# Which products are traded in your supply chain and how do they score on risk indicators?[1]

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[1] This article is based on research of Statistics Netherlands for the Dutch Ministry of Economic Affairs and Climate Policy. So far, five articles (in Dutch) have been published on the website of Statistics Netherlands.

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[3] The opinions expressed in this report are those of the authors and are not necessarily in accordance with the policies of Statistics Netherlands or the Ministry of Economic Affairs and Climate Policy.

**Abstract:** Recent events have highlighted the interdependencies within global value chains (GVCs) more clearly than ever. At the onset of the COVID-19 pandemic, some countries implemented export bans on essential items such as medicines and face masks. Similarly, Russia's invasion of Ukraine and the resulting sanctions drew attention to Europe's reliance on Russian natural gas. Policymakers are increasingly aware of their countries' dependence on foreign sources for critical supplies like food, energy, and other essential products. For instance, the European Union is currently grappling with challenges in sourcing certain rare earth metals vital for the energy transition.

We introduce a novel methodology for estimating upstream supply chains at a detailed product level. For any industry in any country, one can estimate its supply chain (this is well-known) and the products that are traded in each stage (this is new). By integrating the Asian Development Bank's multi-country input-output table, Eurostat's FIGARO supply table, the BACI international trade database, and detailed supply/use tables for the Netherlands, we map inter-industry linkages across countries in the value chain at a granular product level (6-digit Harmonized System goods classification). The BACI database also allows us to calculate indicators commonly linked to risks in the literature, aiding in the identification of strategic dependencies within the supply chain at the product level.

Our approach identifies products in the upstream supply chain at a highly detailed level, which is crucial for policymakers seeking to develop targeted risk mitigation strategies. We demonstrate the method by mapping products in the upstream supply chain of the Dutch pharmaceutical industry. For example, we identified 107 product-country combinations within Dutch imports of goods and 115 product-country combinations further upstream that show relatively high-risk indicators. Notable examples include organic chemicals sourced from China and the United States.

The implications for trade policy are clear: identifying specific products further upstream in the supply chain enables the development of concrete policies to mitigate risks and enhance resilience in GVCs.

**Key words:** global value chain, dependencies, strategic autonomy, supply risk

**JEL codes:** F52 (national security and economic nationalism), F14 (empirical trade study), D57 (IO tables and analysis)

## 1. Introduction

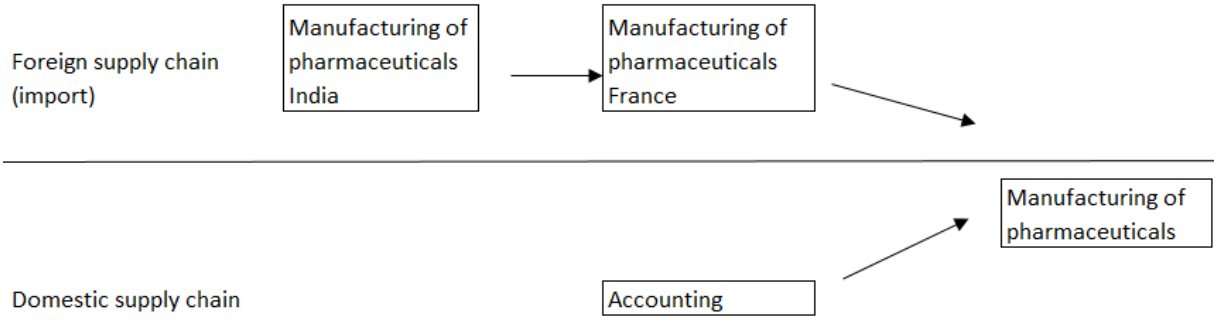
In today's interconnected global landscape, production processes are increasingly interwoven across international borders. The rise of global value chains (GVCs) highlights the fact that the production of manufactured goods depends on inputs sourced from various parts of the world. This fragmentation of production enhances global efficiency, as countries specialize in activities where they have a competitive advantage. However, this interconnectedness also introduces inherent risks: an unforeseen event disrupting production in one location can quickly trigger ripple effects across borders, potentially having a significant impact on the global production of numerous goods. The risk is particularly acute if the disruption occurs in a region that supplies strategic inputs to multiple value chains.

Policymakers are seeking a more comprehensive understanding of potential risks to national security within specific international supply chains. Recent events, such as the COVID-19 pandemic and the war in Ukraine, have underscored the vulnerabilities associated with international trade integration. It can no longer be assumed that global supply chains will operate without disruption; deliberate or

unforeseen interruptions in the supply of critical raw materials or semi-finished products may pose significant risks. As a result, international organizations, such as the European Commission (Arjona et al., 2023) and the OECD (Berthou et al., 2023), are closely examining products in supply chains and developing indicators to assess potential risks.

Currently, most information is either direct trade (but nothing with supply chains) at detailed level or supply chains at industry (but not much detail). The latter situation is depicted for the Dutch pharmaceutical industry in Figure 1.1. The supplies of this industry can be categorized as either direct or indirect. For example, it may directly purchase materials, while materials sourced from India by the French pharmaceutical industry would be indirect supplies since they are used in production for the Dutch pharmaceutical industry.

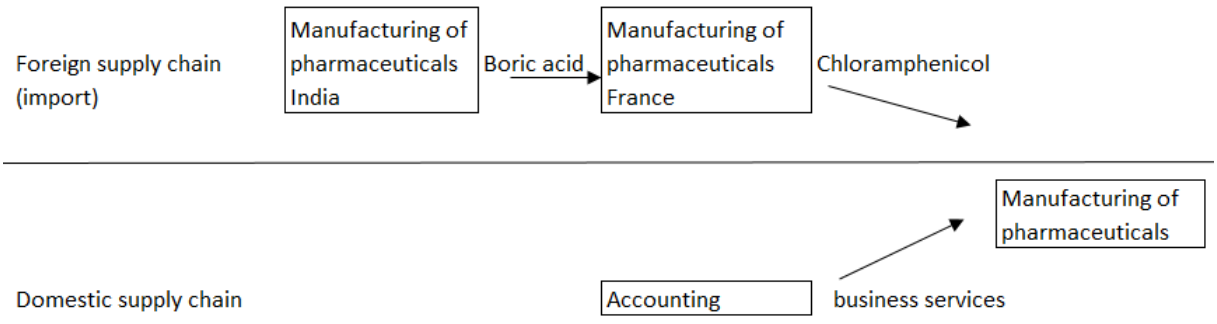
**1.1 Schematic overview of a fictitious supply chain**




**Increase granularity by incorporating product information in the upstream supply chain**

Policymakers aim to gain a deeper understanding of potential risks within various international supply chains. To achieve this, it is essential to map out, in detail, the specific products involved in these supply chains. This paper introduces a new method that provides deeper insights into an industry's supply chain by adding the products traded at each stage of the chain. The new information is depicted in Figure 1.2.

