CPB Netherlands Bureau for
Economic Policy Analysis

Tariff Costs Within Value Chains: A Focus on the Netherlands

Firms deal with different costs when trading internationally, which can impact how competitive they are.
These costs include direct tariffs on imports and exports, as well as additional charges applied at different stages of the trading process.

Dutch firms are more often than EU firms part of international value chains in which tariffs are levied. In addition, Dutch industries participate in value chains that involve relatively high tariffs costs at the EU external border.

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Rutger Teulings, Stefan Boeters,
Daan Freeman, Gerrit Hugo van Heuvelen,
Gerdien Meijerink, Maarten van 't Riet

Summary

Trade costs have a great impact on the competitive position of Dutch companies. These trade costs include all barriers (natural, policy, technical or cultural) that hinder or prevent the flow of goods and services between two trading partners. Tariff costs are the main (monetary) trade costs that are policy-relevant. Earlier, direct tariff costs, such as import tariffs that are a tax on the import of a product, were the most important. But today, it has become more important to examine all tariff costs incurred throughout the value chain, as the production of goods occurs at different stages and locations. A value chain comprises the entire trade chain from raw materials through intermediate inputs (such as semi-finished goods) to final products. Tariffs may be levied at every border crossing in this trade chain. Therefore, in addition to direct tariff costs when exporting, a Dutch firm also faces indirect tariff costs. These may be levied earlier in the chain (upstream), or further down the chain (downstream). These direct and indirect costs together determine the competitive position of Dutch firms.

In this publication, we map both direct and indirect tariff costs for the Netherlands and the European Union (EU). To do so, we use the trade cost index developed by the Netherlands Bureau for Economic Policy Analysis (CPB) based on Miroudot and Nordström (2020). This makes it possible to map total costs across the value chain (see Annex 6.1 and Boeters et al. (2023) for a detailed explanation). The focus of this publication is on tariff costs, an important component of trade costs. Total tariff costs in a value chain can be broken down into several elements: the number of times an intermediate product crosses the border, and the level of tariffs levied at those border crossings. This occurs both upstream and downstream. With the help of a decomposition of the tariff cost index, we gain more insight into tariff costs along the value chain.

Compared to the EU average, Dutch industries are more often part of international value chains, and therefore face more frequent border crossings where tariffs are levied. For both goods and services, Dutch industries have higher upstream and downstream tariff cost indices compared to the EU average. This is mainly because the value chains of Dutch industries have many taxed border crossings. The average tariff at each taxed border passage in the value chains of the Netherlands and the EU is about the same. This means that international trade policy, which sets tariffs worldwide, is extra important for the Netherlands.

In Dutch value chains, an average of 54% of tariff costs are levied upstream at the EU's external border, while downstream is 73%. Upstream, production of components, such as silica production for a computer chip, takes place. Downstream, products are further processed. For example, the computer chip may end up in a smartphone sold to consumers. Especially downstream, there is therefore still relatively much room for the EU to do something about tariff costs for EU countries, and thus also for the Netherlands because Dutch trade policy is set at EU level. On tariff costs levied between non-EU countries, the EU (and thus the Netherlands) has no direct influence. Tariff costs in this part of the value chain can be reduced with international trade treaties with non-EU countries (multilateral treaties).

Several industries deviate significantly from the average Dutch tariff cost index because they are in longer chains and/or are charged with higher tariffs. Services, for example, have much lower tariff costs in the value

chain because they are usually not subject to direct tariffs. But because services and goods value chains can be intertwined, services do face indirect tariffs. There are also differences within goods and services industries. Some industries import relatively heavily taxed intermediate products, such as the garment industry. Other industries are part of relatively long, international value chains with many taxed border crossings, such as the automotive and chemical industries. Yet other industries have chains that are mainly nationally oriented, such as the Dutch mineral extraction industry. As a result, total tariff costs for these latter industries are lower than the Dutch average.

The value chains in which Dutch industries participate span a greater physical distance than other EU industries. Tariff costs are only one part of total trade costs. In addition to tariffs, these include, for example, non-tariff measures (such as specifications that products have to meet) or transport and insurance costs. Unfortunately, no data are available on these other costs. However, we do have data on the physical distances products travel in a value chain. These are often seen as a good indicator of overall trade costs. This is because transport costs increase with distance, but also because, for example, differences in culture and preferences are generally greater between countries that are far apart. On the other hand, countries that are closer together will have a history where they traded more with each other, and have therefore converged economically. All this suggests that total trade costs between countries will be higher if they are further apart. Our tariff cost index for value chains correlates strongly with the distance index. The distance and tariff cost index show similar patterns, which hold true for both the Netherlands and the EU. It is therefore plausible that the patterns we found based on tariffs will also apply for total trade costs.

1 Introduction

In the last four decades, international trade flows have changed significantly. Not only has international trade increased, its structure has also changed. The production of goods (and later services) has become increasingly fragmented into different stages spread across different geographical locations. In such production chains, value is added at different stages, which is why we call them 'value chains'. Despite the recent slowdown in globalisation, the fragmentation of value chains remains crucial for understanding trade flows. This fragmentation has been facilitated by, among other things, a combination of the revolution in information and communication technology, an accelerated reduction of trade barriers through trade agreements and China's accession to the World Trade Organisation in 2001 (Antras and Chor, 2021). In geographically fragmented production chains, firms use foreign imported parts and components (i.e. inputs), and producers of intermediate inputs sell their output back abroad. Johnson and Noguera (2012) estimate that trade in intermediate inputs accounts for more than half of world trade.[1]

Value chains change the analysis of international trade. Instead of analysing bilateral trade between two countries (or two firms), the whole chain is analysed. For example, in an analysis of trade tariffs, CPB has previously analysed only tariffs between pairs of countries (Freeman et al., 2022). An analysis into trade tariffs that includes value chains takes tariffs into account at all stages, from raw material to end user. Trade tariffs cumulate across the value chain, and a change in a tariff between two countries can therefore have an impact in a completely different location in the world.

CPB has renewed the tools for the analysis of international trade.[2] First, Boeters et al (2023) replace the existing gravity model with a *state-of-the-art* gravity model with value chains in line with the model of Caliendo and Parro (2015). In addition, a new set of tools is developed: a trade cost index that includes the cumulation of trade costs (e.g. tariffs) across the value chain (see also Appendix 6.1). This new toolbox is more in line with relevant discussions that call for the analysis of *counterfactuals*, such as, for example, a fragmentation of global trade into regional blocks. The International Monetary Fund (IMF) calls this geo-economic fragmentation. [3]

Trade costs are diverse, but we focus on two sub-aspects in this study: tariffs and distances. Tariffs are a clear and directly monetizable example of trade costs. Other trade costs (see section 3 for an explanation of different trade costs) are more difficult to quantify. However, we do have information on distances. These turn out to be a good proxy for trade costs. Not only because transport costs increase with distance, but also because differences in, for example, culture and preferences increase with distance.[4]

The total tariff costs in a value chain are determined by several factors: the length of the value chain, the times an intermediate product crosses the border, whether tariffs are levied at that border crossing and how high these tariffs are. Using this decomposition, we can gain more insight into the role that tariffs play in the value chain. In this study, we present the tariff cost index and decomposition for 2019 and show the initial results. These descriptive statistics prove to be a rich source of information on global trade, with differences across countries and industries.

Tariff costs increase downstream, which has several implications. First, there is the phenomenon of tariff escalation: tariffs are higher for more processed goods (see Corden, 1966 and Shapiro, 2021 for a recent

[1] In the 2019 FIGARO data, we find a percentage of 56% of the total value of world trade.
[2] The Ministry of Foreign Affairs contributes to the development and future applications of these tools with multi-year funding.
[3] IMF blog, 22 May 2022 (link).
[4] By distance here, we mean the physical distance a value chain spans upstream or downstream. This is different from the length of a value chain. The latter refers to the number of different stages of production in a value chain.

update). Second, tariffs are levied throughout the value chain and accumulate. Thus, the level of tariff costs contained in an input or output that a firm uses depends on where in the value chain the firm is located. Thus, in addition to production costs in and comparative advantages of countries, firms must also consider where downstream production stages should be located from a trade cost perspective (Moxnes and Johnson, 2016; Antràs and De Gortari, 2020).

The role of trade policy changes with the perspective of value chains. In today's more interconnected world, both the costs of trade protectionism and the benefits of multilateral openness are much higher than previously thought (Miroudot et al., 2013). In a world with mostly bilateral trade, protectionist policies with import tariffs can protect domestic producers from international competition. But in value chains where exporters often use imported intermediate inputs, a tax on imports is also a tax on exports and can thus undermine export competitiveness. A recent example is the steel tariffs levied by the US government; studies show that these have also hurt US exports (see, for example, Bown and Zhang, 2019; Barattieri and Cacciatore, 2023). Since services are often intertwined in value chains for goods, trade policy will have to take this into account. Tariffs imposed on goods imports also affect the costs of services that use these goods as inputs (OECD, 2013).

This publication is organised as follows. In section 2 we discuss the concept of the value chain, its length, and the other components needed to construct the tariff cost indices. The different types of trade costs in the value chain are discussed in detail in section 3. The results of calculating the tariff cost index are reviewed in section 4. Section 5 discusses the role of distances as a proxy for trade costs and its correlation with tariffs. Finally, section 6 appendices with a discussion of source data and more detailed results.

