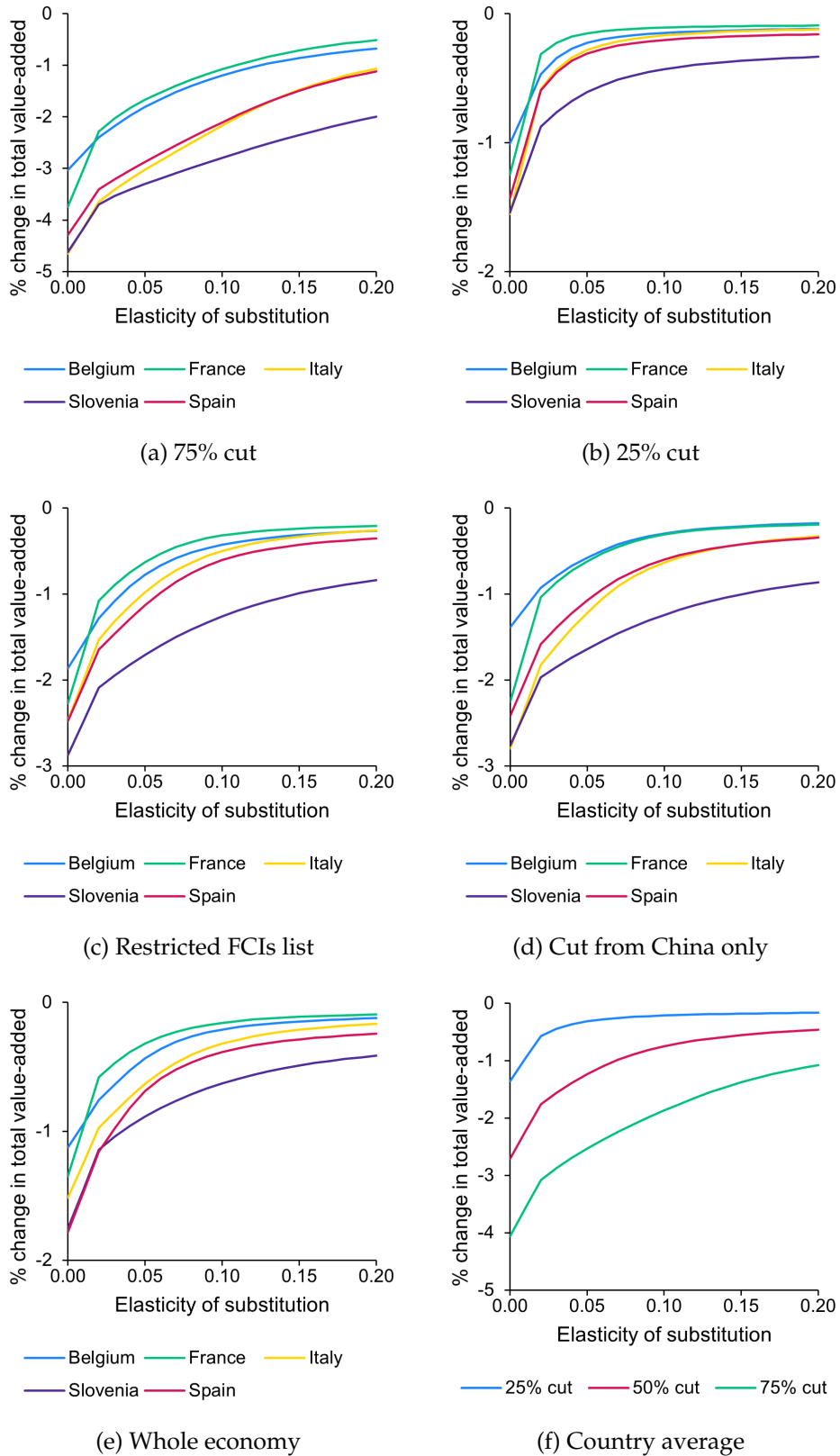
(f) Country average

Notes: The restricted list includes inputs that are advanced technology products, products crucial for the green transition and highly concentrated raw materials, at the global level. The country average is a simple average; the results are very similar using a weighted average.