**1.2 Schematic overview of a fictitious supply chain with product detail**




Following this, several indicators related to risk —based on a report by the European Commission (Arjona et al., 2023)—were calculated for the identified products. The Dutch Ministry of Economic Affairs and Climate Policy provided threshold values to refine the selection further. Key criteria included a minimum import value of €10,000 for a product from a specific country and a highly concentrated supply of that product in the global market. This approach reveals where dependencies arise upstream in the value chain of a specific industry, as well as the extent of these dependencies. With this information, policymakers can assess whether dependencies on specific countries or

industries are desirable or present significant risks. This framework allows us to address key questions such as:

- What are the product-country combinations in the supply chain of the Dutch pharmaceutical industry that meet risk-related criteria from the literature?
- What categories of products are frequently encountered in this context?
- Which countries appear most often?

This paper presents findings related to the Dutch pharmaceutical industry's supply chain, including both the products that the Netherlands imports directly and those exchanged between other countries, representing indirect imports.

**The new information and its (im)possibilities**

This study provides a quantitative overview of the supply chain, covering 34 industries across more than 60 countries and involving over 5,000 products. For example, it includes estimates of the supply of iron ore from Australia to China, which is ultimately used by the Dutch pharmaceutical industry. However, it is important to note that detailed data on intra-country trade and trade in services is limited. Further refinement can be achieved either quantitatively (e.g., by expanding the range of industries while narrowing the number of countries) or qualitatively, focusing on identifying niche products that may play a critical role but are relatively small in scope.

The estimates provided come with considerable uncertainty. For instance, determining the exact quantity of iron ore supplied by Australia to China that is eventually used in the Dutch pharmaceutical sector is inherently challenging, necessitating certain assumptions in the estimation process. These assumptions are discussed in detail in the relevant section. Due to the methodology used, certain unexpected products may appear in the tables. For instance, soybeans may show up, even though their role in the pharmaceutical supply chain is questionable. Statistics Netherlands lacks the sector-specific data needed to provide clarity on these anomalies. This challenge extends to individual enterprises as well; while businesses may be familiar with their own procurement and production processes, tracing supply chain details several steps upstream can be difficult or even impossible.

Therefore, the list of products in the supply chain that score highly on risk indicators is not a definitive enumeration of strategic dependencies. Rather, it serves as an indicative list that can guide further investigation. These estimates are not final metrics, nor do they represent absolute truths.

**Structure of the paper**

The remainder of this paper is organized as follows. Section 2 discusses the data. Section 3 provides a description of the methodology, followed by Section 4, which presents the results. Section 5 contains a discussion of the methodology, including possible improvements. Section 6 concludes. The annex lists the countries and industries included in the analysis.

## 2. Data

All data pertains to the year 2019. This data comes from several sources:

- **The Dutch industry-by-industry input-output table** is yearly compiled by Statistics Netherlands. It shows the relationships between industries, inputs (such as wages, gross exploitation surplus, taxes, subsidies, and imports), and outputs (including exports, consumption, and gross fixed capital formation). It encompasses approximately 130 different

industries. The components of this input-output table can be disaggregated at the product level, allowing for the identification of specific products involved in inter-industry supply, those exported or sold to meet domestic final demand, and the products imported and utilized by various industries. This latter aspect is particularly useful for mapping the international supply chain of the Dutch pharmaceutical industry.

- **The Dutch international trade in goods and services statistics** is compiled by Statistics Netherlands as well. these statistics provide a detailed product dimension for goods (less detailed for services) and a comprehensive country dimension, covering all countries globally.
- **The BACI[4] dataset (Gaulier and Zignago, 2010)** describes international trade in goods at the product level, country-by-country. Trade is described at a highly granular product level, around 5000 distinct products. In cases where confidentiality is a concern, the dataset offers estimates for confidential portions of international trade and addresses trade imbalances through specific assumptions (e.g., reconciling discrepancies between Germany's imports from the Netherlands and the Netherlands' exports to Germany). However, it does not include adjustments for re-exports.
- The **FIGARO supply and use table** presents data for 64 industries across about 50 countries, detailing the value of each product (which may be a good or a service) produced or used by those industries. This data is used to connect Dutch imports of a product to the specific industry producing it.
- The **Asian Development Bank (ADB) multi country input-output table (MCIO)** is similar to the Dutch input-output table, the MCIO describes the interconnections between industries, inputs, and outputs, but it does so for over 60 countries and 35 industries. For example, it illustrates the link between the mining and quarrying industry in Chile and the manufacturing of metal products in the United Kingdom.

## 3. Methods

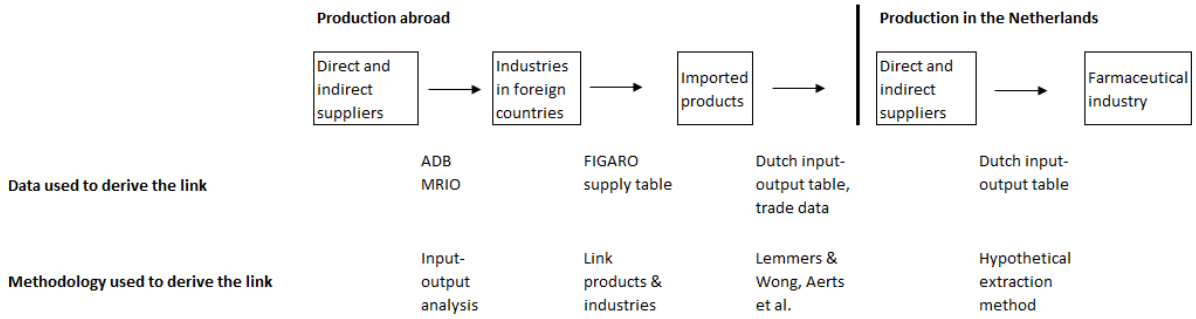
Our methodology consists of three main components. First, we map the international supply chain of an industry in the Netherlands at the country and industry level. Next, we incorporate product details, resulting in a dataset that captures mutual deliveries by product at the 6-digit level of the Harmonized System goods classification for each combination of country A x industry A1 with country B x industry B1 (where A is different from B). Finally, we link this information to the indicators that the literature associates with risk.