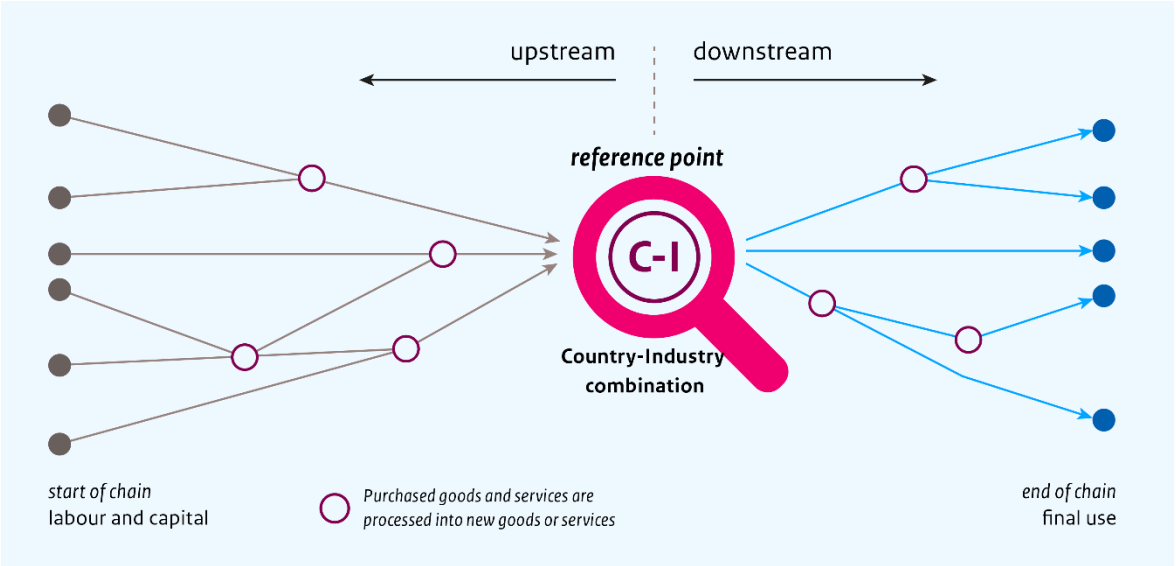
2 Value chains and border crossings

2.1 Value chain definition

The term value chain refers to production chains where components or semi-finished products are made (for goods) at different locations, or where services add value to an intermediate or final product. These locations may be in different countries. Antràs and Chor (2021) use a broad definition of a value chain: "a series of stages involved in producing a product or service that is sold to consumers, with each stage adding value, and with at least two stages being produced in different countries". These stages are also referred to as production stages (Fally, 2012). Miroudot and Nordström (2020) are more specific than Antràs and Chor (2021); they link the notion of value chains to the combination of a sector, or industry, and the country in which a production stage is located. A country-industry (L-I) combination therefore includes all intermediate supplies in which this L-B combination is involved, either as a buyer or as a supplier.

We can imagine the web of all global connections between industries as an extremely large fishing net, the tangle of threads representing intermediate supplies. If we take one knot between thumb and forefinger, so to speak, and lift it out, the direct and indirect connections are also lifted up (see figure 2.1). Such a node is a country-industry combination, which is the statistical unit on which data of intermediate deliveries are available, namely from one country-industry combination to another. The deliveries can remain domestic or remain in the same industry.

Figure 2.1 Illustration of the value chain of a country-industry combination (L-B) with all related intermediate supplies



2.2 Length of value chain, number of border crossings and tariffs

The length of a value chain helps determine the level of tariff costs. We measure the length of a value chain by identifying and counting the different stages of production. An example of a simple value chain is: a baker baking bread that is sold to consumers, who sources his flour from the miller, who in turn buys the wheat from the farmer who has bought the wheat seed from a grower, and that grower produces across the border. However, we are dealing with much more complex processes and, in particular, highly aggregated data. For a detailed description of the underlying methodology, see Annex 6.1.3.

The measure of the length in our definition of a value chain uses the notion of countable stages of production (Fally, 2012).[5] This measure assigns incremental weights to the value added realised in the different production stages. So weight 1 for the value added of the final production itself, weight 2 for the direct inputs, weight 3 for the inputs of the direct inputs, and so on. This creates a weighted average of the length of the different input stages. As the value added share of distant inputs becomes increasingly small, the calculation converges. This length measure forms the basis of our tariff cost index.

The measure of the length of a value chain can be calculated either upstream or downstream. The measure described above is upstream (i.e. backstreams) in the production chain tostreams the primary production factors. Conversely, the length of the value chain can also be calculated downstream: how many stages are there before the product of a country-industry combination reaches the end user? Again, we use the step weights for the stages of production, and downstream (i.e. forstream) these are combined with the value of final use (instead of value added at upstream length). Because the final share of one unit of product reaching a final user many stages further as an input will be small, this measure also converges. Figure 2.1 shows that two lengths can always be calculated for a given value chain: upstream (backstream) and downstream (forstream).[6] Note that the perspective is the position of the country-industry combination. Other measures take the perspective of, for example, the end user; the direction to the country-industry combination is then always upstream.

The average value of the length of downstream chains is 2.3 steps (i.e. production stages). The average value of the length of upstream chains is exactly one step less. This difference is explained by the fact that we always include the step to the end user in the downstream length but not in the upstream length.

Whether intermediate supplies cross national borders is another factor determining tariff costs. For the measure of border crossings, we again use the chain length method, but instead of weighting by the number of steps (i.e. production stages), we now weight by the number of border crossings. This measure indicates how 'global' a value chain is. Value chains are largely domestic. The average values of number of border crossings are 0.3 and 0.5 for upstream and downstream, respectively.

Not only is the number of border crossings important for tariff charges, but also whether they occur in a free trade agreement, such as the European Union (EU) or the North American Free Trade Agreement (NAFTA). These often involve reduced tariffs, or none at all. To construct the tariff cost index, we track how

[5] The idea of chain length with incrementally increasing weights for the production stages is first found in the *average propagation length* of Dietzenbacher et al. (2005).
[6] The *average propagation length* is a measure between two country-industry combinations and is equal in both directions.

many border crossings there are that impose a tariff. Finally, we determine the average tariff per border passage where a tariff is imposed. Combining these four components together gives the tariff cost index.[7]

2.3 Construction of the upstream and downstream tariff cost index

Tariff costs accumulate within a value chain. A producer in a given country and industry may pay import tariffs on imported inputs. But the foreign supplier of these inputs may also have paid import tariffs on his imported inputs. And even domestically sourced inputs, which are not directly subject to tariffs, may again be indirectly subject to tariffs. As a result, a change in tariffs somewhere in the world may affect a country-industry combination elsewhere in the world.

We distinguish upstream and downstream tariff costs. Above, we described tariff costs for a country-industry combination that accumulate upstream through the supply chain. Conversely, downstream through the chain, i.e. through intermediate customers, there can also be an accumulation of tariff costs. For both directions (see figure 2.1), we calculate indices. For the downstream index, we include not only the tariffs on intermediate use, but also those on final use. As a result, the two indices cannot be compared one-to-one.[8]

The data in a world input-output (IO) table allows traceability of trade chains and calculation of measures such as chain length. This data source is described in more detail in Annex 6.2. The world IO table contains the value of all intermediate supplies between all industries, both domestic and abroad. Combining this information with data on tariffs, we can calculate indices. For a precise description, see Annex 6.1.

We decompose the tariff index into: length of chain, border crossings, border crossings with tariff ('taxed part') and average rates across all border crossings with tariffs. Tariff cost indices can be calculated directly or constructed from these components (see also section 2.2). The components can provide insight into why indices differ. Even when values of the indices are the same, their composition may differ. The components of the in section 4 calculated tariff indices are presented in Annex 6.3.

In a similar way, we also calculate a distance index, as distances are a good proxy for trade costs. Tariffs represent only a part of trading costs, which is why we present a distance index in addition to the tariff cost index. We discuss this in section 3. The calculation is analogous.

[7] Value chains with exactly one country border passage are also part of our analysis, which differs from Antràs and Chor's (2021) definition.

[8] If we were to include end-use tariffs in the upstream index as well, the two indices, aggregated, are identical. Here, we have chosen the perspective of the country-industry combination as a producer, and the upstream index indicates the cumulative tariff costs the producer faces.

3 Trade costs in the value chain

In this publication, we focus on tariff costs, but these are only part of the total costs involved in trading. The trade cost index we present in 6.1 can therefore be used for a broader concept of trade costs, consisting of a broader set of different costs. By trade costs we therefore mean all barriers (natural, policy, technical or cultural) that impede or prevent the flow of goods and services between two trading partners (see table 3.1).

Table 3.1 Types of trade costs

Trade costs	Policy	Monetarily measurable	Information
Rates	Yes	Yes	Available
NTMs	Yes	No	Restricted
Transport & insurance	No	Yes	Restricted
Cultural/communication	No	No	Available
Natural/geographical	No	No	Available
Other	No	No	Not available

Tariff costs are the main monetary trade costs that are policy relevant. In addition, for policy purposes, non-tariff measures (NTMs) are obviously important because these trade costs arise directly from policy.[9] An advantage of tariffs is that they are easily quantifiable (in euros) and the necessary information is available for both countries and industries (Anderson and Van Wincoop, 2004). In section 4 we therefore focus on results based on tariffs. NTMs are difficult to quantify, moreover, it is not easy to get a complete overview of the prevailing NTMs between countries. Transport costs are in principle monetarily measurable, but information at a detailed level is lacking. Another part of trade costs can only be derived indirectly because these costs are not monetary (think of language, standards, regulations or the establishment climate in a country (Moïsé and Le Bris, 2013)).

Quantifying non-monetary trade costs requires estimating *ad valorem* equivalents. This involves converting the trade impact of non-monetary trade costs to a tariff with similar impact. This can be done using a gravity equation. Non-monetary and unmeasured trade costs then explain *missing trade*: a trade flow between two countries that is lower than one would expect based on the economic size of the exporting and importing country and the geographical distance between them. However, this involves additional estimates and assumptions (see, for example, Ghodsi and Stehrer, 2022).

Trade decreases with increasing distance between two countries (Disdier and Head, 2008). This explains why the gravity model is one of the most important models to describe international trade (Head and Mayer, 2014). In the gravity model, trade between two countries decreases the further apart they are. This not only revolves around physical distance, but also cultural (e.g. do two countries speak the same language?) or economic distance (e.g. do two countries have a single market?). If two countries speak the same language or have an internal market, trade costs are lower and they will therefore trade more. In addition, tariffs obviously play an important role.

