WORKING paper

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Made in France and Reshoring in Multi-Regional Input-Output Tables[1]

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Abstract

Made in France, defined as domestic value added content of the final domestic demand, fell by 11 points between 1965 and 2019, from 89% to 78%. This downward trend is common to European countries and reflects the growing globalization process of recent decades. The location of a production plant in France has consequences throughout the value chain. These spillovers increase the positive effects of setting up a new plant on economic activity and employment in France, compared to the creation of a similar plant abroad. The spillover effect, defined as the total value added of the new plant and its suppliers compared to the value added of the new plant alone, and simulated here under the strong assumption that the supply chain of the new plant is similar to those of existing firms, would be around 2.0 in manufacturing industry and 1.6 in market services. If greenhouse gas emissions from production increase in France, they decrease worldwide, since production in France is less carbon-intensive than in the countries that supply imports.

Keywords: Multi-Regional Input-Output Model, Reshoring, Carbon Footprint

JEL classification: C67, F62, Q53

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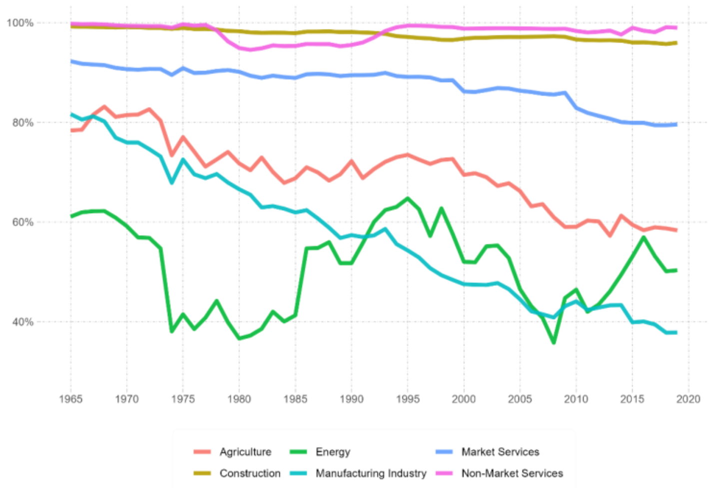
NON-TECHNICAL SUMMARY

In this paper, we calculate 'made in' indicators using multi-regional input-output tables. The 'made in' of a country represents the share of domestic value added in the country's final demand. The 'made in France' indicator declined between 1965 and 2019, falling from 89% to 78%. In 2019, it is high in construction (96%) and market services (80%), but much lower in manufactured goods (38%) compared to 82% in 1965. In services, domestic demand is associated with domestic production, particularly in sectors such as food services, health, and education. Moreover, intermediate consumption in services largely corresponds to domestic production. In contrast, industrial and agricultural goods, as well as their intermediate consumption, are often imported.

Domestic Value added Content in Final Demand by Product (in %)



Sources: LRWIOD, WIOD, and FIGARO, authors' calculations.

The 'made in' indicator has similarly declined in other major European countries such as Germany, Spain, and Italy. In 2019, these countries exhibited similar 'made in', while less populated countries like Ireland and the Netherlands, which are more integrated into international trade, had lower rates. This downward trend reflects the expansion of global value chains and the increasing integration of China into global trade. Since the 2000s, 'made in China' has been replacing 'made in Europe' in French consumption. The share of 'made in China' in manufactured goods consumed in France increased, while the share of ‘made in France’ in domestically consumed stood at only 38% in 2019, having significantly declined since 1965. Furthermore, around 30% of French exports in 2019 consisted of imported products, compared to 15% in 1965, highlighting the increasing participation in global value chains.

The effect of diversification on economic volatility is ambiguous and contingent on the underlying sources of shocks. When shocks are primarily country-specific (domestic policy uncertainty, etc.) trade integration can serve as a buffer. By enabling firms to diversify across multiple countries and supply chains, trade reduces reliance on any single national economy. In this paper, by contrast, we focus on sectoral shocks, such as geopolitical, climate-related, or supply chain disruptions and we measure trade vulnerabilities of French economy at this level. A product consumed in France can be particularly vulnerable to these risks when it has 1) a high import content, 2) a high concentration in a few sectors and countries, and 3) a French import structure similar to that of other countries, indicating a concentrated global supply that constraints import diversification. The sectors where vulnerabilities, measured according to these criteria, are most pronounced are pharmaceuticals, textiles, refining, other transport equipment, and IT.

We also propose an accounting exercise illustrating the spillover effects of setting up a new plant in France rather than abroad, linked to the interconnections of value chains as measured in multi-regional input-output tables. The initial plant's purchases of inputs generate additional production for these suppliers, which in turn uses intermediate consumption, and so on. The supply chain, both domestic and global, faces additional demand and therefore increases production accordingly. Consequently, economic activity, employment, and CO_2 emissions varies in each country. These effects are simulated here by substituting part of the imports of goods with domestic production, while keeping total demand unchanged. In this exercise, if a manufacturing plant producing € 1 billion of value added were reshored in France rather than abroad, the value added in France would increase by € 2.0 billion, with a spillover effect on the supply chains of this new plant amounting to € 1.0 billion. This would create 24,400 jobs in France, 10,500 directly and 13,900 indirectly. While this exercise provides estimates of employment creation, it does not make an explicit assumption about whether these jobs are filled by previously unemployed individuals or those moving from other firms. The methodology relies on the existing average employment intensity of the sector. Furthermore, the model does not account for potential resource constraints, including in the labour market that could affect the actual employment creation.

Made in France et réindustrialisation : une approche par les tableaux entrées-sorties internationaux

RÉSUMÉ

Le *made in* France, défini comme le contenu en valeur ajoutée française de la demande intérieure finale française, a baissé de 11 points entre 1965 et 2019, passant de 89% à 78%. Cette tendance à la baisse du contenu domestique est commune aux pays européens et reflète la mondialisation croissante des dernières décennies. Cette étude illustre les effets d'entraînement sur l'ensemble de l'activité de la localisation d'une activité en France plutôt qu'à l'étranger. La modélisation mobilise un tableau international des entrées-sorties pour la structure de la production mondiale, et construit des scénarii contrefactuels, où certains biens seraient produits en France plutôt qu'à l'étranger, en tenant compte de l'origine géographique des ressources et des consommations intermédiaires. L'effet d'entraînement simulé ici sous l'hypothèse que les chaînes de fournisseurs des nouveaux établissements seraient similaires à celles des filières existantes, serait de l'ordre de 2,0 dans l'industrie manufacturière, et de 1,6 dans les services marchands. En revanche, si les émissions de gaz à effet de serre de la production augmentaient en France, elles diminueraient au niveau mondial car la production est aujourd'hui moins carbonée en France que dans les pays fournisseurs des importations.

Mots-clés : tableaux internationaux des entrées-sorties, réindustrialisation, empreinte carbone

Codes JEL : C67, F62, Q53

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1 Introduction

Trade and economic integration lead to gains in purchasing power, productivity, and access to higher-quality or more diverse products. However, the disruptions in global supply chains have reinforced the case for reshoring strategic activities, in the aftermath of the COVID-19 crisis (e.g., pharmaceutical products and electronic components) and the war in Ukraine (e.g., natural gas). Furthermore, the challenges of the ecological transition—especially the need to reduce greenhouse gas emissions and the carbon footprint—are increasingly relevant.

The objective of this study is to highlight the spillover effects stemming from interconnections of value chains, as measured in multi-regional input-output tables. Specifically, it aims to compare the effects of establishing a new plant in France versus production abroad. The extent of these spillover effects varies depending on production technologies and economic sectors. Depending on production technologies and supply chain complexity, the multiplier effects on employment, economic activity, and greenhouse gas emissions of an establishment in France can be more or less pronounced. We calculate the extent of these effects at a detailed sectoral level through an accounting exercise.

This study first presents several stylized facts regarding France's integration into international trade and that of its partners since 1965, using indicators characterizing the national value added content of consumed products, referred to as 'made in'. These indicators were obtained over a long period by linking three multi-regional input-output tables (LR-WIOD, WIOD and FIGARO) and performing a back-calculation of series when reconciliation was necessary. The study then estimates the effects of establishing a new plant in France versus a location abroad, assuming the same total global value added and unchanged final consumption, but with structurally modified intermediate consumption and final demand (with a net-zero sum).

These estimates are based on multi-regional input-output tables. Our method constructs counterfactual scenarios for the global economy, where certain goods are produced in France instead of abroad, considering the geographical origin of resources and intermediate consumption. Under the strong assumption that the production technologies and value chains of the new facilities would be similar to existing ones, we describe the spillover effects on economic activity and employment of locating production in France rather than abroad, and the consequences for CO_2 emissions.

These results highlight the spillover effects on economic activity and employment and their variations across sectors, which could help in targeting attractiveness policies according to different objectives (growth, reducing vulnerabilities, lowering CO_2 emissions).The sectors most vulnerable to external shocks include pharmaceuticals, textiles, refining, other transport equipment, and electronic computing. The sectors with the most significant spillover effects on value added and employment include agri-food, automotive, and the wood and paper industries. Finally, the sectors where relocating production to France has the greatest potential to reduce global CO_2 emissions are chemicals, electrical equipment, and metal products.

The Trade in Value Added literature has predominantly focused on indicators of foreign value added embedded in exports and global supply chains (Johnson and Noguera (2012)). In contrast, we focus on the domestic value added content of final demand, what we call 'made in'. Our approach documents how much of a country's consumption is actually produced within its own borders, offering a complementary perspective to the literature.