### 3.1 Deriving the supply chain

The data and methods necessary to derive the supply chain are summarized in Figure 3.1.1.

[4] CEPII (Centre d'études prospectives et d'informations internationales) compiles the BACI (Base pour l'Analyse du Commerce International) dataset.

### 3.1.1 Data and methods used in deriving the supply chain




The first step in deriving the supply chain focuses on the Dutch pharmaceutical industry. By using a variation of the hypothetical extraction method (see Dietzenbacher et al. 2019 and Miller & Blair, 2009) on the Dutch input-output table, this study estimates the production in each Dutch industry that is related to the pharmaceutical sector. This analysis includes both direct and indirect supplies.

The second step involves estimating the imports required by each Dutch supplying industry to produce for the Dutch pharmaceutical sector. The methodology developed by Lemmers and Wong (2019) is employed to determine how imports of a specific product from a given country are allocated for domestic use in the Netherlands versus re-exports. Following this, the approach of Aerts et al. (2022) is used to allocate these imports from particular countries to various industries within the Netherlands. This allocation is then linked to the imports of Dutch industries that supply both directly and indirectly to the pharmaceutical industry. The outcome is a dataset with Dutch imports of goods and services ultimately destined for the pharmaceutical industry, by product and country of origin.

The third step maps the imported goods and services to specific industries within the exporting countries using the FIGARO supply table (Remond-Tiedrez and Rueda-Cantuche, 2019). It provides insights into the industries in those countries that produce the relevant products. This resulting dataset details direct production by industry by country for ultimate use in the Dutch pharmaceutical industry.

The fourth step quantifies the indirect production by industry and country for ultimate use in the Dutch pharmaceutical industry. This is achieved through standard input-output analysis applied to a multi-country input-output table (MCIO), since Statistics Netherlands lacks detailed information on trade within foreign value chains. In this study, we utilize the MCIO from the Asian Development Bank.

## 3.2 Deriving detailed product level

In the previous step, we estimated the production in each industry in each foreign country for ultimate use by the Dutch pharmaceutical industry. Refining methodologies similar to those of Berthou et al. (2023) and the compilers of MCIO tables such as WIOD, FIGARO, and TiVA, we developed a technique to refine product-level information within the upstream supply chain. The result is a dataset that captures bilateral trade of products (at the 6-digit level of the Harmonized System goods classification) between foreign industries. The three main data sources used in this analysis are as follows:

1. A multi-country input-output table with underlying supply table, MCIO
2. International trade data (e.g., BACI from CEPII or BIMTS from OECD, Cassimon et al. 2024), ITD
3. Detailed supply and use tables or input-output tables of a given country, DSUT

The main idea is to enhance the detail of the MCIO data using international trade data. For example, if the MCIO data indicates that the metal manufacturing industry in the United Kingdom sells metal products to furniture manufacturers and car manufacturers in Germany, the ITMS data can specify that these metal products include large steel plates and small screws. If furniture manufacturers purchase 10% of the total metal products, we might assume they also purchase 10% of both the steel plates and the small screws. This is the methodology proposed by Berthou et al. (2023).

However, such assumptions may not always yield plausible results. For this reason, we aim to enhance the credibility of our results by incorporating more detailed product-level information. The primary source of heterogeneity in the supply and use of specific products tends to stem from the users—there are few suppliers of metal products, but many different users. More detailed information regarding the use of a product by a given industry can be obtained from a detailed national use table (DSUT) or from a country that publishes such data at a detailed level, such as Japan (Japanese Government Statistics, 2023).

This detailed DSUT data might reveal that furniture manufacturers purchase only small screws and no steel plates, while car manufacturers exclusively buy steel plates and not small screws. This information can be leveraged to clarify that metal manufacturers in the United Kingdom supply steel plates to German car manufacturers and small screws to German furniture manufacturers. The method in more detail:

**Incorporating coarse product data with use tables**

We combine the data from Section 3.1 (production by industry by country) with the FIGARO supply and use tables, which outline the products produced and used by each industry, respectively. The level of detail in both tables is limited. Metal manufacturers in the United Kingdom supply metal products to German car manufacturers and German furniture manufacturers.

Subsequently, we utilize the Dutch use table to refine the product information in the FIGARO data at the dimension of the user. The reason to focus on this dimension is that a product is generally produced by a few industries but may be used by many industries. The result is a more detailed understanding of what industry A1 in country A exports to industry B1 in country B at the product level, providing greater specificity than the initial FIGARO data while still remaining relatively coarse. Dutch car manufacturers use metal products in the form of steel plates and Dutch furniture manufacturers use metal products in the form of screws. It is assumed that metal manufacturers in the United Kingdom supply steel plates to German car manufacturers and screws to German furniture manufacturers.

**Refine the product level with trade data**

In this step, we first remove products from the BACI dataset that are not categorized as intermediates according to the BEC classification. This process is standard practice (see, e.g., Timmer et al. (2015) in the context of WIOD), as this stage of the global value chain focuses on intermediate trade rather than trade in final goods. The resulting dataset does not align perfectly with the totals from the previous step regarding what country A sells to country B at a coarse level. Therefore, we weight the data at coarse level to reconcile these totals. The value of small and large plates of steel is 110 in the BACI data, the value of steel plates is 100 in the coarser data, the 110 is weighted to 100.