Distance is a good proxy for all kinds of trade costs, because typically all kinds of trade costs increase with physical distance between trading partners (Anderson and Van Wincoop, 2004; Head and Mayer, 2014). Transport costs are the most obvious trade costs that increase with distance. But also, for example, the difference between different cultures increases with distance (Grossman, 1998). Countries that are closer

[9] NTMs include sanitary and phytosanitary (SPS) and technical barriers to trade (TBT).

together often have more similar cultures, speak a similar language and have often established closer economic ties over time. Thus, the Netherlands will be more similar to Germany than to China. Blum and Goldfarb (2006) show that Americans are more likely to visit websites from countries closer to the United States, despite the fact that a physically greater distance does not increase costs. This is especially true for taste-dependent websites such as websites about music and games. They therefore conclude that distance is a proxy for taste, which is difficult to capture in a trade index. Rauch (1999) shows that distance is more important for heterogeneous than for homogeneous goods. He argues that search costs are higher for heterogeneous goods and thus distance is also a proxy for search costs. In section 5 we therefore show the distance index, by which we do not look at weighted tariff costs in a value chain, but at weighted distances. Not because we are necessarily interested in how much physical distance spans value chains like this, but precisely because it gives an indication of the broad concept of trade costs.

4 Tariff costs in the value chain

In this section, we compare the tariff cost index of the Netherlands with the EU and other countries. In section 4.1 we compare the total tariff cost indices of different countries. How does the Netherlands differ from the EU, the US and China? For example, if the Netherlands has lower indices on average, its value chains may be better set up to avoid (high) tariffs, which may bring cost advantages. In section 4.2 we deepen the comparison by looking at value chain lengths of Dutch industries and compare them with EU averages. If value chains of industries differ widely, EU trade policies, but also between non-EU countries, will affect different industries differently. Finally, in section 4.3 we examine where the tariff costs of Dutch chains are levied. Is it mainly when products enter or leave the Netherlands, or just at the EU border?

We find that Dutch value chains are longer than the EU average, upstream and downstream. Dutch value chains therefore cross more borders on average than the EU average, within and outside the EU. As a result, Dutch industries' tariff cost indices tend to be higher than in other EU countries, despite average tariffs being similar. Thus, Dutch producers tend to pay more direct and indirect tariff costs because used inputs are more often (indirectly) sourced from outside the EU. Dutch downstream value chains tend to have more international outlets compared to the EU.

Tariff costs for all countries are higher upstream than downstream, especially for goods. This is partly *by design* because the number of downstream production stages is one higher, as it includes final demand. However, the main contribution to the difference is explained by the fact that average tariffs in downstream chains are much higher (see, e.g. figure 4.3).[10] Although tariffs vary widely through the value chain, there is the phenomenon of escalating tariffs where commodity tariffs are lowest and highest far down the value chain (Amiti, 2004).

Disparities between goods and services are evident in their tariff cost indices. Notably, the index for goods surpasses that of services, both in the upstream and downstream sectors. This discrepancy primarily stems from the absence of tariffs on the majority of service trades. The tariff cost index exclusively encompasses tariff expenses related to the trade of goods employed either upstream or downstream within their respective value chains. This divergence explains the elevated tariff cost index within the manufacturing sectors. The following sections therefore treat the tariff cost index for goods and services separately.

4.1 Netherlands compared to other countries

By analysing the weighted average across all industries by country, we find that the tariff cost of services is substantially lower than that of goods (see figure 4.1).[11] This is because tariffs are not levied on services themselves, but only on the goods used in service value chains. Consequently, the number of taxed border crossings (not covered by an FTA) is much lower for services than for goods, while the average tariff at these border crossings differs little (see figure 4.2 and 4.3 , bottom left and right).

[10] Despite the fact that we do not explicitly include that tariffs on products from the same sector can differ depending on use, average tariffs on products from sectors that are often downstream are higher, such as the food processing industry.
[11] We weight each country's industries with the corresponding value added of the respective industry.

Figure 4.1 Tariff cost index of goods and services for different countries

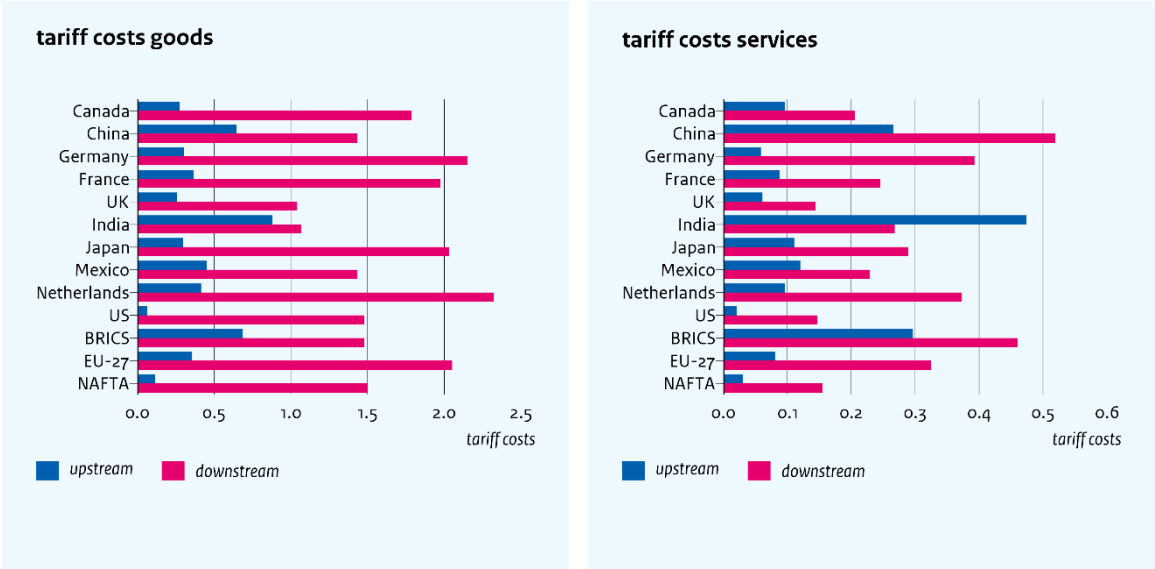


Figure note: To get a tariff cost index by country, we weight the tariff cost index by value added industry. EU-27 is the weighted average of all 27 EU countries, where we use value added by country as weight. Figures are for 2019.

The Netherlands, as a trading nation, is deeply embedded within global value chains that exhibit a higher degree of internationalization compared to the EU average. This heightened international involvement reflects in the Netherlands' elevated tariff cost indices for both goods and services, both upstream and downstream, surpassing the mean indices of the 27 EU member states. Interestingly, despite this contrast, the average tariffs imposed at border checkpoints demonstrate minimal variance. In fact, these tariffs often register as greater for the broader EU-27, except for upstream services. This discrepancy in indices can be attributed to the intricate nature of the value chains in which the Netherlands plays a role. These value chains tend to traverse international boundaries more frequently, necessitating interactions with tariff-bearing borders (as depicted in figure 4.2 and 4.3). Consequently, this dynamic culminates in the Netherlands facing higher trade cost indices. Subsequently, the ensuing subsection will elucidate these disparities, drawing upon select industry examples. Examining downstream value chains, the Dutch tariff cost indices for both goods and services exhibit similarities with those of Germany. Upstream, a parallel is drawn with France in terms of the tariff cost index. Notably, downstream French value chains exhibit a lesser degree of internationalization, while the upstream segment of German value chains experiences fewer instances of tariff-bearing border crossings.

The trade of the Netherlands and the EU is more global than that of the US and the UK. Anderson and Van Wincoop (2003) show that the US-Canada border causes trade to be 44% lower, between the US and the rest of the world it is even 60% lower. US states trade with each other a factor of 2.2 more than with Canadian provinces. Similar to the US, the EU is one market, where trade between member states is almost as smooth as within member states themselves. This is because all trade barriers (such as tariffs, but also NTMs) have been removed as much as possible. Nevertheless, on average, EU member states are more often part of more international value chains that also run outside the EU than the US is part of value chains that run outside the US. We see that despite comparability of average tariffs across value chains, trade cost indices are higher for the EU. This is due to a higher number of border crossings that are also more frequently taxed. Also, the UK has much lower tariff cost indices than the Netherlands and the EU because the value chains the UK is part of are less international and pass through a taxed border less frequently. This is particularly true downstream.

China is very similar to the EU at the aggregate level in terms of trade statistics, but if we compare tariff cost indices among themselves, we see large differences (see figure 4.1). Both have a trade surplus,

exporting 14% of the world total, while China imports 15% and the EU 17% of the world total.[12] By comparison, the US has fairly similar import (17%) and export (14%) shares, but a trade deficit. China nevertheless has much higher tariff cost indices. This is due to two reasons: in value chains of Chinese industries, tariffs are levied slightly more frequently and the tariff rates paid are higher on average. An exception pertains to downstream goods index, which holds significance for China as a prominent exporter of goods. In this case, we see that the average tariff for the EU-27 and China is in the same order of magnitude, but in value chains linked to the EU-27, tariffs are imposed with greater frequency (see figure 4.2).