Our original approach also complements the literature on the role of production networks in explaining macroeconomic fluctuations, which incorporates the input-output approach in general equilibrium to study the aggregate effects of microeconomic shocks (Acemoglu et al., 2012). Gabaix (2011) shows that the presence of very large firms is a source of GDP volatility: shocks affecting these firms are not offset by shocks affecting smaller firms and induce fluctuations at the aggregate level. Assuming Cobb-Douglas preferences and technologies, where production factor shares are linked by the Leontief matrix, this literature decomposes the effect of sectoral shocks (natural disasters, etc.) on aggregate GDP evolution. The starting point of these studies is the extension of Hulten (1978)'s theorem, which initially shows that the elasticity of total factor productivity to a microeconomic shock equals the share of a firm or sector's revenue in GDP, also known as the Domar weight. This result led to minimizing the role of production networks in macroeconomic models. If a sector's revenue share is sufficient to quantify the macroeconomic impact of a sectoral shock, inter-sectoral links can be disregarded. However, Baqaee and Farhi (2019) demonstrate that supply chain vulnerabilities, factor complementarities, and economies of scale can lead to nonlinear effects following sectoral shocks. For example, considering these frictions triples the estimated impact of the oil shocks on global GDP in the 1970s (from 0.23% to 0.61%). These multi-sector general equilibrium models have recently been used to analyze the effects of the COVID-19 crisis (Baqaee and Farhi, 2021, Izquierdo et al., 2022) and to estimate the impact of the gas embargo following the Ukraine crisis (Bachmann et al., 2022 for Germany and Baqaee et al., 2022 for France). They are relevant for analyzing the propagation of shocks within global value chains. For instance, the 2011 Tohoku earthquake in Japan has been used to study the transmission of this supply shock via global supply chains (Carvalho et al., 2021).

The article is structured as follows. The first section outlines stylized facts about France's deeper integration into international trade as well as that of its partners. The second section presents the vulnerabilities facing the French economy in the context of global value chain participation. The third section presents the results of sectoral simulations on attractiveness policies.

2 The Domestic Value Added Content of Demand in Major European Economies

In this section, we analyze the evolution of made in France since 1965. We also examine the situation of made in France compared to other European countries and major economic areas such as the United States, the European Union, and China.

2.1 Assessing Made in France on Multi-Regional Input-Output Tables

For a seller, labeling a product as made in France is subject to strict regulations. A product is considered to originate from the country where it underwent its last substantial transformation [1]. These transformations can be identified by a change in the product's customs tariff classification (within the international customs nomenclature) or by a criterion of value added percentage attributed to this last transformation (45% in the European Union). This legal definition of made in France differs from the one used in this study. To avoid the 45% threshold effect and obtain a continuous rather than binary measure of 'made in', we assess the domestic value added content for each consumed product. If a shirt is produced in France and consists of 44% French value added, it is not legally considered 'made in France'. However, from the statistical perspective adopted here, 44% of the shirt is considered 'made in France'.

The 'made in' indicator can be calculated using the national input-output table (Nicholson and Noonan, 2014, Bourgeois and Briand, 2019a), but this does not account for the fact that some imports may also contain French-origin content. For example, an imported car containing a steering wheel manufactured in France would be considered fully imported. Using multi-regional input-output tables allows for a more comprehensive quantification. Made in France is defined as the content of French value added embedded in final domestic demand C_{VA}, relative to total final domestic demand [2]. This indicator measures the share of how much is "made and purchased" in a given country. Formally, the 'made in' of country j is expressed as:

$$\text{made in}_j = \frac{\sum_k C_{VA(j,k),j}}{D_j^{tot}} \tag{1}$$

with D_j^{tot} representing the total final demand of country j. The value $C_{VA(i,k),j}$ corresponds to the value added content of final demand: it measures the geographical origin

1. Substantial transformation means that the good underwent a fundamental change in form, appearance, nature, or character

2. The concept of 'made in' is different from the share of expenditure on domestic goods $\lambda = \frac{D^d}{D^{tot}}$, a sufficient statistic for the effects of trade liberalization on welfare in Arkolakis et al. (2012).

i of the products k used to satisfy final demand in country j.

$$C_{VA} = \hat{VA} * \hat{P^{-1}} * L * D \tag{2}$$

where $\hat{VA}$ is the diagonal matrix consisting of global value added decomposed by country*sector, $\hat{P^{-1}}$ is the inverse of the diagonal matrix consisting of global production decomposed by country*sector, L is the matrix of Leontief (1986) by country*sector, and D is the global final demand decomposed by country in columns and by country*sector in rows.

2.2 Since 1965, Made in France Has Declined by 11 Percentage Points

In 2019, across all sectors, 78% of final domestic demand corresponded to French value added, while 22% came from foreign value added. The 'made in France' indicator has significantly declined since 1965 when it stood at 89%. In 2019, in the case of manufactured goods, 38% of goods consumed domestically in France originated in France (Figure 1). This share is higher for energy (50%) and agricultural products (58%), and even more so for market services (80%) and construction (96%).

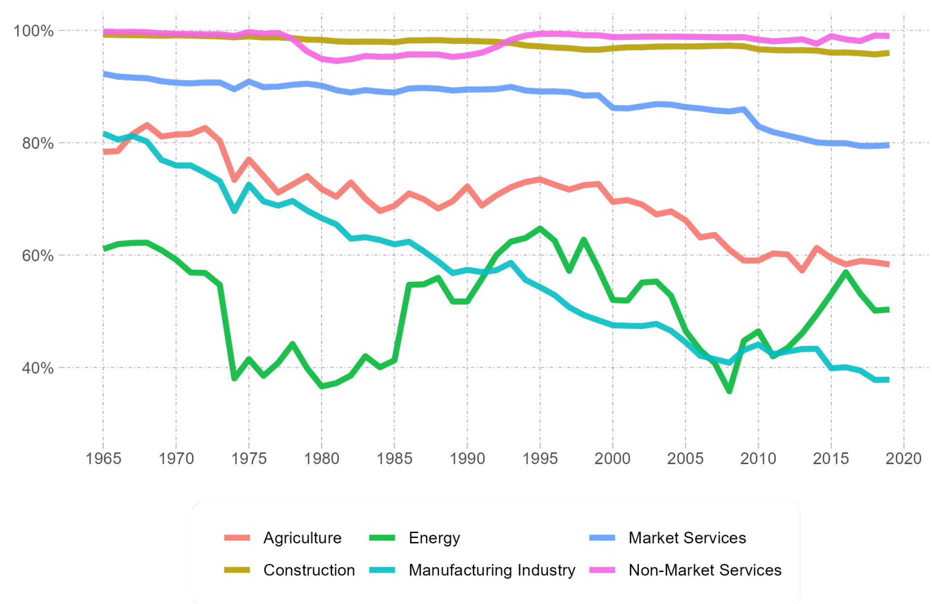
The composition of final demand by product largely explains both the level and evolution of 'made in' indicators. In most countries, the 'made in' indicator is close to 100% in construction and significantly higher in services than in manufacturing, agriculture, or energy. In the services sector, domestic demand is closely tied to resident production, particularly in hospitality, healthcare, and education. Moreover, intermediate consumption in services mainly consists of resident production. In contrast, industrial and agricultural goods can be imported. When a final good is produced domestically, its production often includes high imported content. In the energy sector, a large portion of production is domestic, but fossil raw materials, which constitute only part of France's energy mix, are imported in countries like France that lack such resources. If French refining production is roughly proportional to imported volumes, the 'made in' indicator of the energy sector fluctuates significantly over time due to variations in hydrocarbon prices.

2.3 The Made in indicator Has Declined Similarly in Large European Countries

A country's size[3] plays a key role in determining the 'made in' indicator. Larger countries meet a greater share of their final domestic demand from their own produc-

3. Measured by its GDP or population

FIGURE 1 – Domestic Value added Content in Final Demand by Product (in %)



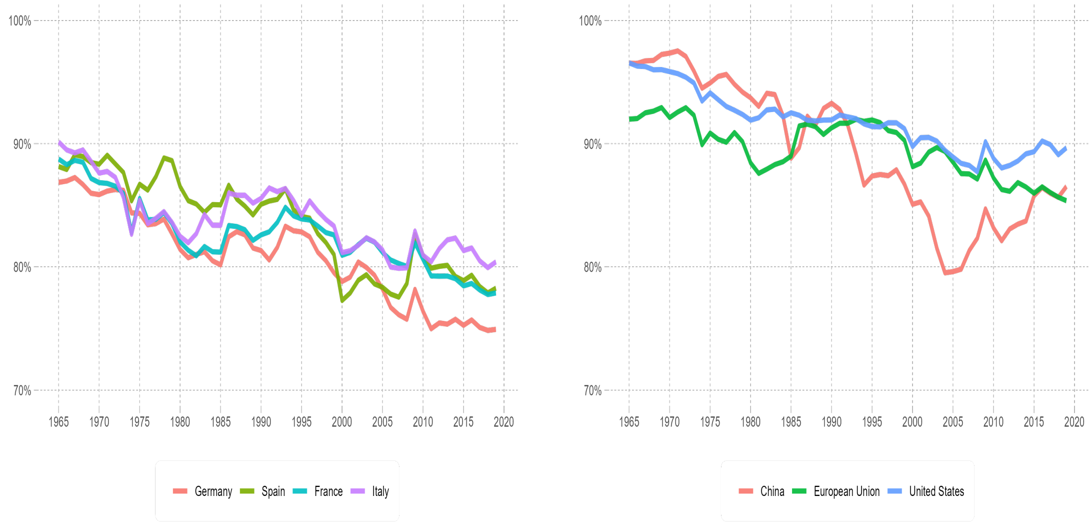
Notes: The 'made in' indicator measures the domestic value added content of final domestic demand. In 2019, the 'made in France' indicator in the manufacturing industry was 38%. Scope: France. Sources: LR-WIOD, WIOD, and FIGARO, authors' calculations.