Next, we apply a proportionality assumption to split the data. For instance, if metal manufacturing in the United Kingdom sells steel plates to German car manufacturers, and the (re-weighted) BACI data indicates that steel plates consist of 20% small plates and 80% large plates, we assume that the same distribution applies to the plates sold by the UK metal manufacturing sector to German car manufacturers. Metal manufacturers in the United Kingdom supply small steel plates of value 20 and large steel plates of value 80 to German car manufacturers. The trade data might show that the screws sold by the United Kingdom to Germany are all small. Then this holds for the screws that metal manufacturers in the United Kingdom supply to furniture manufacturers in Germany as well.

The outcome of this step provides a detailed overview of what industry A1 in country A exports to industry B1 in country B at a refined product level. In summary, we compile "Global" export-import tables at a detailed level (HS 6-digit) that are fully aligned with the ADB MCIO.

### 3.3 Risk indicators to flag products and the threshold value employed

We now turn to the indicators that the literature associates with risks. The indicators used in our study are based on a document from the European Commission (Arjona et al., 2023), focusing solely on the product level. The thresholds are (with the exception of import value and centrality) determined on the basis of the document of the European Commission and the U.S. Department of Justice. The indicators are the following:

**Import value** by country of import. It is evident that transactions of negligible amounts, such as 5 euros, lack significance. To maintain clarity in the output, a threshold of 10,000 euros was implemented for each product exchanged between two countries. These countries need not exclusively involve the Netherlands. The evaluated value pertains to the portion that ultimately contributes to the production of the Dutch pharmaceutical industry. For instance, if Germany supplies 1 million euros worth of boxes to France, and 9,000 euros ultimately benefits the Dutch pharmaceutical industry, the combination of Germany-France boxes would not be flagged.

**World market concentration** is assessed using the Herfindahl-Hirschman index. This indicator determines whether a product holds a high concentration within the global market. A threshold value of 0.25 is applied. This is the threshold utilized by the U.S. Department of Justice in evaluating market concentration after mergers and acquisitions. If the indicator surpasses 0.25, the market is categorized as highly concentrated. The indicator's computation involves the following steps: for each country that exports the product, determine its share in the world market, square these shares, and subsequently sum them. For instance, suppose the world market consists of four countries with shares of 10%, 20%, 30%, and 40%, respectively. In this case, the indicator would be 0.01 + 0.04 + 0.09 + 0.16 = 0.30.

**Import diversification of the Netherlands** is assessed using the Herfindahl-Hirschman index at the product level. However, this indicator specifically focuses on the market of foreign suppliers catering to the Dutch market. The same threshold value employed for world market concentration is also applied in this context. This analysis aims to determine whether the Netherlands obtains these products from a limited number of suppliers, or the import market exhibits significant diversity.

**Non-EU share in EU-imports**, $\frac{extra\ EU\ import\ value}{total\ EU\ import\ value}$, indicates the significance of production outside the EU and serves as a proxy for scarcity within the EU. The mentioned European Commission report adopts a threshold value of 0.5 (50 percent) in this context.

**Substitution ratio EU**, $\frac{extra\ EU\ import\ value^{EU}}{total\ EU\ export\ value^{EU}}$, provides insight into the extent to which imports from non-EU countries could be replaced by domestic EU production in the event of trade disruptions. The previously mentioned European Commission report employs a threshold value of 1 in this context.

**Centrality** is an indicator derived from network analysis that facilitates the identification of countries crucial to numerous other countries within a trade network. This is because if a central player experiences a trade disruption, it could have significant repercussions for global trade dynamics.

**A composite indicator (score) that consolidates all indicators**

The Ministry of Economic Affairs and Climate Policy prefers to consider all indicators rather than solely relying on the import value of flagged products, recognizing the significance of each indicator. To achieve this, it seeks a composite indicator that consolidates the diverse indicators. Constructing such a composite indicator is often subjective due to the necessity of assigning weights to the various indicators and their values. To address this, Statistics Netherlands used a straightforward "score" indicator. The "score" is composed as follows:

- If any of the aforementioned indicators surpass the threshold value, it receives 1 point.
- If any of the aforementioned indicators significantly exceed the threshold value, it gains 2 points.

The final score is determined by summing up the points obtained from the five indicators. The specified threshold values are provided in Table 3.3.1.

### 3.3.1 Indicators and threshold values

| Indicator | Score 1 point | Score 2 points | Higher score |
|---|---|---|---|
| World market concentration | >= 0.25 and < 0.4 | >= 0.4 | Higher risk |
| Import diversification | >= 0.25 and < 0.4 | >= 0.4 | Higher risk |
| Non-EU share in EU-imports | >=50 and < 75 | > 75 | Higher risk |
| Substitution ratio EU | >=1 and < 2 | >= 2 | Higher risk |
| Centrality | >=2.058 and <2.412 | >= 2.412 | Higher risk |

To illustrate, consider the following hypothetical example. The import of antibiotics from Germany destined for use by the Dutch pharmaceutical industry amounts to 9,000 euros. The world market concentration for antibiotics is measured at 0.26. In this case, the import value of antibiotics from Germany is lower than the 10,000-euro threshold, so antibiotics from Germany do not score on this indicator. The world market concentration of antibiotics is 0.26, which is above the 0.25 threshold, but below the 0.4 threshold. Therefore, antibiotics from Germany do score on this indicator, for one point.

**Flagged goods**

We call product x country combinations that score at least one point on each of the aforementioned indicators "flagged goods". The European Commission calls the indicators risk indicators and uses it to flag "EU strategic dependencies and vulnerabilities".

Statistics Netherlands does not map out risks. It only compiles indicators that are, according to the literature, risk indicators. Subsequently, Statistics Netherlands determines whether the indicators rise above the thresholds or not. Then it provides a numeric interpretation of the results. A policy-oriented interpretation and decision whether something is a risk or not has to be made by others.

Statistics Netherlands cannot indicate whether a specific country is a risk or not. It only provides objective numeric information. Other institutions can also indicate if a country is similar to the Netherlands, for example in geopolitical views, or how large the possibility is that a country will pressure the Netherlands using trade.

## 4. Results: products in the international supply chain and risk indicators

The results consist of two parts: Dutch imports and foreign imports, all intended for ultimate use by the Dutch pharmaceutical industry. The rationale behind this breakdown is that the Netherlands can exert more influence over its own imports compared to imports by other countries.