Figure A13: Decomposition of Value-added Change (in %) by Exposed Firm Size
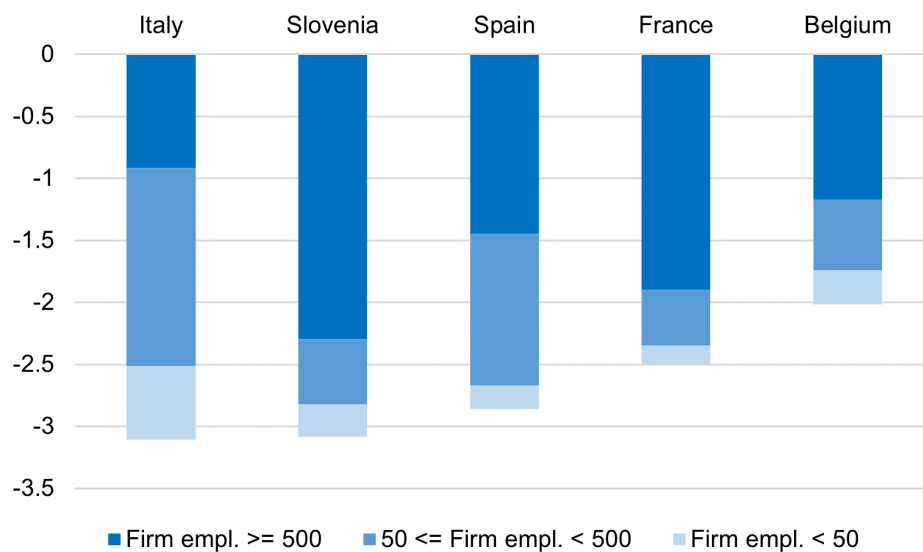
Notes: Firm size is measured as number of full-time equivalent employees. Includes only manufacturing firms importing FCIs from China-aligned countries.

Figure A14: Aggregate Value-added Change (in %) across Regions for the Whole Economy
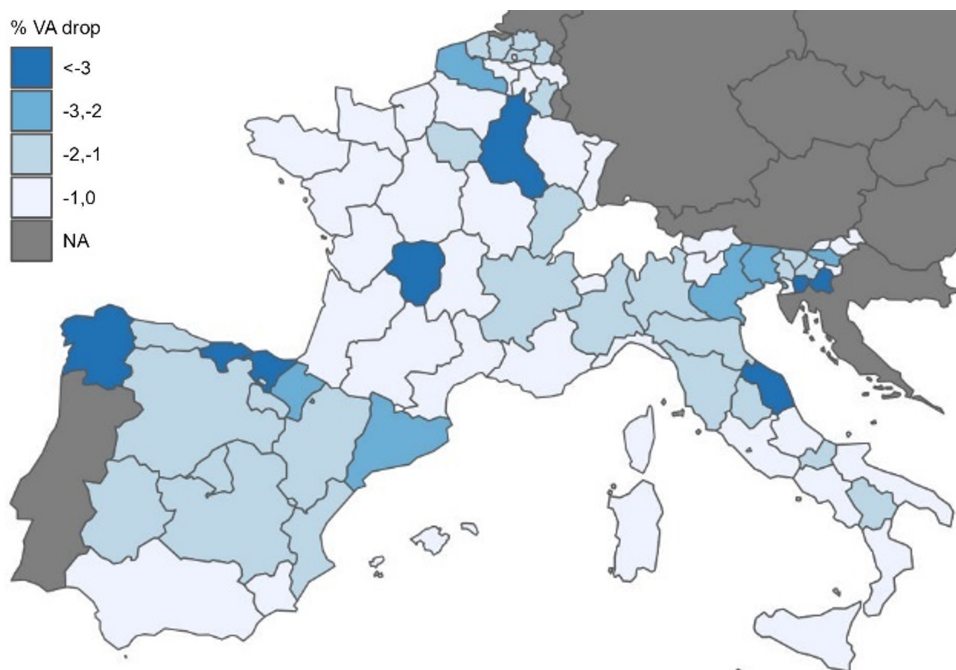
Notes: Figure A14 reports the change in value added (in %) across regions, for a 50% drop in supply of FCIs from China-aligned countries ($\sigma = 0$).