tion. Across all sectors, the 'made in' indicator was similar in European countries of comparable size in 2019, with 75% in Germany, 78% in Spain, and 80% in Italy (Figure 2). Ireland and the Netherlands, smaller and more deeply integrated into international trade, had lower 'made in' (44% and 63%, respectively). By contrast, the 'made in' indicator was higher for the European Union as a whole (85%), similar to the United States (90%) and China (87%) (Figure 2). The decline in 'made in France' was similar to that of its major European neighbors, irrespective of whether the countries had current account surpluses or deficits or whether they had high or low structural unemployment. This trend reflects the global phenomenon of extended global value chains, especially with China's integration over the past 30 years. In China, the 'made in' indicator has actually increased since 2014, driven by strong domestic demand and growing production capacity following its accession to the World Trade Organization (WTO). The rise in the 'Made in China' indicator is driven by its manufactured goods component. Noticeably, Made in USA for manufactured goods has been broadly stable since 2015, in line with Derrick and Hawk (2024).

The breakdown of the 'made in' indicator by sector varies across countries. In 2019, France's 'made in' indicators for services and agriculture are greater than those of Ger-

FIGURE 2 – Domestic Value Added Content in Final Demand (in %)

(a) European countries | (b) Large economic areas



Notes: The 'made in' indicator measures the domestic value added content of final domestic demand. In 2019, the 'made in' France share across all sectors was 78%.
Sources: LR-WIOD, WIOD, and FIGARO, authors' calculations.

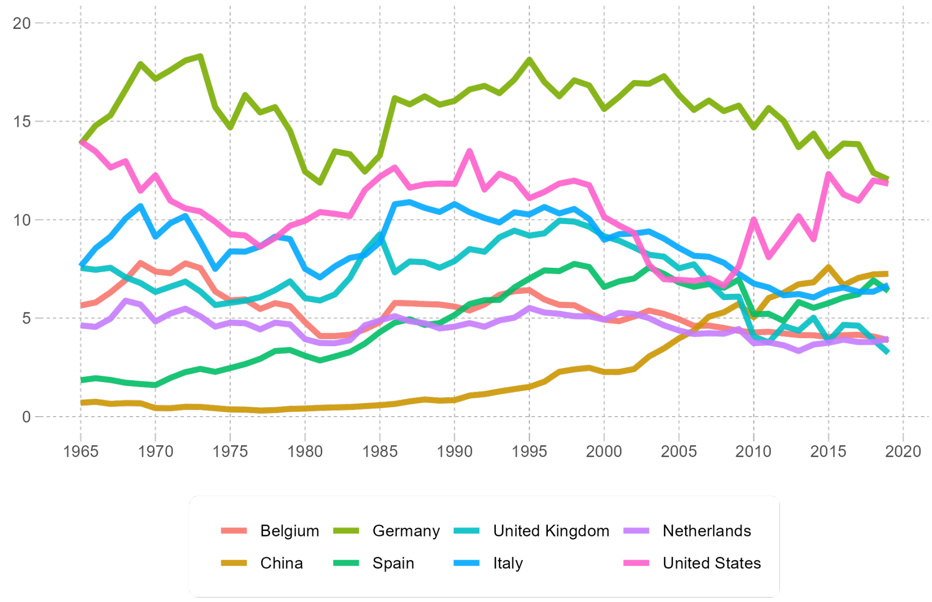
many. On the contrary, France's 'made in' indicator for manufactured goods (38%) was lower than Germany's (52%) and Italy's (51%), and slightly below Spain's (40%). Between 1965 and 2019, the 'made in' indicator for manufactured goods declined by 44 percentage points in France and by 33 points in Germany. For agricultural products, the decline was 20 points in France and 28 points in Germany.

2.4 Made in China Has Replaced Made in Europe in French Consumption

In line with the decline of 'made in France' since 1965, foreign value added constitutes a significant share of French consumption. Between 2000, just before China joined the WTO, and 2019, China's share in the imported content of French final demand (made in China) increased by 5.0 percentage points (Figure 3). Meanwhile, the share of European partners has declined, with particularly sharp drops for the United Kingdom (-5.9 points), Germany (-3.6 points), and Italy (-2.3 points). The share of imports from Spain remained stable (-0.2 points), while that from the United States increased (+1.7 points).

In 2019, the imported content of products consumed in France primarily originated from Germany (12.0%), the United States (11.8%), and to a lesser extent China (7.3%), Italy (6.7%), and Spain (6.4%). Imports from Germany are diverse, whereas some pro-

FIGURE 3 – Structure of Imported Content in Final Domestic Demand in France by Country of Origin (in %)



Note: In 2019, 12% of the imported content of products consumed in France came from Germany.
Sources: LR-WIOD, WIOD, and FIGARO, authors' calculations.

ducts predominantly come from a single country, such as computers from China or automobiles from Spain.

2.5 Nearly 30% of French Exports Consist of Imported Products

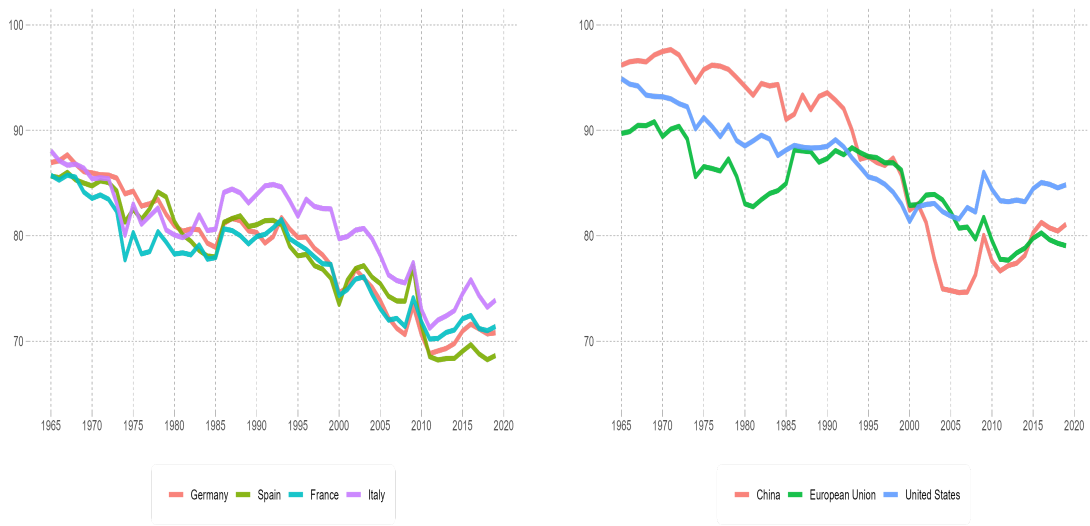
The 'made in' France indicator can be complemented by an indicator of the French value added content in exports, allowing for an assessment of both domestic and foreign uses of the value added produced in France (Johnson and Noguera, 2012). This indicator also provides a more precise measure of the actual component produced in France within French exports, taking into account that exports partially rely on imported inputs for their production. It is calculated based on Foster-McGregor and Stehrer (2013) and provides insight into the degree of integration into global value chains (Hummels et al., 2001).

Since 1965, the domestic value added content of French exports has decreased by nearly 14 percentage points, with a stabilization since 2011 (Figure 4). In 2019, exports contained 71% domestic value added and 29% foreign value added. The share of domestic value added in exports is highest for transport equipment and business services.

FIGURE 4 – Domestic Value Added Content of Exports (in %)

(a) in European countries

(b) in major economies



Notes: In 2019, domestic value added accounted for 71% of French exports.
Sources: LR-WIOD, WIOD, and FIGARO, authors' calculations

The decline in domestic value added content between 1965 and 2011, followed by stabilization, is also observed in Germany, Spain, and Italy, aligning with the slowdown in global value chain integration since 2008. Italy stands out with a higher share of domestic value added content. Among the largest economic regions, the domestic value added content of exports for the entire European Union stands at 79%, compared to 81% for China and 85% for the United States, the latter of which has seen a slight increase in this share since 2000.

3 Vulnerability of the French Economy's Value Chains

3.1 The Manufacturing Industry, More Integrated into Global Value Chains, Is More Exposed to Their Disruptions

The expansion of value chains increases risks related to the control of supply sources for France and its partners. On contrary, international trade also plays a role in lessening volatility by enabling diversification of supply (Caselli et al. (2020)). This diversification can reduce vulnerability to domestic shocks, provided import patterns aren't excessively concentrated. Our focus is however on a specific category of supply-side shocks stemming from disruptions in value chains, such as geopolitical events, climatic incidents, etc. The vulnerability of a given economic sector in this context depends on multiple factors. First, if imports represent a significant share of intermediate consumption, its production is highly exposed to external shocks. Second, if imports are concentrated in a small number of countries and supplying sectors, the sector may struggle to adapt to disruptions affecting one of these countries. This difficulty is exacerbated if other countries in the world import from the same suppliers. Indeed, a low diversification of import origins may reflect a global supply that is concentrated in a few key countries, causing bottlenecks in case of shocks (Berthou et al., 2020).