**Dutch imports**

Within Dutch imports, a total of 107 product-country combinations have been flagged based on the selected indicators and their respective thresholds. This concerns goods imported by both the Dutch pharmaceutical industry and its associated suppliers, originating from abroad but used within the Netherlands. It is important to note that these goods may include products seemingly unrelated to pharmaceuticals, such as soybeans. For all 107 of these combinations, each of the risk indicators exceeds its designated threshold value.

The comprehensive dataset containing the flagged goods and their corresponding indicators can be accessed in a tailored set of tables that accompanies Lemmers et al. (2023). To provide a clearer understanding, this text delves into two specific examples from the mentioned table. Following this, the discussion is supplemented with several graphs illustrating the frequency of particular product categories and countries.

### 4.4.1 Two examples of flagged goods, 2019

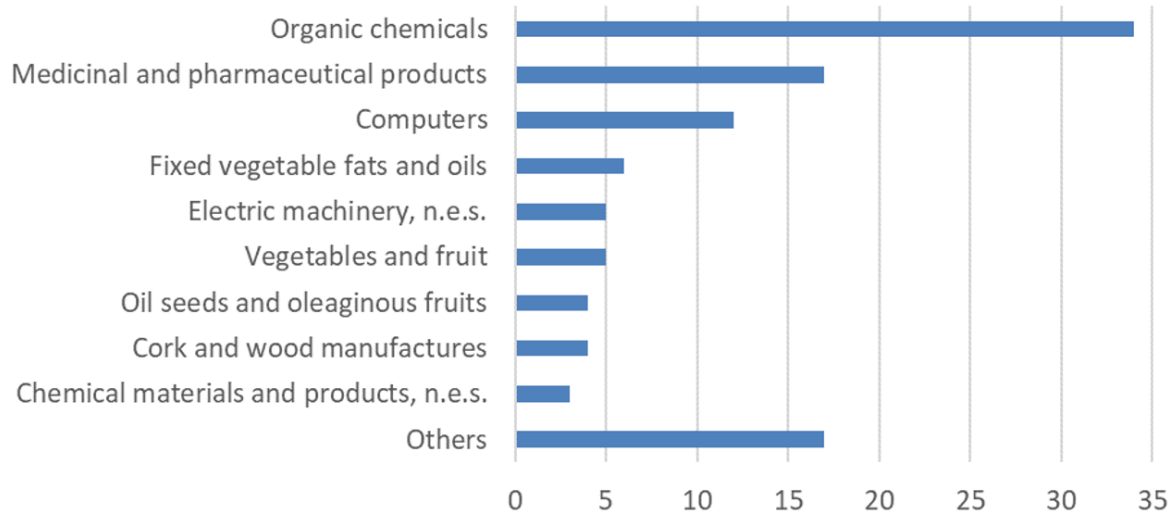
| | Castor oil | Chloramphenicol |
|---|---|---|
| Originating from | Germany | China |
| Import value | 15.000 euros | 1,2 million euros |
| Share of country in world market | 2% | 90% |
| Share of country in imports of this product | 45% | 83% |
| World market concentration | 0,77 | 0,81 |
| Dutch import diversification | 0,42 | 0,71 |
| Non-EU share in EU-imports | 77% | 79% |
| Substitution ratio EU | 3,12 | 2,64 |
| Centrality | In highest quarter | In upper half |

Source: Statistics Netherlands calculations based on ADB, Eurostat/JRC, BACI

At the request of the Ministry of Economic Affairs and Climate, the project compiled a list of goods that exhibit relatively high scores across multiple indicators, rather than sorting them by import value. Consequently, products that receive noteworthy scores on indicators but might possess relatively low import values are positioned prominently on the list. One product (from two countries) receives the maximum score across all five indicators. This specific product is castor oil from both Germany and India, each accounting for 15 thousand euros. Additionally, various products achieve the maximum score of two points on four out of the five indicators, while still scoring one point on the remaining indicator. Among these, the product with the highest import value is chloramphenicol (an antibiotic) from China, with a value of 1.2 million euros.

For both product-country combinations, the supplying country has a significant portion of the total Dutch import value for that product. Specifically, 45 percent of all castor oil stems from Germany, while 83 percent of all chloramphenicol originates from China. Furthermore, these products have a high level of concentration in the world market; the concentration measure surpasses the threshold value of 0.4 set by Arjona et al. (2023). Similarly, the Dutch import market exhibits a substantial degree of concentration, albeit less than the global market. Notably, over three-quarters (77 and 79 percent) of imports from EU countries originate from non-EU countries. As a result, the substitution ratio, which indicates the relative proportions of imports from outside the EU compared to EU exports, is notably high. This means that it could be difficult to substitute imports from outside the EU by EU production. Lastly, the centrality of castor oil places it in the highest quartile (top 25 percent), while the centrality of chloramphenicol positions it within the upper half.

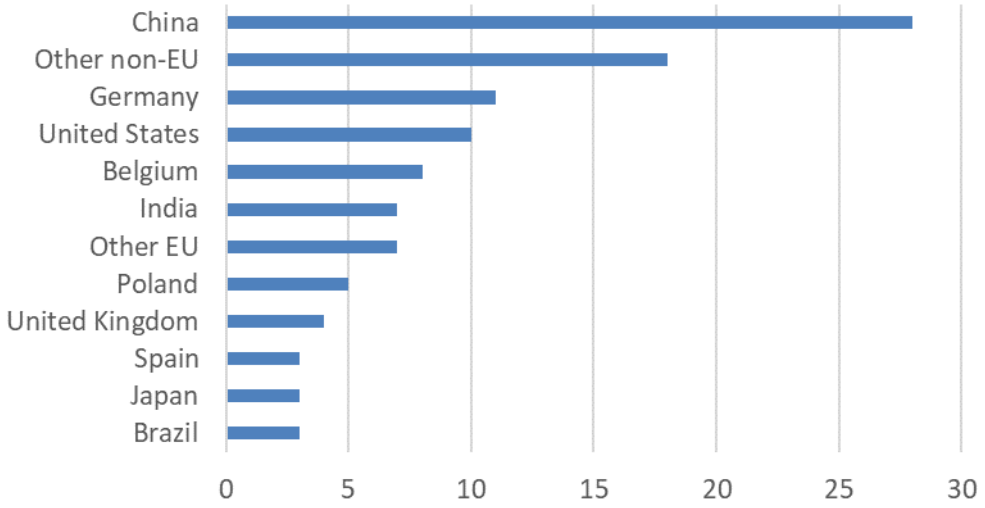
### 4.4.2 Flagged goods in the supply chain of the pharmaceutical industry, Dutch imports, by product category, 2019




Source: Statistics Netherlands calculations based on ADB, Eurostat/JRC, BACI

The identified flagged goods have been grouped into several product categories. Those with the most flagged goods are organic chemicals, medicinal and pharmaceutical products, computers, respectively.