Figure A15: Decomposition of Value-added Change (in %) by Sector
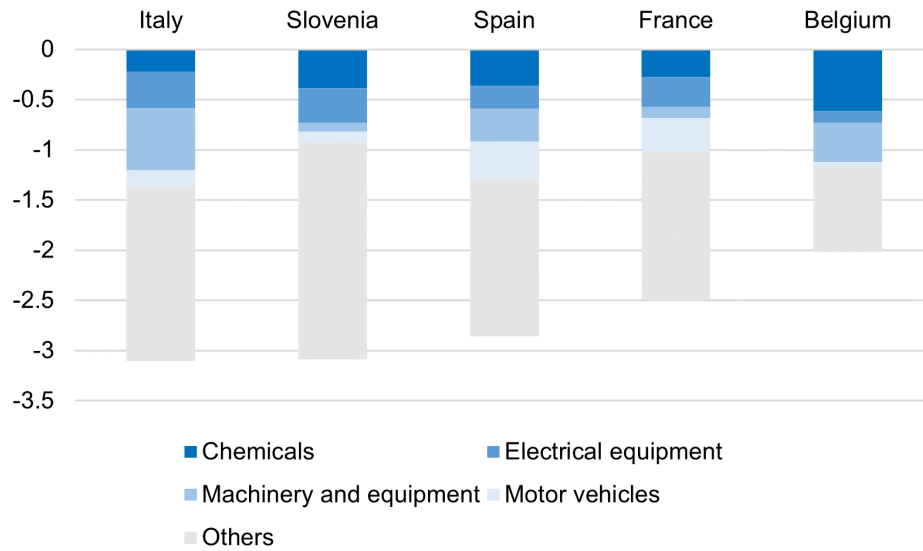
Notes: Only the manufacturing sector is considered. We selected the 5 sectors contributing the most to the drop (average across the 5 countries).

Figure A16: Aggregate Value-added Change across Sectors excluding Manufacturing
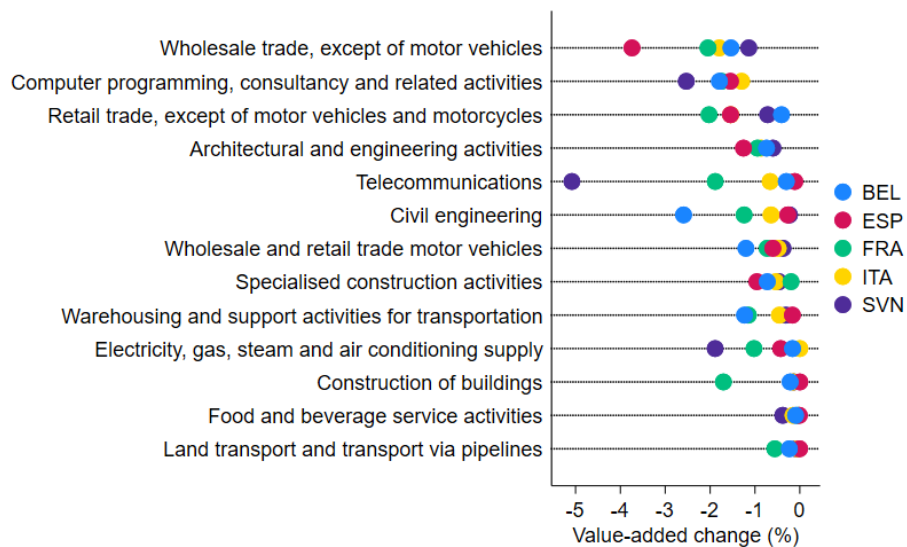
Notes: Figure A16 reports the change in value added (in %) for the most exposed sectors, from a 50% drop in supply of FCIs from China-aligned countries ($\sigma = 0$). Only non-manufacturing sectors with significant shares of value added ($> 1\%$ of total value added) are included.