Bonneau and Nakaa (2020) and Jaravel and Méjean (2021) analyzed the vulnerabilities of the French economy by cross-referencing supplier concentration, geographical origin, and substitutability of goods using detailed Trade data. In total, they identified 121 [4] and 644 [5] imported products vulnerable to supply chain disruptions, depending on the level of data aggregation considered. These vulnerable products are concentrated in China and the United States and in the chemical, agri-food, and metallurgy sectors. Studies conducted at the European level yield similar conclusions, identifying several key sectors such as rare metals, semiconductors, and pharmaceuticals (Vicard and Wibaux, 2023).

We quantify dependencies using a semi-aggregated approach based on a multi-regional input-output table. This approach analyzes the dependence of French final demand on value chains. The data used in this framework allow for an integrated analysis of value chain dependencies, benefiting from the consistency of the input-output framework and a certain homogeneity of data over time and space. As highlighted by Baldwin et al. (2023), this approach accounts for indirect exposure to a shock, even if it does not provide details on risks associated with dependencies on very specific products such as electronic chips, batteries, or critical materials essential for the ecological transition.

To adequately measure the vulnerability of supply chains, it is crucial to assess the exposure to risks upstream in the value chain [6]. The concentration of imported value added content in French final demand is calculated using the Herfindahl-Hirschmann index (Hirschman, 1958):

$$H_j = \sum_{(i \neq j,k)} \left(\frac{C_{VA(i,k),j}}{\sum_{(i' \neq j,k')} C_{VA(i',k'),j}}\right)^2 \tag{3}$$

where $C_{VA(i,k),j}$ represents the value added produced in sector k of country i incor-

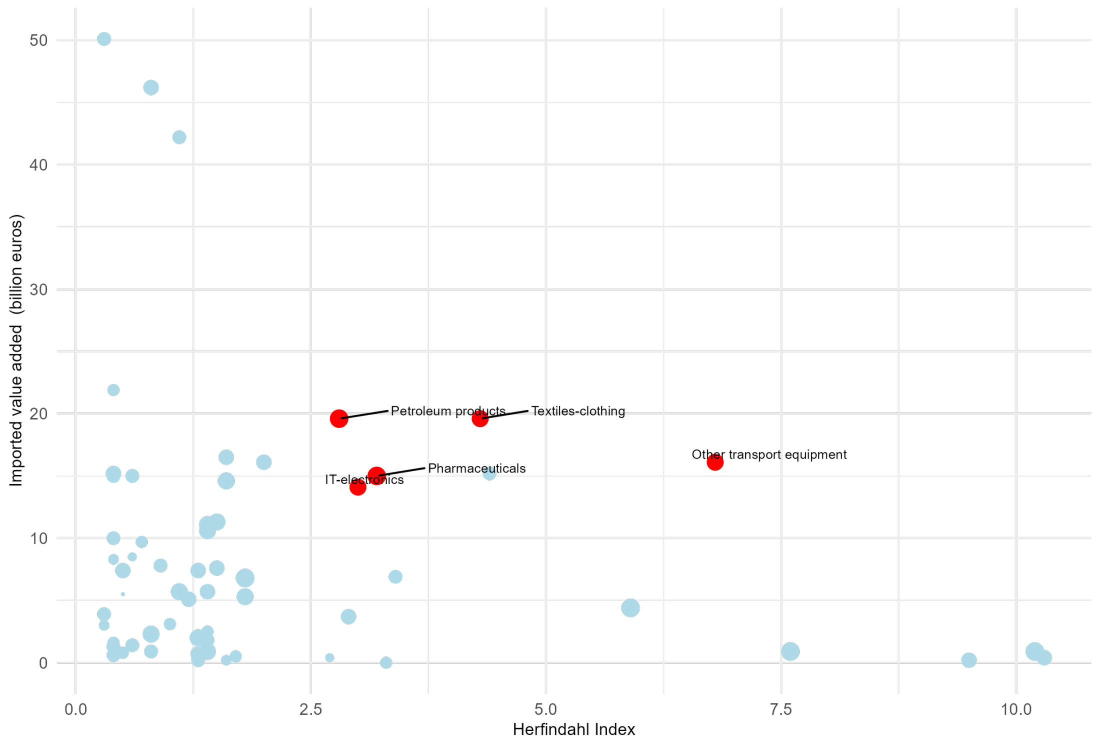
4. Out of 4,927 products (6-digit Combined Nomenclature)
5. Out of 9,334 products (8-digit Combined Nomenclature)
6. The direct exposure to risks, referring to the countries and sectors from which France imports, is analyzed in Appendix A.

porated into the final demand of France (country j). When H_j is close to 0, the imported content of final demand is diversified across many sectors and countries. Conversely, when it is close to 1, it is highly concentrated. The Pearson correlation coefficient between $C_{VA(i,k),j}$ and $C_{VA(i,k),j'}$ indicates how similar the imported content structures of final demand are between two countries j and j'. If this coefficient is close to 1, supplier structures are similar, leading to a form of common dependency that increases vulnerability. Since this indicator describes the concentration of imported content in French final demand (rather than in French intermediate consumption), it provides more insight into demand-side vulnerabilities (at the household consumption level) than supply-side vulnerabilities (business inputs).

Additionally, we examine the correlation between France's sourcing structure and that of the rest of the world to assess whether this concentration is specific to France or shared globally. This indicator is represented by the size of the points in Figure 5, which is close to 1 for most sectors of the French economy. Some sectors emerge as particularly vulnerable, meeting three criteria: a high share of imported content in French final demand; a structure of imported content showing greater than average concentration of imported value added (measured by the Herfindahl index); and a French import structure similar to that of other countries, indicating a globally concentrated supply that may hinder diversification.

The sectors meeting all three criteria that can be considered particularly vulnerable to external shocks include transportation equipment manufacturing (excluding automobiles), textile and apparel manufacturing, refined petroleum products, pharmaceuticals, and information technology and electronics. To a lesser extent, the final demand for agricultural products appears somewhat concentrated, but its low correlation with other countries' import structures suggests that this may be due to geographic proximity constraints, such as food preservation requirements. Services incorporate few imports and therefore do not present significant vulnerabilities (product groups located at the bottom right of Figure 5).

FIGURE 5 – Imported Value Added Content in French Final Demand and Market Concentration by Sector, France, 2019



Notes: The size of the points represents the correlation between the structure of imported content in France and in the Rest of the world. This correlation is close to 1 for most sectors of the French economy. The market concentration is the Herfindahl index of product suppliers. The final demand of the French economy contains 16.1 billion euros of imported products from the 'other transport equipment manufacturing' sector with a Herfindahl index of 6.8. Moreover, the country-product structure of origin for this sector is highly correlated with that of other countries (0.9). Scope: France.
Source: Eurostat, FIGARO 2022, authors' calculations.

3.2 What Strategies Can Reduce the Risks Associated with Value Chain Vulnerabilities?

The participation in global value chains allows businesses to benefit from productivity gains. However, it has also increased their exposure to risks related to geopolitics, climate, or supply shocks, among others. Several risk mitigation strategies are already implemented by businesses and states, or have been strengthened recently.

Governments adopted de-risking strategies in designing new industrial policies aimed at enhancing public sector efficiency, particularly in fostering emerging technologies and industries (Juhász et al. (2023)). A notable example is China's 'Made in China 2025' initiative, launched in 2015, which sets specific domestic production targets for essential components and materials to reduce reliance on foreign technologies. This plan prioritizes ten sectors, including information technology, advanced robotics, new energy vehicles, and new materials. Similarly, in 2022, the United States enacted the Inflation Reduction Act (IRA), implementing substantial industrial support measures with local content requirements. These strategies can be categorized into four groups:

— The creation of strategic reserves helps to cope with short-term supply disruptions. This strategy has long been implemented governments, organizations, or businesses for low-value added strategic products such as petroleum or minerals. At the business level, Lafrogne-Joussier et al. (2023) show that during the COVID-19 crisis in France, the use of inventories helped manufacturing companies mitigate input shortages, while geographic diversification of suppliers had less impact.

— Diversification of supply sources reduces dependence on a single supplier. This strategy is more effective in the long term, as it requires investment in finding new suppliers and establishing durable relationships. Empirically, Martin et al. (2023) introduce a new measure of trade relationship rigidity, which quantifies these vulnerabilities for 5,000 product categories. Markets with higher 'trade rigidities' are more sensitive and experience stronger negative effects from uncertainty shocks.

— Restrictions on sourcing require companies to use products or services from partner countries.

— Incentives aimed at influencing the location choices of national or international businesses to reshore part of production within the national territory. These incentives are most commonly provided through subsidies (Evenett et al., 2024) or regulatory measures (e.g., provision of industrial sites). The simulations in the next section specifically examine the expected outcomes of such strategies, depending on the targeted economic sectors.

4 The Effects of Setting up a New Plant in France Compared to Abroad

This section presents the simulated effects of setting up a new plant in France compared to abroad on economic variables and emissions, taking into account interactions related to value chains.

4.1 Counterfactuals for Setting up a New Plant in France

The simulations allow for a comparison the effect of substituting part of the imports of goods with domestic production, with unchanged total demand. Under the assumption of linearity of effects, they are equivalent to comparing a situation where a new plant is established in France with a situation where the new plant is established abroad. These simulations do not explicitly model the instruments that would achieve this objective of substituting part of the imports with domestic production but highlight the spillover effects linked to the intertwining of value chains as traced in multi-regional input-output tables. This accounting exercise highlights the mechanisms at play and provides orders of magnitude for the effects on emissions and employment.