### 4.4.3 Flagged goods in the supply chain of the pharmaceutical industry, Dutch imports, by import partner, 2019



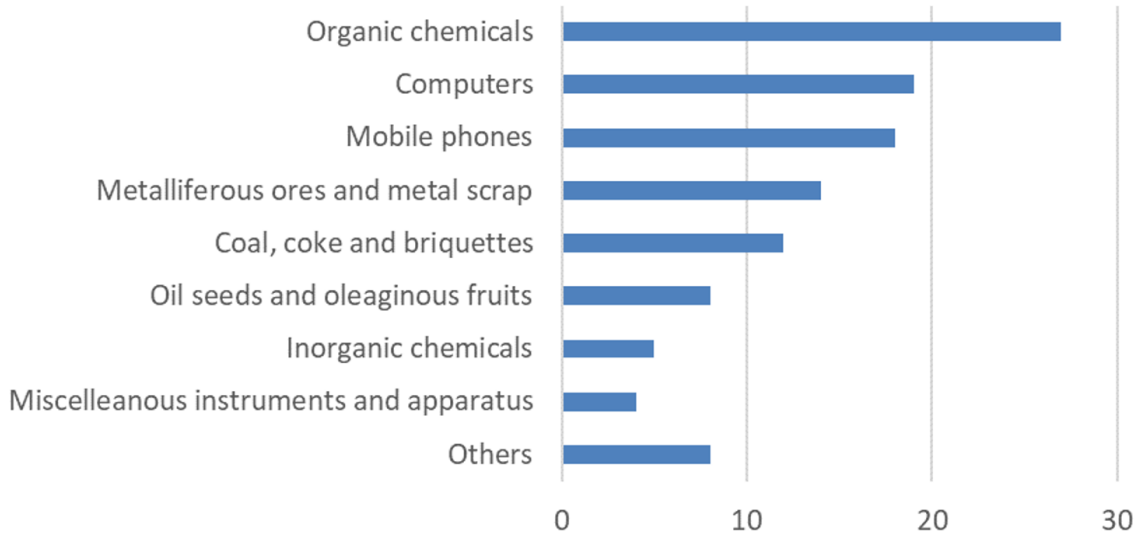

Source: Statistics Netherlands calculations based on ADB, Eurostat/JRC, BACI

The countries from which the Netherlands imports the flagged goods predominantly are China, Germany and the United States. This is not surprising since these countries are the most important trading partners for the Netherlands. Several flagged goods originate from “various non-EU countries”. The detailed tables show that this mainly concerns Rest of World (occurring 5 times, a collective category of smaller countries), along with Taiwan, Malaysia, Indonesia, and Canada (each occurring twice). Moreover, there are several other countries that each appear once among the flagged goods.

**Foreign imports**

We now shift our focus to products, ultimately destined for use in the Dutch pharmaceutical industry, traded between countries other than the Netherlands. It concerns product by country of export by country of import combinations. For instance, iron ore from Australia exported to China. We consider the combinations that surpass the threshold for each of the indicators associated with risk. This yielded 115 of such combinations. To delve deeper into these goods and the associated indicators, one can consult Table 2 of Lemmers et al. (2023). We will now present several figures that illustrate the frequency with which specific product categories and countries appear.

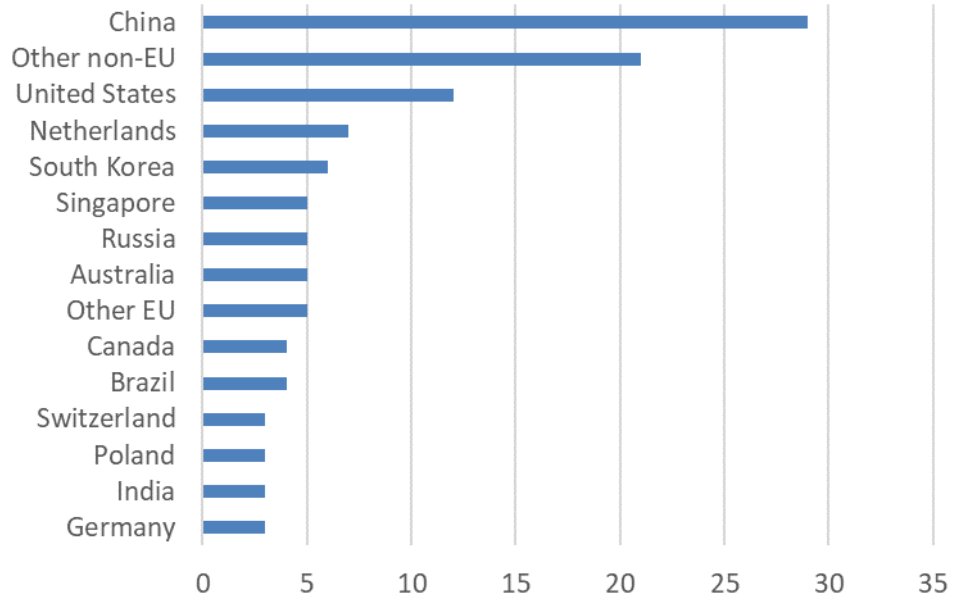
### 4.4.4 Flagged goods used in the upstream supply chain of the Dutch pharmaceutical industry, by product category, 2019




Source: Statistics Netherlands calculations based on ADB, Eurostat/JRC, BACI

The flagged goods have been condensed into several product groups. The diversity is more pronounced compared to the Dutch imports. While organic chemical products and computers remain prevalent categories, medicinal and pharmaceutical products are notably absent. This stems from their limited involvement in intermediate production stages. In contrast, raw materials like metal ores and coal emerge more frequently. Additionally, mobile phones feature in this chart, although this occurrence may likely be influenced by the adopted methodology.