Figure 4.2 Decomposition of upstream and downstream tariff cost index for land-based goods

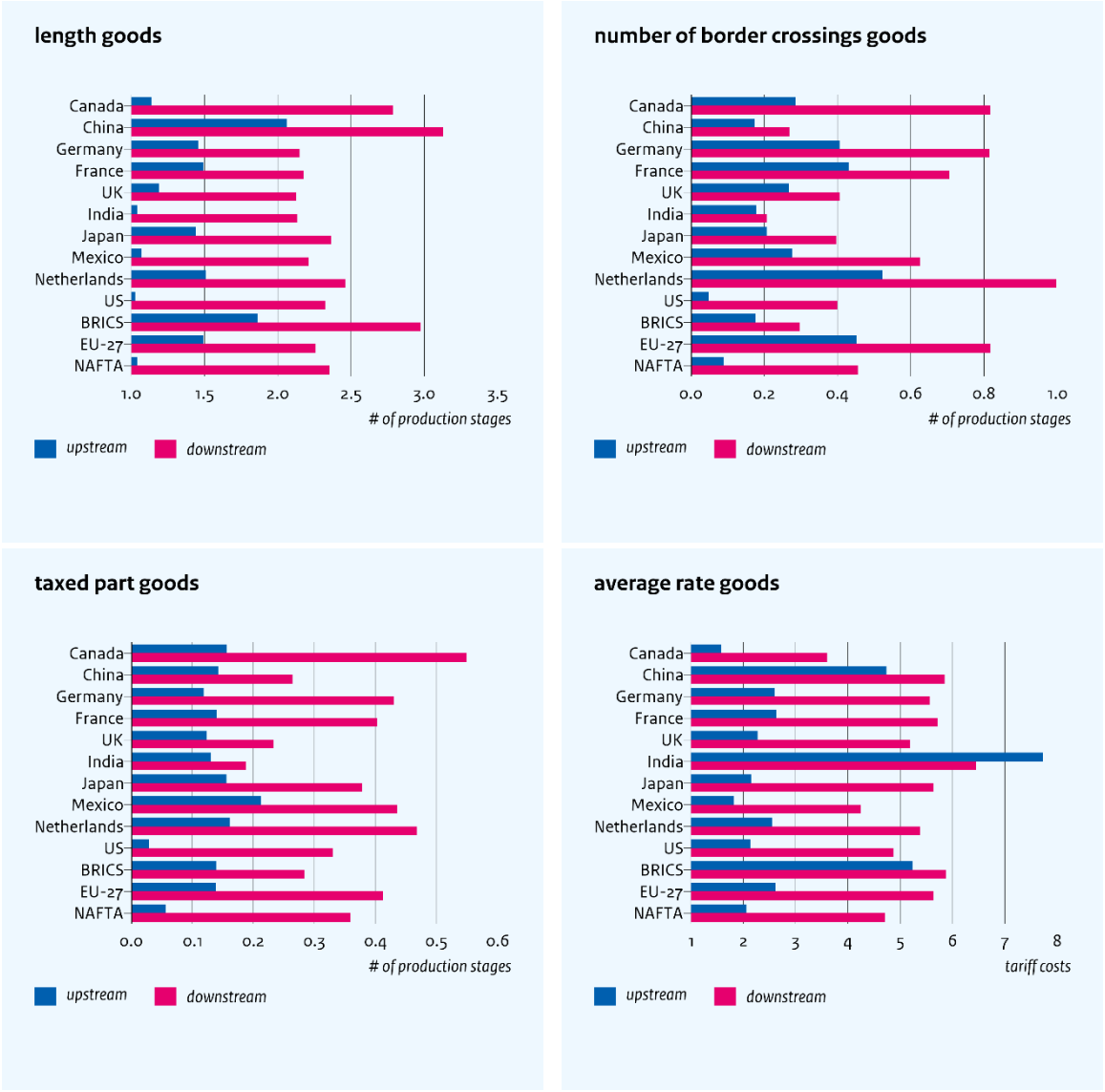


Figure note: To get a decomposition of the tariff cost index by country, we weight each industry with value added. EU-27 is the weighted average of all 27 EU countries, where we use value added per country as a weight. See table 6.1 for an explanation of the terms. Figures are for 2019.

[12] In the calculation of import and export shares, we exclude intra-EU trade for the sake of proper comparison.

Figure 4.3 Decomposition of upstream and downstream tariff cost index for land-based services

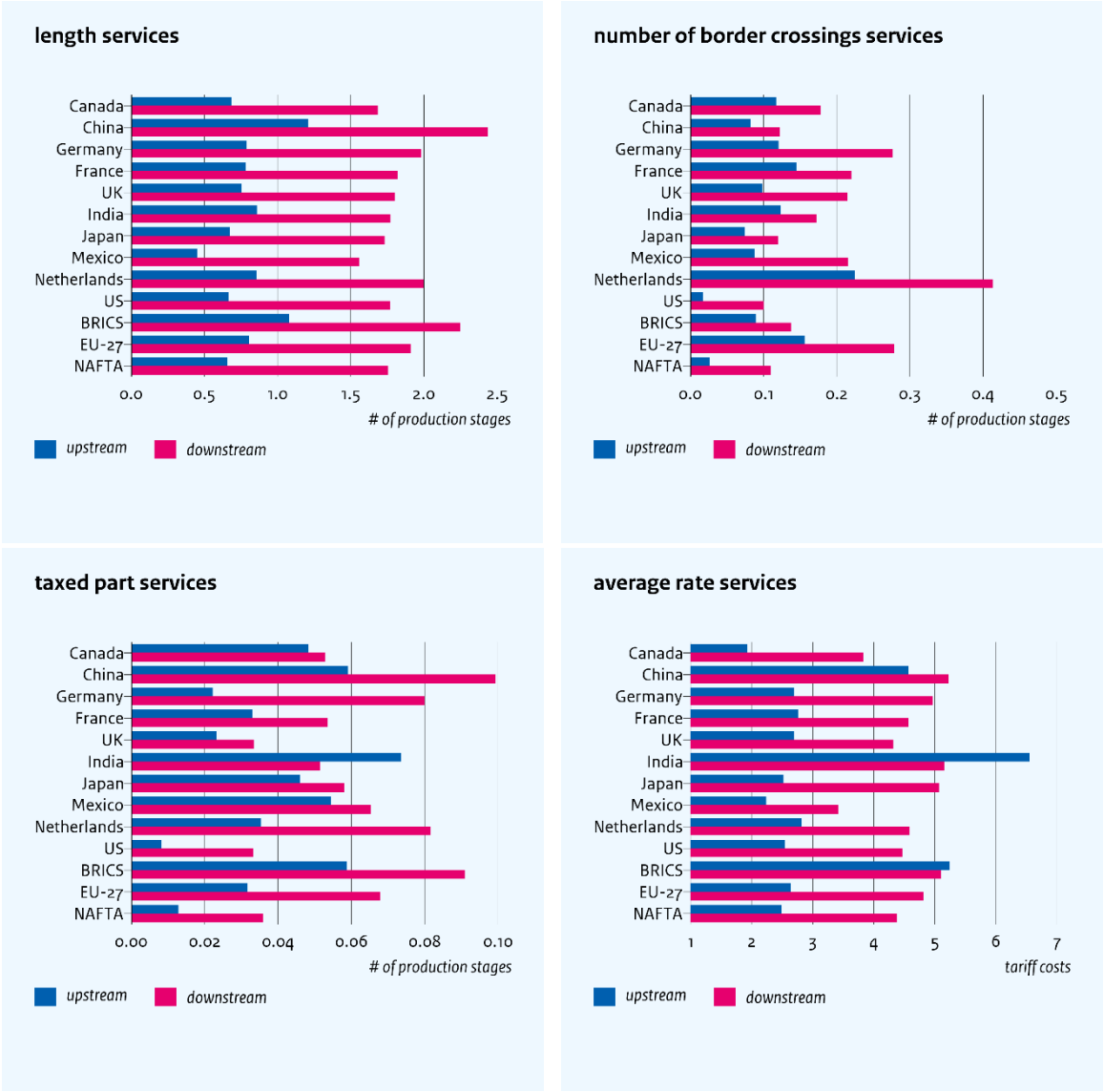


Figure note: To get a decomposition of the tariff cost index by country, we weight each industry with value added. EU-27 is the weighted average of all 27 EU countries, where we use value added per country as a weight. See table 6.1 for an explanation of the terms. Figures are for 2019.

4.2 Openness of industries in the Netherlands and the EU

Nearly every sector within the Netherlands boasts more extensively internationalized value chains compared to the average across the EU. As highlighted in the preceding subsection, the value chains in which the Netherlands participates exhibit a higher degree of internationalization when contrasted with the EU average. In this section, we delve deeper into a comparative analysis of the distinct industries that underpin these value chains. This exploration centres around a specific metric: the number of border crossings within these value chains. In Figure 4.4 we observe the ten industries in which the Netherlands holds the highest cumulative relevant trade cost indices. Notably, an interesting trend emerges: the count of border crossings for Dutch industry value chains consistently surpasses the EU average. This observation underscores that the disparity between the Netherlands and the EU average is not primarily due to specific industries with international value chains being disproportionately large within the Netherlands.

Figure 4.4 Openness of Dutch industries and the EU-27 average

Figure note: Ten industries with the highest tariff cost index. Figures are for 2019.
Note (in alphabetical order): **A01** Agriculture; **C10-12** Food industry; **C13-15** Textile industry; **C16** Timber industry; **C17** Paper industry; **C20** Chemical industry; **C22** Plastics industry; **C24** Basic metal production; **C26** Electrical industry; **C27** Electrical appliance industry; **C28** Machinery industry; **C29** Automotive industry; **C30** Other transport equipment industry; **C31-32** Furniture industry; **G45** Wholesale and retail motor vehicles; **G46** Wholesale trade services other; **H49** Land transport services; **H50** Water transport services; **H51** Air transport services; **H52** Warehousing; **I** Hotels and restaurants; **J59-60** Film and TV; **J61** Telecommunications; **M69-70** Lawyers and accountants; **M72** R&D; **M73** Advertising services; **M74-75** Other business services; **N77** Renting and leasing; **N78** Temporary employment agencies; **N79** Travel; **R93** Sports activities and entertainment; **S95** Repair of computer, household goods. See sections 6.3.2 and 6.3.3 and figure 6.3 to figure 6.10 for the full decomposition terms for the Netherlands and the EU average.

The variation between Dutch value chains and the EU average is not consistent. To illustrate, in the case of goods industries, there are significant variations in the upstream direction for the Netherlands in areas such as food processing (C10-12), electrical engineering (C26), and wood processing (C16). Conversely, for transport equipment (C30) and chemicals (C20), the disparities are notably narrower. Moving downstream, a substantial difference emerges for agriculture (A01) and food processing, where Dutch value chains once again demonstrate heightened internationality. Similar variations are observed within the domain of services. Notably, service industries display notable differences between the Netherlands and the EU average. In the upstream direction, there are pronounced disparities in sectors like film and TV (J59-60) and research and development (M72). On the downstream side, distinctions are conspicuous in land and air transport services (H49 and H52) as well as rental and leasing services (N77).