These simulations are based on several assumptions. The activity substituted for imports is assumed to be produced under the same conditions as domestic production: producing an additional euro of a good in a given country mobilizes the same intermediate consumption, the same employment, and generates as many emissions as the current production of one euro of the same good in that country. It is also assumed that the good whose production is localized in France rather than imported is perfectly substitutable for a good produced elsewhere. The final demands for this good regardless of the country of production are unchanged by the location choice: the same quantity of the good is consumed whether it is produced in France or elsewhere. Similarly, in relative terms, the use of this good is not modified: the distribution of the good produced in France between what is consumed in France and what is exported, and between what is used for final demand and for intermediate consumption, is fixed. In the main scenario, we compare the overall economic activity that would result from establishing an activity in France with the current situation where the production of the same good takes place in all the importing countries of that good.

For example, in 2019, more than half of this production was consumed in France: 25% of the production was consumed in the final demand for this good, and 31% was used as intermediate consumption (to produce other goods in other sectors). The rest was exported: 24% as intermediate consumption for the production of other countries, and 20% consumed in the final demand in these countries. The simulation of a counterfactual maintains this distribution: if France can produce an additional 100 € of an industrial good that was previously produced in the rest of the world, then 25 € of this additional production will be consumed in France (in substitution for 25 € that were previously imported), 20 € will serve the final demand of other countries, 31 € will be used as intermediate consumption to produce other goods in France, and 24 € will be exported to produce other goods abroad. These effects will, of course, have mirror effects in the other countries where this good was initially produced, which would export less goods and import more from France.

However, these initial effects tell only part of the story: producing more in France requires using more inputs (for example, additional battery production on national territory requires consuming more energy, using more electronic components, transport services, etc.). The additional domestic industrial production therefore has cascading effects by stimulating the production of goods used as intermediate consumption. Assuming that the production processes are not modified, if the production of 1 € of the good whose production is localized in France rather than abroad requires using 0.45 € of other industrial goods (of which 0.27 € is produced in France, and 0.18 € in other countries), and 0.60 € of goods from other sectors (of which 0.51 € is produced locally and 0.09 € is imported), localizing 100 € of activity in France rather than abroad would result in an additional increase of 27 € in domestic industrial production and 51 € in production in other sectors. These second-round effects also impact the production of other countries: on the one hand, they produce less locally and therefore use fewer inputs including possibly from France but on the other hand, these effects can be partly offset if they lead to the generation of more inputs used for French production.

We conduct simulations inspired by Dietzenbacher and Lahr (2013) and Dietzenbacher et al. (2019), which consider 'extracting' intermediate consumption or final demand from an economy in a globalized context. The accounting framework of the economy generalizes a Leontief economy to multiple countries (Appendix B).

4.2 Construction of the Counterfactual within the Multi-Regional Input-Output Table

Let P be the vector of global production by sector, D_j the vector of final demand of country j in each of the sectors of each country (including household consumption, business investment, or changes in inventories), and M the matrix of intermediate consumption ($M_{(i,k),(j,l)}$ indicates how much sector l of country j uses as intermediate consumption in product k of country i, ordered by country and then by sector within each country), the resources-uses balance within the global economy for the production of sector k of country i is: $P_{(i,k)} = \sum_{(j,l)} M_{(i,k),(j,l)} + \sum_{(j)} D_{(i,k),j}$.

The matrix of technical coefficients $A_{(i,k),(j,l)}$ indicates the consumption of a sector in intermediate products. Each term corresponds to the ratio of intermediate consumption $M_{(i,k),(j,l)}$ to the production $P_{(j,l)}$ of sector l of country j. The coefficient $A_{(i,k),(j,l)}$ corresponds to the quantity of goods from sector k produced in country i required to produce one unit of goods l in country j.

The previous relationship is rewritten as: $P_{(i,k)} = \sum_{(j,l)} A_{(i,k),(j,l)} * P_{(k)} + \sum_{(j)} D_{(i,k),j}$. Letting P be the column vector of national productions $P_{(i,k)}$, A the matrix of $A_{(i,k),(j,l}$, and D_j the column vector of final demands of country j, this is written as: $P = A * P + \sum_{(j)} D_j$.

The accounting relationship between production and final demand involves these technical coefficients: $P = L * \sum_j Dj$ with L the Leontief matrix defined by $L = (I - A)^{-1}$.

In practice, the estimates simulate an ex-ante increase in value added of 1 billion € for a given sector: formally, for a sector k_0, if the initial production of France (indexed by i_0) was $P(i_0, k_0)$, corresponding to an initial value added of

$$VA_{(i_0,k_0)} = \left(1 - \sum_{(i,k)} A_{(i,k),(i_0,k_0)}\right) P_{(i_0,k_0)} \tag{4}$$

this means that the production is increased by $\alpha = 100/VA_{(i_0,k_0)}\%$.

Locating the production of goods in France rather than importing them results in an increase of $\alpha\%$ in the technical coefficients (domestic and exported) of the row indexed by (i_0, k_0) of the MRIO and of the row indexed by (i_0,k_0) of the final demand of each country (i.e., the consumption in goods of sector k_0 that are produced in country i_0). And then, by a decrease in the technical coefficients and final demand in the rows k_0 corresponding to imports from all other countries in the world from all other countries in the world (except France).

Consider an operator R that modifies the structure of the matrix of technical coefficients A and final demand by country. R thus transforms the matrix A into $B = R(A, i_0, k_0, \alpha)$:

$$\begin{aligned}
B_{(i,k),(j,l)} &= A_{(i,k),(j,l)}(1+\alpha) \quad \text{if } k = k_0 \text{ and } i = i_0 \\
B_{(i,k),(j,l)} &= A_{(i,k),(j,l)} \quad \text{if } k = k_0 \text{ and } i \neq i_0 \text{ and } i = j \\
B_{(i,k),(j,l)} &= A_{(i,k),(j,l)} \frac{1 + \alpha A_{(i_0,k_0),(j,l)}}{\sum_{i \neq i_0, i=j} A_{(i,k_0),(j,l)}} \quad \text{if } k = k_0 \text{ and } i \neq i_0 \text{ and } i \neq j \\
B_{(i,k),(j,l)} &= A_{(i,k),(j,l)} \quad \text{if } k \neq k_0
\end{aligned}$$

where the sector whose activity is localized in France rather than abroad is k_0 in country i_0. R transforms final demand in the same way, with sector l playing no role since there are only three dimensions (i, k, j).

The production of each of the sectors of the global economy adjusts to this demand and to this structure of intermediate consumption:

$$P(i_0, k_0, \alpha) = (I - R(A, i_0, k_0, \alpha))^{-1} * R(D, i_0, k_0, \alpha) \tag{5}$$

The total final demand for each product in each country is unchanged, so global

GDP, which is also equal to total global final demand, is unchanged.

The change in GDP of country j is given by the change in the sum of the value added of the sectors:

$$\sum_l \left(P(i_0,k_0,\alpha)_{(j,l)} - \sum_{(i,k)} R(A,i_0,k_0,\alpha)_{(i,k),(j,l)} P(i_0,k_0,\alpha)_{(j,l)} \right.$$
$$\left. - \left(P_{(j,l)} - \sum_{(i,k)} A_{(i,k),(j,l)} P_{(j,l)} \right) \right)$$

For each simulation, a production multiplier is calculated by relating the ex-post evolution of French production to the ex-ante evolution of production, i.e.:

$$\frac{\sum_l (P(i_0,k_0,\alpha)_{(j,l)} - P_{(j,l)})}{\alpha P(i_0,k_0)}$$

Let $w_{(j,l)}$ be the employment content of the production of sector l of country j, i.e., the number of jobs in this sector divided by the production of this sector, the evolution of employment in country j is given by:

$$\sum_l w_{(j,l)} * (P(i_0,k_0,\alpha)_{(j,l)} - P_{(j,l)}) \tag{6}$$

Employment contents are not directly calculable, as employment data are not available for some countries. Employment intensity coefficients of value added by sector (employment/VA) are calculated from FIGARO and full-time equivalent employment data from Eurostat for France, then applied to the developments of value added by sector.

Similarly, global greenhouse gas emissions (excluding direct emissions from households) are obtained using the vector of GHG content of sector l of country j:

$$\sum_l e_{(j,l)} * (P(i_0,k_0,\alpha)_{(j,l)} - P_{(j,l)}) \tag{7}$$

This exercise seeks to highlight the mechanisms underlying the complexity of value chains but does not capture all their effects. We are not interested in the precise conditions that would allow observing such a location arbitrage of activity, and it is assumed that there are no supply constraints or bottlenecks in the other sectors following a change in demand. The initial investment and its possible spillover effects related to the setting up a new plant is not taken into account. Capital flows, for a French firm setting up abroad and outgoing for a foreign plant setting up in France, are not modeled: the described effect on the trade balance may be more or less reflected in the current account depending on the nationality of the company concerned. The modeling neglects macroeconomic feedback effects through prices or income, which could partly counteract or, conversely, amplify some of the effects. This modeling does not provide information on the effects on the fiscal stance or well-being.