### 4.4.5 Flagged goods used in the upstream supply chain of the Dutch pharmaceutical industry, by import partner, 2019




Source: Statistics Netherlands calculations based on ADB, Eurostat/JRC, BACI

Countries that are relatively often associated with the flagged foreign products are China, the United States, and even the Netherlands itself. It is not surprising that major economies such as China and the US rank high in this figure. The Netherlands' notable position can be attributed to its role as a direct supplier to countries like Germany and Belgium, which in turn sell goods to the Netherlands. The category "Other non-EU" in this figure consists of Rest of World (12 occurrences, representing a collective grouping of smaller countries), along with Japan and Thailand (each appearing twice). Additionally, several other countries appear once in this context.

It is worth noting that a single product might be supplied through various industries. Several factors could account for this phenomenon. The variations might arise due to different products categorized under a relatively broad product description (e.g., "specific amino acids"). Alternatively, multiple industries could supply the same product; for instance, both agriculture and the food industry might contribute to the supply of jam. However, it is also plausible that this occurrence might be an artifact stemming from the methodology and data employed, particularly when dealing with relatively small quantities.

## 5. Discussion of methodology and possible improvements

This section first discusses some limitations of the methodology while proposing avenues for improvement. Then it explains several choices, including those that relate to the choice of the reference year and the MCIO that was used.

### 5.1 Limitations of the methodology

- The number of countries in the analysis for country of production is 62, see Annex 2. Note that it does not include countries in Africa, which are important for mining and quarrying. Currently, there are no high quality MCIOs that contain many African countries. In the future, this will be the case, see the AfCIOT project (Gong et al., 2023).
- It is unknown how supply chains exactly look like. Consider the following fictitious example. Suppose the Dutch pharmaceutical industry buys from the German chemical industry. The German chemical industry buys from the petroleum industry and agriculture in Germany, among others. Then the assumption is that the Dutch pharmaceutical industry is also linked to the petroleum industry and agriculture in Germany. This is a common assumption in input-output analysis. In reality, there might only be a link with the chemical industry. The only way to improve this is through interviews with companies of interest, their suppliers and so on. This is very time-consuming, and it was beyond the scope of this study.
- To improve the analysis with trade information at the product level, a specific Eurostat/JRC dataset could be used instead of the BACI data. The advantage of this dataset is that it excluded re-exports. It only contains imports that are actually used within the importing country. However, it is important to note that the Eurostat/JRC data is not publicly accessible. Nonetheless, a project conducted by Eurostat/JRC itself, such as one aimed at tracing products within EU supply chains, can certainly use this data.
- There is a clear merit in employing more detailed data for supply and use at the product level per industry, sourced from countries like the United States and Japan where it is available. This enables to see in more detail which industries use which goods and services. It prevents that

the inputs of “metal products” for the furniture industry and the car industry are exactly the same detailed products, since they both use “metal products”. It might show that the furniture industry mainly uses screws, and the car industry mainly uses steel plates. This approach demands a substantial investment of time and resources.

- Detecting niches is only possible with qualitative research or product-level analyses.

### 5.2 Choice for reporting year 2019

For the analysis, Statistics Netherlands chose reporting year 2019. 2020 is a distorted year because of the strong economic shock caused by the coronavirus. This gives a distorted picture of supply (and dependencies) of industries within countries, but also between countries because of lockdowns and production stops. At the start of the project, there was no information about 2021 available.

### 5.3 Choosing Asian Development Bank's MCIO

Input-output tables are used to map the specified supply chains of strategic industries within the Netherlands. Such tables show for each industry how much it supplies to other industries, where the industry purchases its own required goods and services, and how much the industry produces and exports. To make estimates about value chains, the combination of trade statistics and input-output table is necessary. A multi-regional input-output (MCIO) table ties together supply and use tables and/or input-output tables from different countries, so that dependencies with industries in other countries can also be identified. Input-output analysis can be used to calculate how much industry A in country B produces for the strategic industry in the Netherlands. For the analysis in this project, Statistics Netherlands chose the Asian Development Bank's MCIO. At the start of the project, it was the MCIO with the most countries while reporting about 2019. It contains information for 62 countries and 35 industries. This is more countries than in Eurostat's FIGARO MCIO.

### 5.4 Using detailed Dutch data instead of starting directly with input-output analysis

An alternative approach to 3.1 would be to conduct input-output analysis directly without delving into the specifics of the Netherlands. However, Statistics Netherlands intentionally refrained from this strategy for several reasons. First, in some MCIOs, the pharmaceutical industry is merged with the total chemical industry. Then one has to assume that the supply chain of the pharmaceutical industry is equal to that of the entire chemical sector, which is not ideal. Second, the Netherlands is known to be inadequately integrated within existing MCIOs, as highlighted by Edens et al. (2015). This inadequacy arises from re-exports, which refer to products that are imported and then exported with minimal alteration. Given the prominence of re-exports in the Netherlands, they present considerable challenges in constructing MCIOs. The lack of comprehensive information compels MCIO compilers to make assumptions that may not yield optimal results (Lemmers, 2013). Given that Statistics Netherlands possesses more detailed data, it was used to generate more accurate estimations.

## 6. Conclusion

In recent years, there has been growing attention on supply chain dependencies. Policymakers are increasingly interested in identifying which countries their nation relies on for essential goods such as energy, food, and other critical products. These dependencies can be either direct (imports from a specific country) or indirect (e.g., goods and services from Country A used by Country B to produce

items for the home country). However, until now it was only possible to map direct trade dependencies at detailed level (imports) or to map the complete supply chain at industry by country level.

The key contribution of our paper is the introduction of a novel methodology for estimating upstream supply chains at a detailed product level. For any industry in any country, one can now estimate its supply chain and the products that are traded in each stage at detailed level. Our approach utilizes BACI international trade data, in conjunction with use tables for the Netherlands, FIGARO supply and use tables, and the MCIO from ADB. By integrating these resources, we have mapped the connections between industries across countries within the value chain at a granular product level. Additionally, we used the BACI database to calculate indicators commonly associated with risk in the literature. In this paper, we have applied these risk indicators to the detailed product-level supply chain of the Dutch pharmaceutical industry.