Trade policy holds greater significance for sectors characterized by international value chains. Considering that the value chains of Dutch industries typically traverse borders more frequently on average, they are inherently more exposed to tariffs and other trade-related costs. Consequently, facilitating smoother trade would potentially yield higher benefits for these industries, on average. This principle extends not only to EU trade policies but also to agreements involving third countries, particularly those integrated into the value chains of Dutch industries. Conversely, it's important to acknowledge the converse scenario: if tariffs are heightened or imposed more frequently, the adverse impact on these industries would be more pronounced. Given that Dutch industries possess value chains of heightened internationality compared to the EU norm, the Netherlands, as a whole, would exhibit a higher average sensitivity to trade policies.

4.3 Tariff costs in value chains of Dutch industries

We observe substantial variations in tariff costs across different Dutch industries. We delve into the underlying factors driving these disparities using the decomposition method elucidated in section 2.2. Some industries might grapple with significant taxation on the products they import or export. Conversely, certain sectors are integrated into value chains that span extensive distances across international borders, while others are ensconced within shorter value chains primarily circumscribed within domestic boundaries. For an analogous depiction of the EU-27 average, refer to section 6.3.1 in the Annex.

In value chains for goods, we compare average import tariffs applied to inputs and outputs of Dutch industries by utilizing a comprehensive tariff cost index. Employing the upstream index, we discern the proportion of tariff costs attributed to the direct import of inputs. Conversely, in the downstream index, this portion pertains to the direct export of Dutch products. Remarkably, when isolating the initial upstream and downstream steps in value chains, the direct shares of the tariff cost index amount to 33% (upstream) and 26% (downstream).[13] This underscores that a substantial proportion of tariff costs isn't directly imposed at the first step but rather farther up the value chain. However, from a policy perspective, it's pivotal to discern which tariffs can be influenced, bearing in mind that Dutch trade policy is governed at the EU level.

For the purposes of policy formulation, it becomes relevant to ascertain the share of tariffs levied at European borders. By design, both upstream and downstream tariff costs attributed to the EU external border are higher than the direct tariff costs borne by the Netherlands. Upstream, imported intermediary products from the EU may trace their origins to outside the EU in an earlier stage of production, even without encountering a direct tariff. Consequently, an indirect tariff becomes applicable at the EU's external border. Similarly, intermediate products destined for other EU countries might eventually find their way to non-EU countries at a later production stage, incurring tariff costs at the EU's external border. The trade policy enacted by the EU dictates the tariff costs associated with import flows at the EU's external border via import duties. In addition, EU policies can exert influence over the import duties imposed by non-EU nations on trade flows exiting the EU, achieved through bilateral trade agreements. It's important to note that tariffs imposed between third countries, positioned not at the EU border but elsewhere, pose more intricate challenges for manipulation. However, this objective can be achieved through the pursuit of multilateral trade agreements.[14]

[13] The size of the difference with the share levied at the EU border is partly because tariffs do not usually apply to trade in services, but they are indirectly taxed if they have been used for (incorporated into) goods production for the export market.
[14] Bilateral agreements can have an impact by shifting trade, though. If the EU enters into a bilateral trade agreement with, say, Japan, it is also likely that Japan and EU countries will trade more, at the expense of trade with other third countries. This may cause the value chains of Dutch industries and thus the tariff cost index to shift. This is because Japanese industries may again have different suppliers than former trading partners. This second-order effect is beyond the scope of this publication, but is discussed further in Boeters et al. (2023).

The average share of tariff costs in the value chains of Dutch industries levied at the EU border is 54% (upstream) and 73% (downstream). This means that 46% of tariff costs levied in upstream value chains of Dutch industries outside the EU between third countries are outside the direct influence of EU trade policy. Consequently, EU policy concerning tariff costs takes on pronounced significance within downstream value chains, while its relevance is somewhat diminished within upstream chains. This underscores the intricate interdependence of other EU nations within the value chains of Dutch industries, emphasizing the pivotal role played by EU trade policy.

4.3.1 Goods

Figure 4.5 (left) shows that for the Netherlands, the upstream tariff cost index is highest for the garment industry (C13T15) and car production (C29), but this has several reasons. For car production, the supply chain is long and international, but the tariffs paid are relatively low. In contrast, the garment industry also operates within an international chain, yet it is notably shorter and contends with markedly higher average tariffs. So for car manufacturing, the upstream trade cost index is relatively high because the chain is often tariff-based with relatively low individual tariffs that accumulate over the length of the value chain. For the garment industry, on the other hand, high individual tariffs matter a lot because the chain is relatively short. See also figure 6.3 in the appendix.

Regarding the downstream tariff cost index (figure 4.5 , right), food production stands out. Specifically, it is the food value chain, encompassing both agriculture (A01) and food processing (C10T12), that draws attention. Notably, the average tariff payments within this value chain significantly exceed those in other industries. However, it's important to note that the value chains of agriculture and food processing are not inherently longer or more internationally extended than other chains. Consequently, the elevated index can be attributed to the presence of relatively elevated tariffs. Figure 6.4 in the annex illustrates this.

Direct tariffs levied in the first step are limited for the upstream value chains compared to the whole index (figure 4.5, left). The tariff rates at the first step are the tariff rates applicable to the first stages of production for products that Dutch industries produce (downstream) or use as inputs (upstream), i.e. excluding tariff costs further up the value chain. For most goods sectors, the tariff paid on the first step by Dutch industries is less than half the size of the total upstream index. This illustrates that bilateral tariffs between the Netherlands and other (non-EU) countries determine only half of the total tariff costs that Dutch goods producers ultimately pay on their inputs.

Downstream, direct tariff charges in the first step are also lower than the tariff cost index, with much variation across industries (see figure 4.5, right). Especially in the food industry (C10T12) and the other transport equipment industry (C30), tariffs on Dutch exports account for a sizeable share of the downstream tariff cost index. This is because these industries have relatively short chains, limiting the scope for additional tariffs further upstream. In sectors with short upstream value chains, such as the base metal industry (C24) and the paper industry (C17), the share of direct tariffs is relatively small. The total tariff costs incurred on the way from an industry's output to the final consumer consist only to a limited extent of direct tariffs on Dutch exports, given that downstream value chains are relatively long and often taxed.

The share of total tariff rates levied at the EU external border is considerably higher downstream than the direct tariff charges paid by the Netherlands in the first step, while upstream the difference is limited. The downstream variation is more pronounced due to the extensive stages of production that Dutch value chains traverse, both within the EU and frequently beyond its borders. Consequently, there's an increased likelihood that at subsequent points within the value chain, the EU's external border is either encountered anew or revisited, leading to the imposition of tariff costs.

Figure 4.5 Average upstream and downstream Dutch tariff cost index for different freight industries

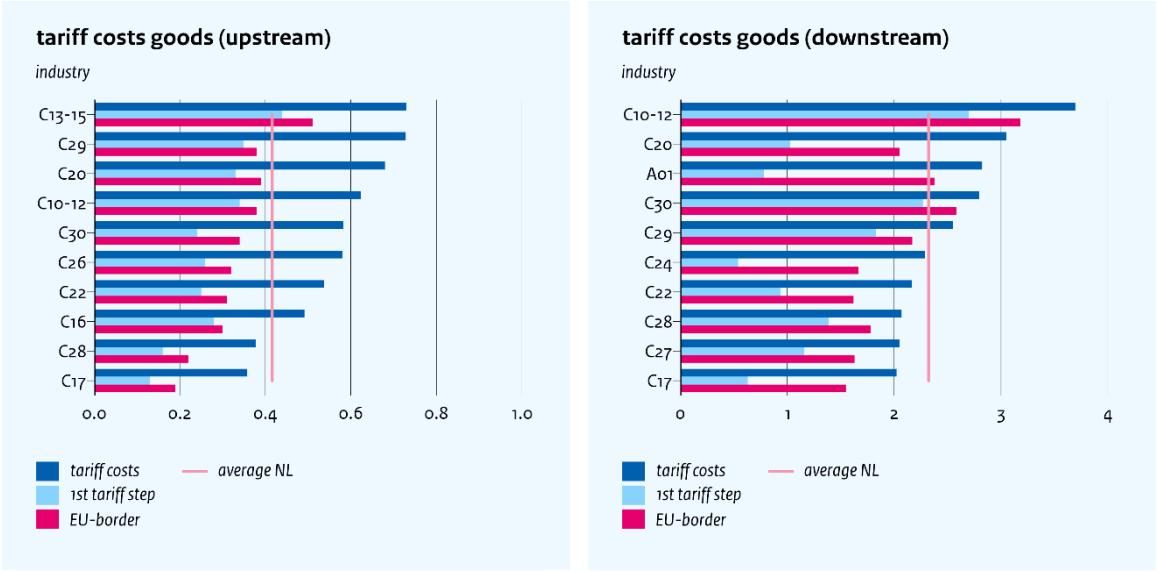


Figure note: Ten industries with the highest tariff cost index. Average for the Netherlands shows the weighted average across all Dutch industries with each industry's value added as a weight. Figures are for 2019.
Note (in alphabetical order): **A01** Agriculture; **C10-12** Food industry; **C13-15** Textile industry; **C16** Timber industry; **C17** Paper industry; **C20** Chemical industry; **C22** Plastics industry; **C24** Basic metal production; **C26** Electrical industry; **C27** Electrical appliance industry; **C28** Machinery industry; **C29** Automotive industry; **C30** Other transport equipment industry; **C31-32** Furniture industry.

4.3.2 Services

For services, the average tariff costs differ much more than for goods (see figure 4.6**).** This holds for both the upstream and downstream tariff cost index. Additionally, a noteworthy observation is that, in comparison to goods, the tariff costs associated with the top 10 industries in the upstream and downstream service value chains exhibit substantial disparities. Consequently, the two tariff cost indices in the domain of services manifest a more pronounced negative correlation than their counterparts in the realm of goods. For service industries, the index's composition is predominantly influenced by the length of the value chain. Industries characterized by value chains that encompass numerous upstream stages typically tend to possess a higher upstream tariff cost index, while conversely, those with fewer upstream stages exhibit the opposite pattern.