4.3 More Activity and Employment Induced by Locating Activity in the Manufacturing Industry

According to the simulations, if a manufacturing plant producing 1 billion € of value added were established in France rather than abroad, the value added in France would increase by 2.0 billion € in total, with a spillover effect on the supply chains of this plant amounting to 1.0 billion €. The value added multiplier, i.e., the total increase in value added relative to the increase in value added of the additional plant, is therefore equal to 2.0 in the manufacturing industry (table 1). Within the manufacturing industry, this value added multiplier is particularly high when the plant's activity is in the agri-food industry and the automotive industry (2.6), as well as in the wood and paper industry (2.2). The spillover effect on the rest of the economy is lower with a new plant in construction (value added multiplier equal to 1.9), agriculture (1.7), and market services (1.6).

TABLE 1 – Effects on value added, production, and made in of establishing activity in France rather than abroad

Sector	Share in market value added (in %)	Effect on value added (in billion €)	Total effect on production (in billion €)	Direct effects (in billion €)	Indirect effects (in billion €)	Production multiplier (unitless)	Effects on made in (in percentage points)
Agriculture	2.4	1.7	3.8	2.2	1.6	1.7	0.057
Manufacturing branches:	14.3	2	5.5	3.2	2.3	1.7	0.039
- Agri-food	2.7	2.6	7	3.5	3.5	2	0.082
- Extractive industries	0.1	3.3	19.1	14.1	5	1.4	0.083
- Capital goods	1.9	1.7	4.3	2.7	1.6	1.6	0.013
including IT products	0.8	1.5	3.1	2.1	1	1.5	0.008
including Electrical equipment	0.4	1.8	4.6	2.9	1.7	1.6	0.015
including Machinery and equipment	0.7	2	5.4	3.2	2.2	1.7	0.017
- Transport equipment	2.1	2.2	6.9	4.2	2.7	1.6	0.021
including Automobiles	0.8	2.6	8.5	4.9	3.6	1.7	0.035
including Other transport equipment	1.3	1.9	5.8	3.8	2	1.5	0.008
- Other manufacturing industries	7.5	1.8	4.6	2.8	1.8	1.6	0.041
including Textiles	0.3	1.9	4.9	3	1.9	1.6	0.030
including Woodworking	0.7	2.2	5.8	3.2	2.6	1.8	0.061
including Chemical products	1.3	1.8	4.7	2.9	1.8	1.6	0.016
including Pharmaceutical products	0.8	1.5	3.1	2.1	1	1.5	0.010
including Metal products	1.2	1.8	4.4	2.6	1.8	1.7	0.044
including Others	1.8	1.7	3.9	2.4	1.5	1.6	0.039
Electricity/Gas	3.3	2.1	5.9	3	2.9	2	0.066
Construction	7.2	1.9	4.5	2.5	2	1.8	0.083
Market services:	72.9	1.6	2.9	1.8	1.1	1.6	0.053
- Trade	13	1.7	3.4	2	1.4	1.7	0.053
- Information and communication	6.9	1.6	3	1.9	1.1	1.6	0.057
- Scientific activities	17.9	1.7	3.2	1.9	1.3	1.7	0.052
Entire market economy	100	1.7	3.5	2.1	1.4	1.7	0.050

Notes: Each row indicates the effect of establishing activity in the relevant sector in France rather than abroad, corresponding to 1 billion € of value added. Due to rounding, the sum of the parts may not perfectly match the whole. The impact on value added can also be interpreted as a value added multiplier, mirroring its effect on the trade balance. Establishing a new plant, corresponding to 1 billion € of value added, in the automotive sector in France rather than abroad, would induce 2.6 billion € of value added in total in the French economy. Automotive production would increase by 8.5 billion €, of which 4.9 billion € in the new plant and 3.6 billion € in the rest of the economy, resulting in a production multiplier of 1.7. The 'made in France' indicator would increase by 0.035 percentage points.
Scope: France. Source: Eurostat, FIGARO 2022, authors' calculations

The amount of production required for a plant to create 1 billion € of value added is more or less high depending on the importance of intermediate consumption in the production process: in the automotive industry, for example, a new plant must ensure production of 4.9 billion € to generate a value added of 1 billion €, because inputs represent a particularly high share of production. In the coke and oil refining sector, characterized by a very high share of intermediate consumption in production, the required production is even higher. In market services, which use relatively few inputs, the production of the plant for 1 billion € of value added is 1.9 billion €.

This production has spillover effects: the purchases of inputs by the initial plant generate additional production for these suppliers, this production itself mobilizes intermediate consumption, and so on. The entire supply chain, both French and foreign, faces additional demand and therefore increases its production accordingly. And the more the initial plant uses inputs, the more production increases throughout this supply chain. If a plant is established abroad rather than in France, these spillover effects also exist, but they can be expected to be of lesser magnitude in France. The total effect on production cumulates both direct effects and these spillover effects. Comparing the cases of setting up in France rather than abroad requires measuring the spillover effects of establishment in France, net of those of setting up abroad. Depending on the sector in which the new plant is located, production increases in total by 8.5 billion € (automotive industry), 7.0 billion € (agri-food industry), or 2.9 billion € (market services). As more intermediate consumption, both direct and indirect, comes more from France in the agri-food industry than in the automotive industry, the 'made in France' indicator would increase more significantly there.

The effect on employment in France depends not only on the spillover effects but also on the employment intensity of the sectors whose activity is affected. The location in France rather than abroad of manufacturing activity generating directly 1 billion € of value added would create 24,400 jobs in total (table 2). Within the manufacturing sectors, locating of activity in France in the agri-food industry, the wood industry, the automotive industry, and the textile-clothing industry would increase employment the most. Job creation outside the initial plant would be particularly marked in the agri-food industry and the automotive industry; if total job creation is related to employment in the initial plant, these employment multipliers would be very high (2.9 and 3.8).

TABLE 2 – Effects on employment of establishing activity in France rather than abroad (in thousands of persons)

Sector	Share in market value added (in %)	Total effect on employment	Direct effects	Indirect effects	Of which indirect effects on the same sector	Of which indirect effects on other sectors	Employment multiplier (unitless)
Agriculture	2.4	33.9	23.4	10.5	4.7	5.8	1.4
Manufacturing branches:	14.3	24.4	10.5	13.9	0.9	13	2.3
- Agri-food	2.7	37.4	12.8	24.6	1.8	22.8	2.9
- Extractive industries	0.1	31	5	26	0	26	6.2
- Capital goods	1.9	19.4	9.5	9.9	0.2	9.7	2
including IT products	0.8	12.6	6.5	6.1	0.1	6	1.9
including Electrical equipment	0.4	21.7	11.1	10.6	0.2	10.4	2
including Machinery and equipment	0.7	25.4	11.9	13.5	0.2	13.3	2.1
- Transport equipment	2.1	20.8	5.6	15.2	0.2	15	3.7
including Automobiles	0.8	29.5	7.7	21.8	0.3	21.5	3.8
including Other transport equipment	1.3	15.3	4.2	11.1	0.3	10.8	3.6
- Other manufacturing industries	7.5	21.8	11.3	10.5	1	9.5	1.9
including Textiles	0.3	29.6	17.3	12.3	1.4	10.9	1.7
including Woodworking	0.7	30	15.5	14.5	1.3	13.2	1.9
including Chemical products	1.3	14.5	5.5	9	0.3	8.7	2.6
including Pharmaceutical products	0.8	9.8	3.8	6	0	6	2.6
including Metal products	1.2	25.6	15.1	10.5	2.1	8.4	1.7
including Others	1.8	21	12.3	8.7	1.1	7.6	1.7
Electricity/Gas	3.3	14.4	4.5	9.9	2	7.9	3.2
Construction	7.2	27	14.4	12.6	3	9.6	1.9
Market services	72.9	18.2	11.7	6.5	1	5.5	1.6
- Trade	13	25	17	8	0.4	7.6	1.5
- Information and communication	6.9	13.9	7.7	6.2	0.8	5.4	1.8
- Scientific activities	17.9	21.7	14.1	7.6	1.8	5.8	1.5
Entire market economy	100	19.9	11.8	8.1	1.1	7	1.7

Note: Each row indicates the effect of establishing activity in the relevant sector in France rather than abroad, corresponding to 1 billion € of value added. Due to rounding, the sum of the parts may not perfectly match the whole. Establishing a plant, corresponding to 1 billion € of value added, in the automotive sector in France rather than abroad would create 29,500 jobs, of which 7,700 in the new plant and 21,800 in the rest of the economy, resulting in an employment multiplier of 3.8. Scope: France. Source: Eurostat, FIGARO 2022, authors' calculations

An increase in activity in France rather than abroad would also have a positive effect on the French trade balance: the increase in production of a sector of the economy in France would be partly exported, would also allow for a reduction in the imports of goods produced abroad. The demand for French products in the different countries of the world would increase at the expense of similar foreign products. These evolutions therefore have repercussions on the entire global production network: the additional production in France requires additional inputs, mainly from France but also from abroad. Depending on the positioning of countries in the value chains, these different mechanisms are more or less strong. On average, for an activity of 1 billion € in the manufacturing branches located in France rather than with our trading partners, value added would decrease in most countries (by 275 million € (M€) in Germany, 130 M€ in Italy, and 100 M€ in Spain).

4.4 Locating Activity in France Reduces Global CO_2 Emissions

GHG emissions can be measured according to two approaches. First, on a production basis by measuring the emissions that physically occur on national territories. This method, known as the national inventory, is used in countries' international commitments. The second approach, known as the carbon footprint, measures the emissions associated with the consumption of products by the residents of a country, regardless where those products are produced(Wiedmann and Minx, 2008).

It is possible to reconcile the national inventory to the carbon footprint (9.2 tCO_2eq in 2019) by subtracting from the inventory (6.9 tCO_2eq) the GHGs emitted on the territory for exported products (2.5 tCO_2eq) and adding the GHGs emitted abroad for imported products (4.8 tCO_2eq).