This opens new avenues for trade policy: identifying specific products further upstream in the supply chain enables the development of concrete policies to mitigate risks and enhance resilience in GVCs.

Using the risk indicators and their respective threshold values, we identified 107 product-by-country combinations relevant to Dutch imports in the pharmaceutical sector. Each combination represents an import with a value of at least €10,000, where all risk indicators exceeded their thresholds. These flagged products frequently include organic chemicals, medicinal and pharmaceutical products, and computers. China appears most often, followed by Germany and the United States.

We also flagged 115 product-by-country combinations involving importers other than the Netherlands. Commonly identified products include organic chemicals, computers, mobile phones, metal ores, and waste, with China, the United States, and South Korea appearing frequently.

This methodology can be replicated by others for different countries and industries of interest. The primary challenge lies in the availability of detailed product data, which is only partially accessible to the public. Confidentiality concerns result in many undisclosed data points, particularly when examining smaller country-industry combinations. It is worth noting that Eurostat holds confidential data for EU member states. Eurostat could conduct a similar study and ensure confidentiality by aggregating data at appropriate levels. This would provide more detailed results than other researchers could typically achieve.

## 7. References

Aerts, N., Bohn, T., Lemmers, O., Wong, K. F. (2022). Linking micro-data to national input-output tables: By whom and from whom are which products imported and to what end? Paper presented at the 28th IIOA conference in Langkawi.

Arjona, R., Connell, W., Herghelegiu, C. (2023). An enhanced methodology to monitor the EU's strategic dependencies and vulnerabilities. Single Market Economy Papers 14. Brussels: European Commission.

Berthou, A., Samek, L., Haramboure, A. (2023). Granular supply chains: A scoping paper. DSTI/CIIE(2023)2. Organisation for Economic Co-operation and Development.

Cassimon, S., Liberatore, A., Sarrazin, K. (2024). The revamped Balanced International Merchandise Trade dataset (BIMTS). A focus on re-exports. SDD/CSSP/WPTGS(2024)2. Organisation for Economic Co-operation and Development.

Dietzenbacher, E., van Burken, B., Kondo, Y. (2019). Hypothetical extractions from a global perspective. Economic Systems Research, 31(4), 505-519.

Edens, B., Hoekstra, R., Zult, D., Lemmers, O., Wilting, H., Wu, R. (2015). A method to create carbon footprint estimates consistent with national accounts. Economic Systems Research, 27(4), 440-457.

Gaulier, G., Zignago, S. (2010) BACI: International Trade Database at the Product-Level. The 1994-2007 Version. CEPII Working Paper, N°2010-23.

Gong, X., Keeble, E., Boko, D., Deveza, A. (2023). Building AfCIOT and TiVA Indicators in Africa in Support of AfCFTA. Paper presented at the 29th IIOA conference in Alghero.

Japanese Government Statistics (2023). Input-Output Tables for Japan 2015, https://www.e-stat.go.jp/en/stat-search/files?page=1&toukei=00200603&tstat=000001130583

Lemmers, O. (2013). Using enterprise data to improve trade in value added estimates. Paper presented at the OECD Workshop "Measuring Trade in Value-Added.

Lemmers, O., Wong, K. F. (2019). Distinguishing between imports for domestic use and for re-exports: a novel method illustrated for the Netherlands. National Institute Economic Review, 249, R59-R67.

Lemmers, O., Notten, T., Wong, K. F., Dahlmans, D., Prenen, L. (2023). Productieketen farmaceutische industrie, 2019. Statistics Netherlands, Den Haag/Heerlen/Bonaire. In Dutch.

Miller, R. E., Blair, P. D. (2009). Input-output analysis: foundations and extensions. Cambridge university press.

Remond-Tiedrez, I., Rueda-Cantuche, J. M. (Eds.). (2019). EU Inter-country Supply, Use and Input-output Tables: Full International and Global Accounts for Research in Input-output Analysis (FIGARO). Luxembourg: Publications Office of the European Union.

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R., De Vries, G. J. (2015). An illustrated user guide to the world input–output database: the case of global automotive production. Review of International Economics, 23(3), 575-605.

**Annex**

**Countries/regions in the analysis**

| | | |
|---|---|---|
| Australia | Hungary | China |
| Austria | India | Philippines |
| Bangladesh | Indonesia | Poland |
| Belgium | Ireland | Portugal |
| Bhutan | Italy | South Korea |
| Brazil | Japan | Rest of world |
| Brunei | Kazakhstan | Romania |
| Bulgaria | Kyrgyz Republic | Russia |
| Cambodia | Laos | Singapore |
| Canada | Latvia | Slovakia |
| Croatia | Lithuania | Slovenia |
| Cyprus | Luxemburg | Spain |
| Czech Republic | Malaysia | Sri Lanka |
| Denmark | Maldives | Sweden |
| Estonia | Malta | Switzerland |
| Fiji | Mexico | Taiwan |
| Finland | Mongolia | Thailand |
| France | Nepal | Türkiye |
| Germany | Netherlands | United Kingdom |
| Greece | Norway | United States |
| Hong Kong | Pakistan | Vietnam |

**Industries in the analysis**

Agriculture, hunting, forestry, and fishing
Mining and quarrying
Food, beverages, and tobacco
Textiles and textile products
Leather, leather products, and footwear
Wood and products of wood and cork
Pulp, paper, paper products, printing, and publishing
Coke, refined petroleum, and nuclear fuel
Chemicals and chemical products
Rubber and plastics
Other non-metallic minerals
Basic metals and fabricated metal
Machinery, n.e.c.
Electrical and optical equipment
Transport equipment
Manufacturing, n.e.c.; recycling
Electricity, gas, and water supply
Construction
Sale, maintenance, and repair of motor vehicles and motorcycles; retail sale of fuel
Wholesale trade and commission trade, except of motor vehicles and motorcycles

Retail trade, except of motor vehicles and motorcycles; repair of household goods
Hotels and restaurants
Inland transport
Water transport
Air transport
Other supporting and auxiliary transport activities; activities of travel agencies
Post and telecommunications
Financial intermediation
Real estate activities
Renting of machines & equipment and other business activities
Public administration and defense; compulsory social security
Education
Health and social work
Other community, social, and personal services
Private households with employed persons