Among service industries, the Dutch hospitality industry (I) has the highest upstream tariff cost index and for the downstream index it is wholesale trade (G46). This is due to a relatively high openness of the Dutch value chain (see figure 6.5 in the annex). For instance, the upstream value chain of the Dutch hospitality industry uses relatively large amounts of inputs from outside the EU, to which tariffs apply. The Employment activities (N78) and wholesale trade (G46) have the highest downstream tariff cost index. For the Netherlands, healthcare has the lowest downstream tariff cost index.

Figure 4.6 Average upstream and downstream Dutch tariff cost index for different service industries

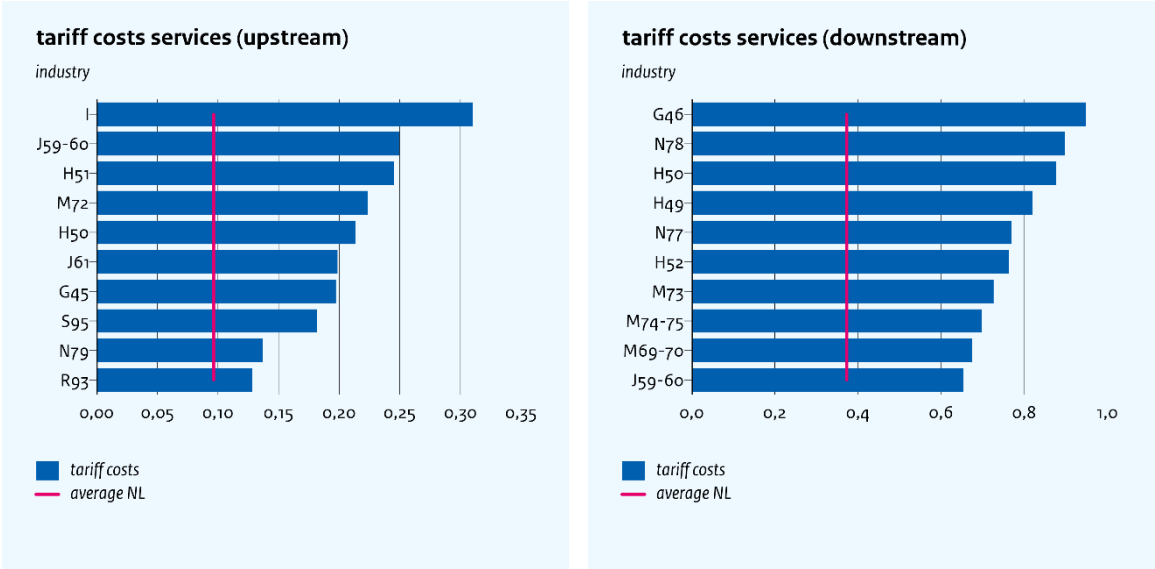


Figure note: Ten industries with the highest tariff cost index. Average for the Netherlands shows the weighted average across all Dutch industries with each industry's value added as a weight. Figures are for 2019.
Note (in alphabetical order): **G45** Wholesale and retail trade of motor vehicles; **G46** Wholesale trade other; **H49** Land transport services; **H50** Water transport services; **H51** Air transport services; **H52** Warehousing; **I** Hospitality; **J59-60** Film and TV; **J61** Telecommunications; **M69-70** Lawyers and accountants; **M72** R&D; **M73** Advertising services; **M74-75** Other business services; **N77** Rental and leasing services; **N78** Temporary employment agencies; **N79** Travel; **R93** Sports activities and entertainment; **S95** Repair of computer, household goods.

5 Distances versus tariffs

The geographical span of a value chain in which the Netherlands is involved nearly always surpasses the average span of value chains across all EU countries combined (as depicted in figure 5.1). The sole exception occurs in the case of goods in the downstream value chain, where the value chain's length is shorter for the Netherlands compared to the EU average. This fact not only underscores the Netherlands' engagement in a greater number of international value chains but also highlights that these value chains, in general, cover larger distances. It's worth noting that the value chains associated with the BRICS countries—both upstream and downstream—tend to traverse more extensive distances on average than those of Western nations.[15] This phenomenon is partly explained by the significant trade volume between these countries and OECD nations in general, with notable focus on the US and the EU. In contrast, the trade patterns of EU countries and the US predominantly revolve around immediate neighbours.[16] For instance, approximately 27% of China's exports are destined for the US and the EU, while 25% of Chinese imports originate from these regions. In comparison, around 21% of total US exports are directed to neighbouring countries Canada and Mexico, constituting 17% of total imports from these nations. Conversely, only about 10% of US exports find their way to China, and roughly 13% of imports are sourced from China.[17]

On average, the span of a value chain within the service industry is shorter than that of goods. The upstream value chain of goods is usually between 800 and 1500 km longer, downstream this quickly increases to 2500 km on average. Similar language and culture are more important for services than for goods, and these

[15] Brazil, Russia, India, China and South Africa.
[16] Another part of the explanation is that the BRICS countries are relatively distant from the other countries in the dataset and countries they trade with are only included in the *rest of the world* category (see section 4.1.1). For example, 15-16% of China's exports and imports are to and from countries that are members of the *Association of Southeast Asian Nations* (ASEAN)b but these countries are not included separately in the data.
[17] These figures are based on FIGARO in 2019.

differences tend to increase with distance (Grossman, 1998; Blum and Goldfarb, 2006). This possibly explains why the distance a service value chain spans is shorter than that of an average goods value chain.

Figure 5.1 Weighted average distance index across all industries at country level

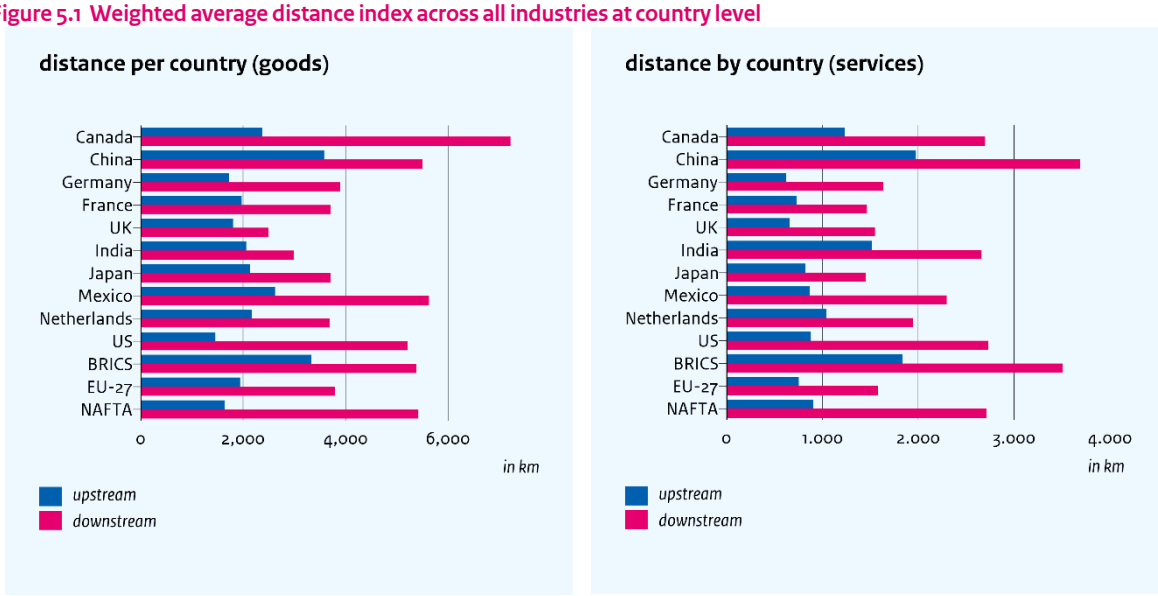


Figure note: To get a distance index by country, we weight the distance index by industry with value added. EU-27 is the weighted average of all 27 EU countries, where we use value added by country as a weight. Figures are for 2019.

The industry-wise average distance index among all 27 EU countries exhibits considerable variation (refer to Figure 6.11 in Annex 6.3.4). Within the upstream goods value chain, the basic metal industry emerges as a significant outlier, while downstream, the chemical industry stands out in terms of the extent covered by the value chain. This is notably reflected in the number of production stages, which exceeds the average for both industries (as indicated in figure 6.7 and figure 6.8). In the context of services, both for upstream and downstream value chains, transport services over water significantly overshadows others. In the broader spectrum of services, a recurring presence is observed from transport services and warehousing industries. Generally, service-oriented value chains tend to encompass notably shorter distances, both upstream and downstream.

A linear relationship exists between the average tariff cost index and distance index across all 27 EU countries for both goods and services (figure 5.2)**.** This means that the greater the distance that the value chain spans, the higher the total tariff costs in this value chain. Not only because intermediate products in value chains that span long distances are more likely to cross an international tariff border, but also because bilateral tariffs between countries that are further apart are on average higher.[18] Baier and Bergstrand (2007) find that nations are inclined to establish free trade agreements with those countries that already share a substantial trade volume, a tendency often observed among geographically proximate countries. Well-known examples are the EU, NAFTA, ASEAN and Mercosur. For EU-27 countries, the directional coefficient of the trend line in goods has a value of 2600 upstream and 400 downstream. Downstream, total tariff costs thus increase by 1 percentage point per 400 km. This is considerably more than downstream, where the increase is less, more than a factor of six. For services the directional coefficient of 10,200 for upstream value chains is also significantly larger than that of 4200 for downstream value chains.