E   Additional tables

Table A2: Summary Statistics for FCIs

		Mean	Min	p10	p50	p90	p99	Max	Obs.
Belgium	# FCIs for each firm	7	1	1	3	19	50	110	2,831
	# Non-FCIs for each firm	28	1	1	6	80	228	612	4,790
	# source countries, FCI × firm	2	1	1	1	3	8	42	20,724
	# source countries, # Non-FCIs × firm	2	1	1	1	3	8	66	133,422
France	# FCIs for each firm	8	1	1	3	18	67	241	8,478
	# Non-FCIs for each firm	32	1	2	12	77	310	1075	12,861
	# source countries, FCI × firm	2	1	1	1	3	11	63	64,494
	# source countries, # Non-FCIs × firm	2	1	1	1	3	10	56	410,549
Italy	# FCIs for each firm	4	1	1	2	10	32	154	15,556
	# Non-FCIs for each firm	12	1	1	3	32	113	610	31,037
	# source countries, FCI × firm	1	1	1	1	2	7	60	66,132
	# source countries, # Non-FCIs × firm	1	1	1	1	2	7	47	367,210
Slovenia	# FCIs for each firm	6	1	1	3	15	38	131	3,644
	# Non-FCIs for each firm	31	1	1	21	68	181	661	5,153
	# source countries, FCI × firm	1	1	1	1	2	7	35	22,391
	# source countries, # Non-FCIs × firm	1	1	1	1	2	6	36	157,756
Spain	# FCIs for each firm	4	1	1	2	8	25	89	4,056
	# Non-FCIs for each firm	14	1	1	8	32	87	572	6,656
	# source countries, FCI × firm	2	1	1	1	3	8	30	15,280
	# source countries, # Non-FCIs × firm	2	1	1	1	3	8	39	92,206
All	# FCIs for each firm	6	1	1	3	14	42	145	6,913
	# Non-FCIs for each firm	23	1	1	10	58	184	706	12,099
	# source countries, FCI × firm	2	1	1	1	3	8	46	37,804
	# source countries, # Non-FCIs × firm	2	1	1	1	3	8	49	232,229

Notes: Table A2 presents summary statistics for imports of FCIs in 2019. The sample includes only manufacturing firms. See Table A3 for the whole economy. The category "all" refers to a simple average of the BFISS countries. In contrast to Table 1 for Spain, Table A2 includes all importing firms — including small ones.

Table A3: Summary Statistics for FCIs (Whole Economy)

		Mean	Min	p10	p50	p90	p99	Max	Obs.
Belgium	# FCIs for each firm	5	1	1	2	13	46	291	16,556
	# Non-FCIs for each firm	16	1	1	2	38	210	2307	38,045
	# source countries, FCI × firm	2	1	1	1	3	9	70	84,907
	# source countries, # Non-FCIs × firm	2	1	1	1	3	9	155	601,000
France	# FCIs for each firm	6	1	1	3	14	51	243	35,169
	# Non-FCIs for each firm	24	1	1	8	58	250	2130	67,004
	# source countries, FCI × firm	2	1	1	1	3	9	63	215,932
	# source countries, # Non-FCIs × firm	2	1	1	1	3	8	81	1,622,609
Italy	# FCIs for each firm	4	1	1	2	10	34	221	33,845
	# Non-FCIs for each firm	12	1	1	3	30	147	2101	74,476
	# source countries, FCI × firm	1	1	1	1	2	7	60	140,559
	# source countries, # Non-FCIs × firm	1	1	1	1	2	7	47	897,737
Slovenia	# FCIs for each firm	5	1	1	3	12	29	289	24,664
	# Non-FCIs for each firm	22	1	1	8	56	145	2547	43,303
	# source countries, FCI × firm	1	1	1	1	2	5	37	129,892
	# source countries, # Non-FCIs × firm	1	1	1	1	2	5	50	940,061
Spain	# FCIs for each firm	3	1	1	1	6	21	137	27,172
	# Non-FCIs for each firm	6	1	1	2	14	60	1091	80,258
	# source countries, FCI × firm	1	1	1	1	2	7	42	76,055
	# source countries, # Non-FCIs × firm	1	1	1	1	2	7	39	487,535
All	# FCIs for each firm	5	1	1	2	11	36	236	27,481
	# Non-FCIs for each firm	16	1	1	5	39	162	2035	60,617
	# source countries, FCI × firm	1	1	1	1	2	7	54	129,469
	# source countries, # Non-FCIs × firm	1	1	1	1	2	7	74	909,788

Notes: Table A3 presents summary statistics for imports of FCIs in 2019. The category "all" refers to a simple average of the countries. In contrast to Table A4 for Spain, Table A3 includes all importing firms, including small ones.