France is characterized by an energy mix and production that is less carbon-intensive than its main economic partners (Bourgeois et al. (2023)). Consequently, if a plant is established in France rather than abroad, a larger share of global GDP is then produced in France, and global greenhouse gas (GHG) emissions are lower. This decrease in global GHG emissions, which is visible regardless of the sector of activity of the economy, is estimated at 0.7 $MtCO_2$ for a new manufacturing plant generating 1 billion € of value added (table 3). In this example, emissions in France increase by 0.5 $MtCO_2$ but decrease by 1.2 $MtCO_2$ in the rest of the world. The French footprint decreases by 0.3 $MtCO_2$. On a larger scale, and under the conditions of this exercise, if manufacturing activity were increased in France by 1 percentage point of GDP in substitution for production elsewhere, global emissions would decrease by 15 $MtCO_2$ (they would decrease by approximately 35 $MtCO_2$ elsewhere) and the carbon footprint of France would decrease by approximately 8 $MtCO_2$.

TABLE 3 – Effects on CO_2 emissions of establishing activity in France rather than abroad (in $ktCO_2$)

Sector	Effects on emissions in the world	Effects on emissions in France	Direct effects	Indirect effects	Emissions multiplier	Effects in other countries	Effects on the carbon footprint of France
Agriculture	-557	482	335	147	1.4	-1039	-354
Manufacturing branches:	-742	533	342	191	1.6	-1275	-291
- Agri-food	-501	467	174	293	2.7	-968	-344
- Extractive industries	-855	5460	5031	429	1.1	-6315	-591
- Capital goods	-723	151	35	116	4.3	-874	-102
including IT products	-485	83	17	66	4.9	-568	-55
including Electrical equipment	-1121	173	47	126	3.7	-1294	-196
including Machinery and equipment	-749	213	47	166	4.5	-962	-98
- Transport equipment	-660	185	31	154	6	-845	-89
including Automobiles	-569	329	60	269	5.5	-898	-174
including Other transport equipment	-719	93	13	80	7.2	-812	-34
- Other manufacturing industries	-853	651	474	177	1.4	-1504	-368
including Textiles	-772	226	115	111	2	-998	-277
including Woodworking	-528	452	258	194	1.8	-980	-301
including Chemical products	-817	983	777	206	1.3	-1800	-125
including Pharmaceutical products	-75	130	61	69	2.1	-205	-5
including Metal products	-764	204	48	156	4.2	-968	-393
including Others	-433	116	22	94	5.3	-549	-245
Electricity/Gas	-4844	1065	640	425	1.7	-5909	-3886
Construction	-450	239	68	171	3.5	-689	-442
Market services	-197	101	54	47	1.9	-298	-139
- Trade	-121	107	41	66	2.6	-228	-83
- Information and communication	-73	56	9	47	6.2	-129	-55
- Scientific activities	-101	72	29	43	2.5	-173	-77
Entire market economy	-453	213	122	91	1.7	-666	-309

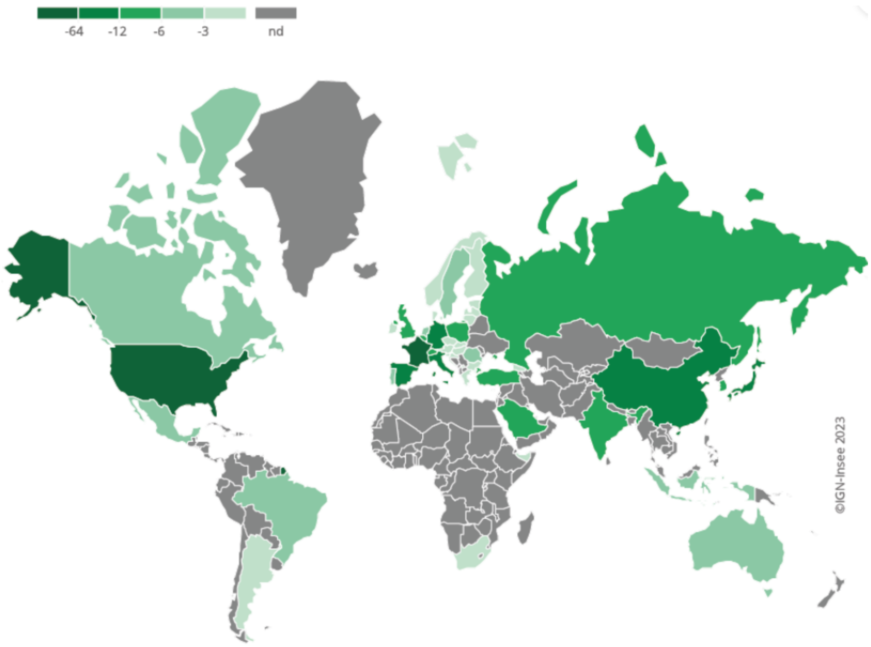
Note: Each row indicates the effect of establishing activity in the relevant sector in France rather than abroad, corresponding to 1 billion € of value added. Due to rounding, the sum of the parts may not perfectly match the whole. Establishing a plant, corresponding to 1 billion € of value added, in the automotive sector in France rather than abroad would increase CO_2 emissions by 330 $ktCO_2$ in France but avoid 900 $ktCO_2$ in other countries, resulting in a net effect on global CO_2 emissions of -570 $ktCO_2$. In this scenario, the CO_2 footprint of France would decrease by 170 $ktCO_2$. Scope: France. Source: Eurostat, FIGARO 2022, authors' calculations

This decrease in global emissions is all the more pronounced where activity increases in France in sectors in which the GHG emission intensity is significantly lower in France than in the rest of the world. For example, both the electrical equipment and chemical products sectors are carbon-intensive in the rest of the world: establishing these activities in France rather than abroad avoids 1,290 and 1,800 ktCO_2 respectively. Meanwhile, the production of electrical equipment is much less carbon-intensive in France than abroad, so emissions increase by only 170 ktCO_2 in France for a plant in this sector, i.e., 13% of the decrease in emissions observed abroad. This is less true for the chemical products sector, for which the increase in national territory is 980 ktCO_2, i.e., 54% of the decrease abroad.

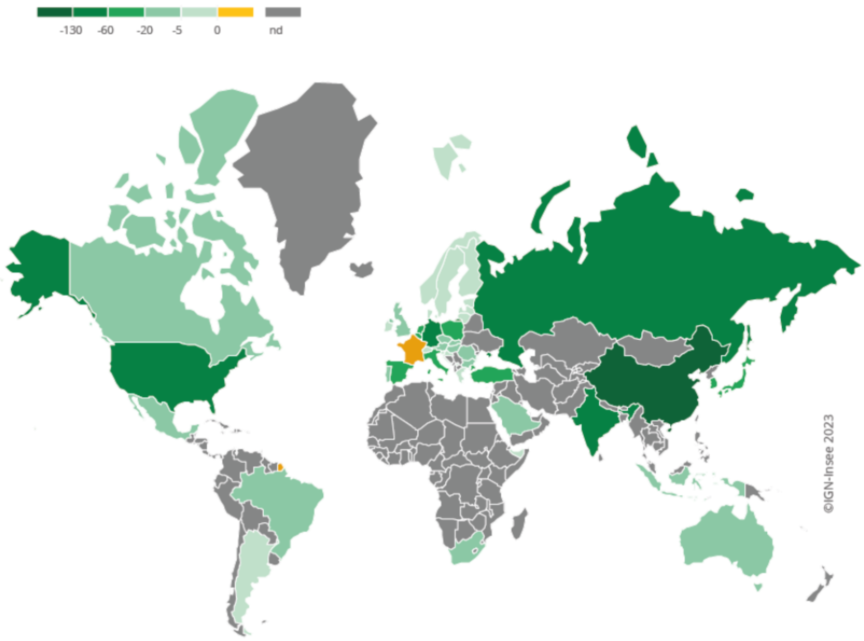
Depending on the emissions generated by setting up of a new plant in France and whether its supply chain involves more or less carbon-intensive sectors, the emissions multiplier will be more or less high. With a plant in the manufacturing sectors, French GHG emissions would thus increase in total by 1.6 times more than the emissions generated by the plant, compared to 1.9 times more in market services and 3.4 times more in construction. However, if the new plant uses less carbon-intensive technologies than an average plant currently producing in the same sector, emissions would increase less. The increase in emissions would then be all the more attenuated than a plant abroad, as production there is more carbon-intensive. This primarily concerns the emissions associated with the plant, as the decarbonization of the entire supply chain of existing suppliers may take time.

The change in the global production structure thus modifies the distribution of GHG emissions. Since it increases French production, locating activity in France rather than abroad increases GHG emissions on French territory, which slows down the achievement of national GHG emission reduction targets, which are based on national inventories. Conversely, production emissions, and thus the national inventory, decrease in most other countries, facilitating the achievement of their national targets. With the location of manufacturing activity in France rather than abroad, the decrease in emissions would be particularly marked in China (-280 ktCO_2), Germany (-80 ktCO_2), Russia, the United States, and India (-70 ktCO_2). As relatively less carbon-intensive French products would then represent a larger share of the consumption of these other countries, the carbon footprint would decrease in all countries (figure 6).