Some industries clearly deviate from the general linear trend. Figure 5.2 shows that the petroleum industry (C19) is a notable outlier. Both upstream and downstream, tariff costs are relatively low despite the length of

[18] For countries less than 1,000 km apart, the average rate is 0.25%, between 1,000 and 5,000 km it is 0.45%, between 5,000 and 10,000 km it is 1.37% and above 10,000 km it is 1.65%. The variation in rates also increases sharply from 2% below 1,000 km to almost 4% above 10,000 km.

the value chain in terms of kilometres. The petroleum industry is part of a highly internationalised value chain with generally low tariffs. We observe a comparable pattern within the service industries of water (H50) and air transport services (H51) (see also figure 6.9 and figure 6.10). By contrast, the textile industry value chains (C13-15) span relatively short distances upstream relative to average high tariff costs (see also figure 6.7 bottom right). This industry often faces high import tariffs when products enter the EU.

Figure 5.2 Correlation between distance index and tariff cost index for the average of goods and services industries across all EU-27 countries

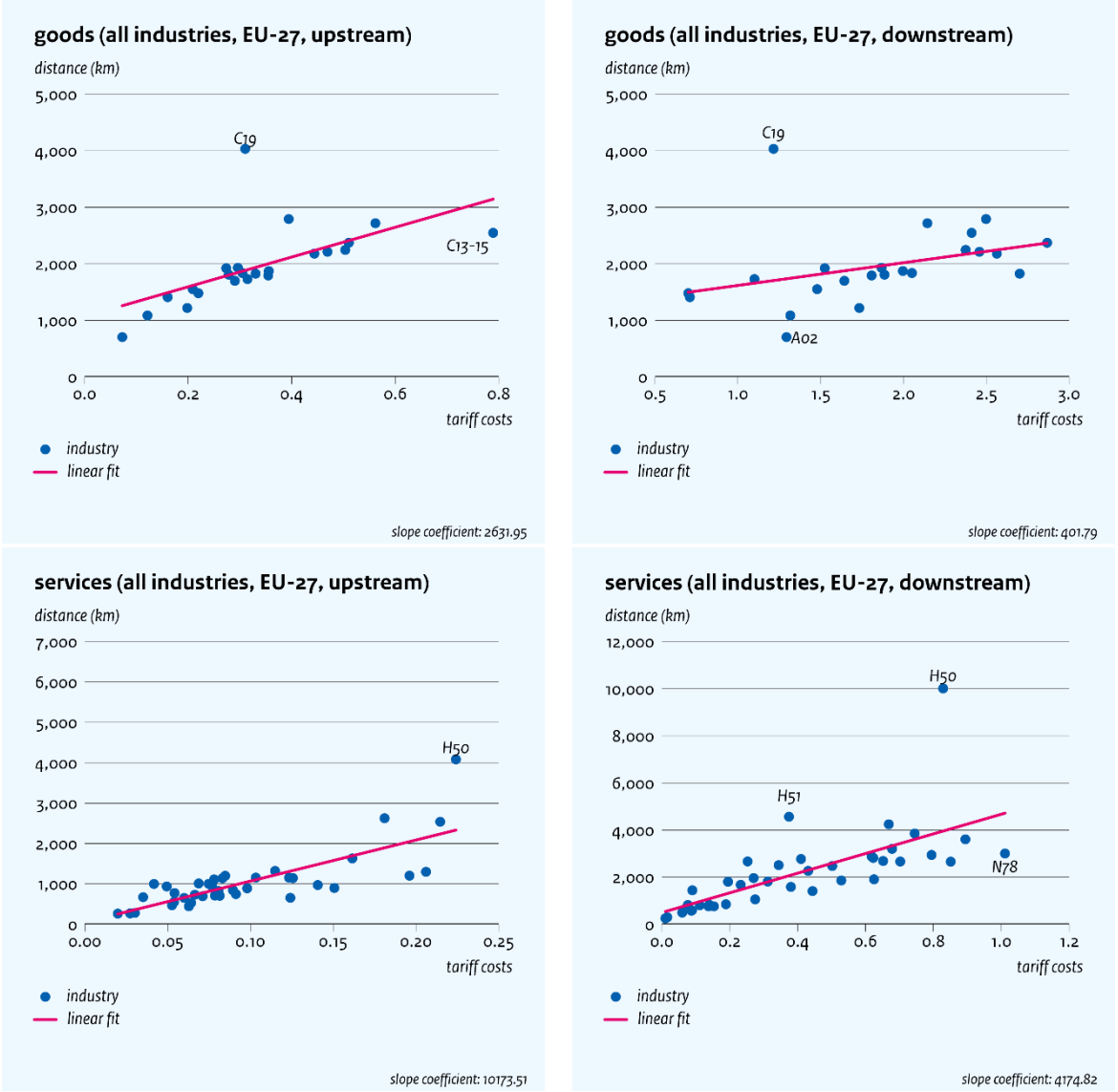


Figure note: The *outliers* indicated are: **A02** Forestry; **C13-15** Textile industry; **C19** Petroleum industry; **H50** Water transport services; **H51** Air transport services; **N78** Employment agencies. Figures are for 2019.

5.1 Netherlands

The value chains involving the Netherlands demonstrate relatively similar upstream and downstream distances, which remain closely aligned with the EU-27 average. However, when contrasting goods and services, we find that the average distance spanned by service industry value chains is notably shorter than that of goods, both for the upstream and downstream directions. ANoteworthy industry-level disparities also emerge, as highlighted in figure 6.12 in annex 6.3.4. Specifically, within the realm of goods, the electrical engineering industry significantly stands out both upstream and downstream. Moreover, in the downstream direction, the chemical industry's value chains also extend over considerable distances. In the realm of services, a prominent observation is the extensive upstream value chain span of the Dutch film and TV industry. Additionally, the water transport sector is remarkable for being associated with value chains that traverse substantial distances in both the upstream and downstream directions.

Likewise, within the value chains in which the Netherlands is an active participant, a consistent trend emerges: both upstream and downstream tariff costs exhibit a linear increase in relation to the extent of the value chain's span (refer to figure 5.3). In a broader context, the tariff costs for goods and services appear to experience a less steep escalation with the increase in upstream or downstream distance compared to the EU-27 average. An exception arises in the upstream segment of service value chains, where the directional coefficient at 8500 is lower than the EU-27 average, albeit by a minimal margin. The precise underlying reason for this divergence remains a subject for future investigation. However, it is pertinent to note that the value chains involving the Netherlands manifest a greater distance (as depicted in Figure 5.1), are more international, and yield higher tariff cost indices (as indicated in Figure 4.1). Conceivably, correlation might play a role.

Similar to the EU-27 average, certain Dutch industries deviate from the linear relationship. Once again, the petroleum industry's value chains (C19), both upstream and downstream, feature relatively low tariff costs despite the extended distances spanned by the value chain. A comparable trend is observed in the electrical industry (C26) upstream and the chemical industry (C20) downstream. A distinct case arises with the food industry (C10-12), where the downstream value chain traverses a relatively short distance relative to tariff costs. This peculiarity can be attributed to the industry encountering higher average tariff costs downstream in the value chain (as demonstrated in figure 6.4 bottom right). Consequently, non-EU countries impose bilateral tariffs averaging at 16% on products from this industry within the EU. This circumstance likely leads to a higher concentration of the value chain within the EU. Within the realm of service industries, the film and TV sector (J59-60) displays a distinct pattern. Its value chains demonstrate relatively low tariff costs upstream in relation to the span of the value chain. This characteristic results in the value chains of this industry being an outlier (see figure 6.5 top right).

Figure 5.3 Correlation between distance index and tariff cost index for goods and services industries at Dutch level