Table A4: Summary Statistics for FCI Importers (Whole Economy)

		Mean	p10	p50	p90	SD	Obs.
Belgium	FCIs, share of firms' total purchases	6.2	0.0	0.6	18.3	14.7	11,997
	FCIs from low-risk countries, share of firm's total purchases	5.9	0.0	0.5	17.1	14.5	9,272
	FCIs from high-risk countries, share of firm's total purchases	3.8	0.0	0.3	9.3	11.0	5,218
France	FCIs, share of firms' total purchases	8.4	0.0	1.0	27.0	17.5	29,400
	FCIs from low-risk countries, share of firm's total purchases	7.3	0.0	0.8	22.5	16.5	24,820
	FCIs from high-risk countries, share of firm's total purchases	5.4	0.0	0.5	15.8	13.7	12,406
Italy	FCIs, share of firms' total purchases	6.7	0.0	1.0	19.8	14.4	28,759
	FCIs from low-risk countries, share of firm's total purchases	5.8	0.0	0.6	16.5	13.8	22,113
	FCIs from high-risk countries, share of firm's total purchases	4.9	0.0	0.9	13.5	11.0	12,811
Slovenia	FCIs, share of firms' total purchases	6.6	0.0	1.2	17.9	14.5	16,277
	FCIs from low-risk countries, share of firm's total purchases	6.0	0.0	1.1	16.2	13.6	15,894
	FCIs from high-risk countries, share of firm's total purchases	4.9	0.0	0.5	12.6	12.5	2,279
Spain	FCIs, share of firms' total purchases	12.5	0.1	2.4	40.8	22.8	8,605
	FCIs from low-risk countries, share of firm's total purchases	11.3	0.1	1.8	36.0	21.8	7,564
	FCIs from high-risk countries, share of firm's total purchases	7.3	0.1	1.3	19.7	16.4	3,447
All	FCIs, share of firms' total purchases	8.1	0.0	1.2	24.7	16.8	19,008
	FCIs from low-risk countries, share of firm's total purchases	7.3	0.0	1.0	21.7	16.0	15,933
	FCIs from high-risk countries, share of firm's total purchases	5.3	0.0	0.7	14.2	12.9	7,232

Notes: Table A4 presents summary statistics for firms importing FCIs in 2019. The variables are expressed in percentages. The category "all" refers to a simple average of the countries. Intermediate goods refer to expenditure on goods and services. All countries but Spain use the population of importing firms; in the case of Spain, the sample corresponds to the importers included in the Directorio. Differences between Spain and the other countries are explained by the fact that the Directorio excludes most small importing firms.

Table A5: FCI Premia (Whole Economy)

Import FCI	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All firms				Extra-EU importers			
	log Employment	log Turnover	log Wages	log Labour Prod.	log Employment	log Turnover	log Wages	log Labour Prod.
Belgium	1.456***	1.872***	0.382***	0.325***	0.801***	0.906***	0.159***	0.142***
	(0.0172)	(0.0196)	(0.00657)	(0.00885)	(0.0222)	(0.0253)	(0.00879)	(0.0119)
Obs.	138,618	138,618	138,618	138,618	19,353	19,353	19,353	19,353
France	1.785***	2.347***	0.310***	0.335***	1.096***	1.175***	0.116***	0.110***
	(0.0112)	(0.0120)	(0.00418)	(0.00518)	(0.0168)	(0.0182)	(0.00729)	(0.00893)
Obs.	1,123,126	1,123,126	1,123,126	1,123,126	39,485	39,485	39,485	39,485
Italy	1.407***	1.947***	0.338***	0.376***	0.813***	0.971***	0.153***	0.165***
	(0.00955)	(0.0106)	(0.00265)	(0.00454)	(0.0117)	(0.0130)	(0.00336)	(0.00593)
Obs.	527,951	527,951	527,951	527,951	57,830	57,830	57,830	57,830
Slovenia	0.755***	1.143***	0.108***	0.214***	0.695***	0.804***	0.103***	0.122***
	(0.0150)	(0.0178)	(0.00439)	(0.00877)	(0.0384)	(0.0471)	(0.0106)	(0.0221)
Obs.	36,368	36,368	36,368	36,368	8,719	8,719	8,719	8,719
Spain	1.154***	1.508***	0.151***	0.317***	0.802***	0.924***	0.0729***	0.138***
	(0.0200)	(0.0229)	(0.00547)	(0.00911)	(0.0249)	(0.0283)	(0.00671)	(0.0116)
Obs.	23,923	23,923	23,923	23,923	13,121	13,121	13,121	13,121
3-digit industry FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Table A5 reports the estimates based on eq. (1) in the main text, for the whole economy. All countries but Spain use the population of importing firms; in the case of Spain, the sample corresponds to the importers included in the Directorio. Differences between Spain and the other countries are explained by the fact that the Directorio excludes most small importing firms. Standard errors clustered at firm level. * significant at 10%, ** significant at 5%, *** significant at 1%.

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Pierre Wunsch

Governor of the National Bank of Belgium