FIGURE 6 – (a) Effects of establishing manufacturing activity in France rather than abroad on the carbon footprint by country, $ktCO_2$ in 2019



(b) Effects of establishing manufacturing activity in France rather than abroad on emissions by country, $ktCO_2$ in 2019



Note: The countries in the 'Rest of the world' zone are not detailed in the FIGARO database of Eurostat. These countries are represented in gray on the map. Establishing manufacturing activity, corresponding to 1 billion € of value added, in France rather than abroad, would reduce the carbon footprint mainly in France (-291 $ktCO_2$), but also in the United States (-84 $ktCO_2$), Germany (-42 $ktCO_2$), and China (-38 $ktCO_2$).
Source: Eurostat, FIGARO 2022, authors' calculations.

Conclusion

The 'made in' France indicator has been declining since 1965, notably due to increasing demand for Chinese products from French consumers over the past two decades. This trend is not unique to France; it is also observed in other major European economies. The vulnerability of supply chains in the manufacturing industry is increasing in a context marked by rising geopolitical and trade tensions.

This study highlights the cascade effects linked to the localization of activities in France rather than abroad, resulting from a greater attractiveness:

— Spillover effects on other sectors of the economy, leading to job creation.

— A reduction in global CO_2 emissions, as a larger share of global production is then produced in France, with a less carbon-intensive energy mix.

— A reduction in vulnerability risk, leading to increased industrial resilience.

The choice of which sector to target with an attractiveness policy depends on the priorities assigned to each objective. If the primary objective is to stimulate economic activity, sectors with high job creation potential, such as automotive or aerospace industries, are the most relevant. If the primary objective is to reduce economic vulnerability, strategic sectors, such as defense or health, are the most critical. If the primary objective is to reduce CO_2 emissions, energy-intensive sectors, such as metallurgy or chemicals, are the most promising. Depending on the objectives pursued, the priority targets are not the same, as no sector has a clear advantage across all dimensions.

The effect of choosing to locate in France rather than abroad in the automotive industry generates spillover effects in the industry and more broadly on the French economy. However, this also results in spillover effects on other countries, due to the intertwining of value chains, such as the reduction in carbon emissions from German metallurgy supplying the French automotive sector, or the decrease in value added from trade between Germany and Spain.

This exercise aims to highlight the mechanisms related to the complexity of value chains but does not allow all the effects to be traced. It relies on several assumptions, notably the stability of production methods and the perfect substitutability of a good produced in France with a good produced elsewhere. Moreover, the modeling does not establish the conditions that would allow for such substitution. The choice of location in one country over another is linked to a business decision, which is not modeled here and depends on both institutional and economic contexts. Furthermore, the simulations ignore the possibility of supply constraints or bottlenecks in other sectors following a change in demand. The initial investment (and its potential spillover effects) related to the establishment of a new plant is not considered. Capital flows, incoming for a French plant establishing abroad and outgoing for a foreign plant establishing in France, are not modeled: the described effect on the trade balance may be more or less reflected in the current account depending on the nationality of the company concerned. The modeling corresponds to a general equilibrium (of the Walrasian type) but neglects macroeconomic feedback effects through prices or income, which could partly counteract or, conversely, amplify some of the effects. This modeling does not provide information on the effects on the fiscal stance or well-being from these changes in production location.

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Online Appendix

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A Direct Measurement of Vulnerability

The vulnerability measure presented in Section 2 is based on the imported content of final demand. However, the direct approach commonly used in the literature describes the concentration of imported intermediate consumption, which provides more insight into supply-side vulnerability than demand-side vulnerability. Jaravel and Méjean (2021) rely on a Herfindahl index of intermediate consumption imports, using detailed customs data. Similarly, Arjona et al. (2023) propose a vulnerability indicator for European Union.

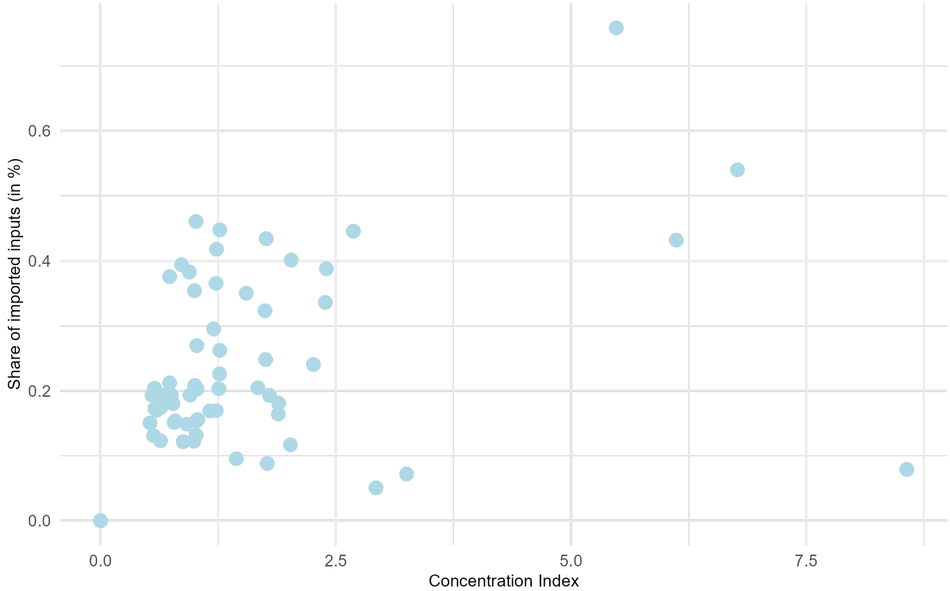
We reproduce this vulnerability calculation for robustness using a MRIO. We measure the concentration of imported inputs based on the intersection of the sector and the country of origin. In the FIGARO database, we have a breakdown by country of origin for each of the 64 sectors of the economy. We can thus determine the Herfindahl index based on the origin structure of imports for each sector:

$$H_j = \sum_{(i \neq j,k)} \left(\frac{M_{(i,k),j}}{\sum_{(i' \neq j,k')} M_{(i',k'),j}} \right)^2 \tag{8}$$

where $M_{(i,k),j}$ is the intermediate consumption of the French sector j in product k from country i. When H_j is close to 0, the intermediate consumption of sector j is diversified across many sectors and countries. Conversely, when it is close to 1, it is highly concentrated.

In France, inputs are most concentrated in industrial sectors (Figure A). The oil refining, textile-clothing, and other transport equipment sectors import a large share of their inputs, and these imported inputs are more concentrated than those of other sectors. The financial services sector appears highly concentrated in terms of input origin, but the share of its imported inputs is low.

Figure A – Share of imported inputs in inputs and concentration index, in France, in 2019



Source: Eurostat, FIGARO 2022, authors' calculations

We calculate the Herfindahl index at the sectoral level of FIGARO. For example, semiconductors are aggregated with other products, and an average effect is determined, which limits the real extent of dependence on a specific input. However, it has the advantage of allowing the simultaneous calculation of the Herfindahl index for different countries and their comparison.

B Data and Accounting Framework

In this study, three multi-regional input-output tables are used: Long run WIOD (Woltjer et al., 2021), WIOD (Timmer et al., 2015), and FIGARO (Remond-Tiedrez and Rueda-Cantuche, 2019). Statistics are iven in current prices (in billions of euros) and cover the period 1965-2019. The employment data relate to the field of national accounting and are produced by national institutes collected by Eurostat (Bourgeois and Briand, 2019b).

Greenhouse gas (GHG) emissions are derived from the environmental extension of FIGARO. In these data, only CO_2 is considered among greenhouse gases. In 2019, the French carbon footprint consisted of 74% carbon dioxide (CO_2), 20% methane, and 6% nitrous oxide.

FIGARO provides a breakdown of 64 sectors for 45 countries, including the 'Rest of the world'. The latter corresponds to all countries not present in the database and have been grouped into a single aggregate (Remond-Tiedrez and Rueda-Cantuche, 2019).

Long-run WIOD covers the period 1965-2000 with a detail of 23 sectors in NAF Rev.1 for 25 countries. WIOD covers the period 2000-2014 with a detail of 56 sectors in NAF Rev.2 for 44 countries. Finally, FIGARO covers the period 2010-2020 with a detail of 64 sectors in NAF Rev.2. The levels of aggregation between the three MRIOs are different. Thus, we perform back calculations when the periods of overlap are problematic. We use the OECD's ICIO database (Yamano, 2016) to verify the choices made for back-calculations, which covers the period 1995-2018.

A multi-regional input-output table is constructed by reconciling the input-output tables of a set of countries. Table B.1 provides a simplified example of a MRIO for two countries. Overall, the columns of the table represent all the inputs into the production of each country-sector. The values in the rows tell us where the output of each country-sector is used (i.e. as intermediate inputs to satisfy final demand).

Table B.1 – Example of a 2-Countries Input-Output Table

Production by Sector (P)	Purchasing Sectors Intermediate Consumption (M)										Final Demand (D)					
	Country A					Country B					Country A			Country B		
	s1	s2	...	...	sn	s1	s2	...	...	sn	Final Consumption	GFCF	Exports	Final Consumption	GFCF	Exports
Country A																
s1																
s2																
...					Q1								Q2			
sn																
Country B																
s1																
s2																
...																
sn																
Value added																
Country A																
Country B						Q3										

Notes: The northwest quadrant Q1 represents the intersectoral links of intermediate consumption by sectors i=1,2,...,n including exports from A to B of intermediates. The northeast quadrant Q2 represents final demand which represents the distribution of sectoral output across consumption (household and government) including exports from A to B of final products. The southeast quadrant Q3 represents the production account where value added is derived. GDP is equal to the sum of final demand or the sum of value added of sectors.