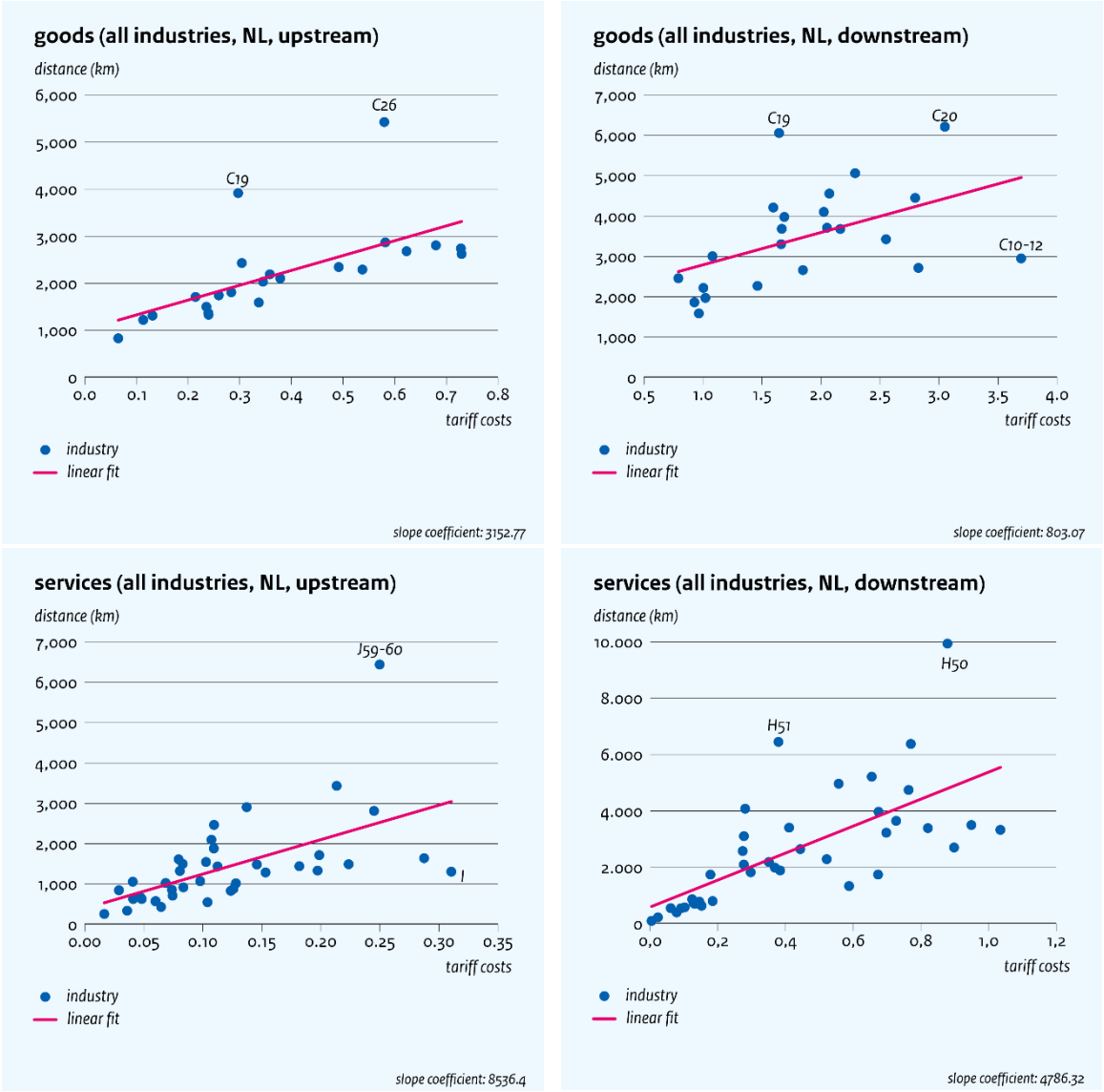


Figure note: The *outliers* indicated are: **C10-12** Food industry; **C19** Petroleum industry; **C20** Chemical industry; **C26** Electrical industry; **H50** Water transport services; **H51** Air transport services; **I** Hospitality industry; **J59-60** Film and TV. Figures are for 2019.

6 Annexes

6.1 Construction of trade cost index

The purpose of the trade cost index is to determine the trade costs incurred along the entire value chain of a product.[19] We have the option to concentrate on either the upstream or the downstream chain. The upstream index captures the sum of trade costs incurred in the production of a good on the intermediate supply value chain as a share of the value of the good produced. The downstream index summarises the trade costs of a good before it becomes part of final consumption. These indices can be calculated using standard methods from input-output analysis. Here, we follow the setup of Miroudot and Nordström (2020). This section also appeared in full in Boeters et al. (2023).

6.1.1 Upstream

For the case of one aggregate industry per country, the upstream (*u*) trade cost index TCI_j^u for imports of intermediate products from country *j* may be calculated as:

$$TCI_j^u = \sum_k \alpha_{kj} t_{kj} + \sum_k \alpha_{kj} \sum_l \alpha_{lk} t_{lk} + \sum_k \alpha_{kj} \sum_l \alpha_{lk} \sum_m \alpha_{ml} t_{ml} + \cdots.$$

TCI_j^u signifies the accumulated trade costs incurred by country *j* across all intermediate products, expressed as a share of the value of gross production. The bilateral trade costs for exports from country k to country j (as a share of the underlying trade value) are given by t_{kj}. The value share α_{kj} is the input coefficient which indicates how many inputs from country *k* are needed in country *j* to produce one good, where $\sum_k \alpha_{kj} < 1$.[20] The first term in the sum indicates the trade costs on direct intermediate supplies, the second term the intermediate supplies in the second step and so on.

The above equation can be rewritten in matrix notation:

$$TCI^u = W^\alpha + A'W^\alpha + A'^2W^\alpha + \cdots.$$

The upstream trade cost index TCI^u summarises all countries and is a $K \times 1$ vector containing the number of countries K. W^α is the $K \times 1$ vector of weighted trade costs in which element j is given by $\sum_k \alpha_{kj}\, t_{kj}$, and A is the $K \times K$ matrix with input coefficients. In all bilateral matrices, the rows represent the exporting country, while the columns represent the importing country. Using the Leontief inverse, this infinite sum can be rewritten to:

$$TCI^u = [I - A']^{-1} W^\alpha,$$

where I the $K \times K$ identity matrix is. Using this formula, it is possible to calculate the upstream trade cost index for each country in one step.

[19] We discuss here the construction of the trade cost index in a general sense. The tariff cost and distance index are a special case of the trade cost index. Apart from tariffs, there are other forms of trade costs: trade and transport margins, non-tariff trade measures (NTMs). These are more complicated, partly due to data availability reasons. Therefore, we leave them aside for now.
[20] In the international literature, these are also *called direct requirement coefficients*.

So far we have assumed an economy aggregated to a single industry, but now we generalise to a *Q*-industry economy:

$$TCI_j^{r,u} = \sum_{k,s} \alpha_{kj}^{sr} t_{kj}^{sr} + \sum_{k,s} \alpha_{kj}^{sr} \sum_{l,u} \alpha_{lk}^{us} t_{lk}^{us} + \sum_{k,s} \alpha_{kj}^{sr} \sum_{l,u} \alpha_{lk}^{us} \sum_{m,v} \alpha_{ml}^{vu} t_{ml}^{vu} + \cdots.$$

Here, upstream trade costs for production in country j and industry r are given by $TCI_j^{r,u}$. All variables contain two additional indices for the supplying and receiving industry. α_{kj}^{sr} is the input coefficient for deliveries from industry s in country k to industry r in country j, and t_{kj}^{sr} are the associated trade costs.[21] Once more, we can depict this using the same matrix format as described earlier, with the distinction that the matrices now encompass dimensions of KQ×KQ. In this representation, the rows correspond to exporting country k and encompass all Q industries, while the columns correspond to importing country j and encompass all Q industries as well.

6.1.2 Downstream

The downstream (*d*) trade cost index of industry *q* in country *i* can be calculated in a similar fashion to the upstream index, only with a different type of value shares for aggregation:

$$TCI_i^{q,d} = \sum_k \left(\varphi_{ik}^q t_{ik}^{qC} + \sum_s \beta_{ik}^{qs} t_{ik}^{qs} \right) + \sum_{k,s} \beta_{ik}^{qs} \sum_l \left(\varphi_{kl}^s t_{kl}^{sC} + \sum_t \beta_{kl}^{st} t_{kl}^{st} \right) + \sum_{k,s} \beta_{ik}^{qs} \sum_{l,t} \beta_{kl}^{st} \sum_m \left(\varphi_{lm}^t t_{lm}^{tC} + \sum_u \beta_{lm}^{tu} t_{lm}^{tu} \right) + \cdots.$$

The value share β_{ik}^{qs} is the output coefficient that indicates the share of the output of industry q in country i that is supplied to industry s in country k; φ_{ik}^q is the output coefficient for final demand in country k.[22] All output coefficients of a good add up to 1: $\varphi_{ik}^q + \sum_{k,s} \beta_{ik}^{qs} = 1$. The corresponding tariff rates are t_{ik}^{qs} and t_{ik}^{qC}.

The equation for the downstream index can also be rewritten in matrix notation:

$$TCI^d = W^\beta + BW^\beta + B^2 W^\beta + \cdots.$$

TCI^d is a $QK \times 1$ vector, W^β is the $QK \times 1$ weighted trade cost vector in which the element W_{iq}^β is given by $W_{iq}^\beta = \sum_k \left(\varphi_{ik}^q t_{ik}^{qC} + \sum_s \beta_{ik}^{qs} t_{ik}^{qs} \right)$. Finally, B the $QK \times QK$ matrix of output coefficients. Using the Ghosh inverse, this sum can be rewritten to:

$$TCI^d = [I - B]^{-1} W^\beta.$$

Using this formula, it is possible to calculate the downstream trade cost index for each country-industry combination.

6.1.3 Trade cost decomposition index

To understand the variations in the upstream or downstream trade cost index among country-industry pairs, it proves useful to dissect the distinct components constituting the trade cost index. For example, two country-industry pairs may have similar trade cost indices, the factors contributing to these two similar indices could be different. The trade cost index for a country-industry combination may be low because the

[21] In practice, trade costs will not vary by receiving industry in most cases. Nevertheless, for symmetry, we add a second industry index *s* here.
[22] In the international literature, these are also called *allocation coefficients*.

value chain in question is largely national or because trade costs in the value chain in question are low. In this section, we deal with the decomposition of the upstream index. This decomposition can be applied in the same way to the downstream index.

The trade cost index for a country-industry combination will, *ceteris paribus*, be higher when: (*i*) value chains are longer, (*ii*) the number of country border crossings in the value chain increases, (*iii*) a country is less likely to participate in FTAs and thus has to pay more often at border crossings (taxed part), and (*iv*) if average tariff rates at taxed border crossings increase. To capture the relative importance of these determinants for the trade cost index, we calculate a set of auxiliary indicators. The calculation of the indicators is rather similar to the calculation of the trade cost index itself. Combined, these indicators lead to the trade cost index.

First, the length of the value chain (D^{lng}) to the country-industry combination equals the value-weighted sum of all intermediate supplies required for production for this and all previous production steps:

$$D^{lng} = [I - A']^{-1} W^{lng}.$$

The calculation corresponds to the trade cost index itself, except for the W-vector. The element of W^{lng} with the indices r, j is given by $\sum_{k,s} \alpha_{kj}^{sr}$. Compared with W^{α} of the trade cost index, the trade cost percentage t_{kj}^{sr} falls away. This measure is equal to the *embodied production stages* minus 1 of Fally (2012). This disparity arises because Fally considers all production stages leading up to and encompassing the combination itself, whereas our examination involves all production stages traversed leading up to the combination.

For the second indicator, the number of country border crossings in the value chain (D^{int}), only value flows that cross the border are included:

$$D^{int} = [I - A']^{-1} W^{int}.$$

Again, the only difference in the calculation is in the W-vector. The element of W^{int} with the indices r, j is given by $\sum_{k,s} \alpha_{kj}^{sr} \iota_{kj}^{sr}(k \neq j)$. $\iota_{kj}^{sr}(k \neq j)$ is an indicator variable that takes the value 1 if $k \neq j$ and 0 otherwise. Miroudot and Nordström (2020) have a similar measure called foreign production stages.

The third indicator is the number of border crossings where trade costs are incurred in the value chain (D^{cst}). Here, only the value flows for which trade costs are incurred are included:

$$D^{cst} = [I - A']^{-1} W^{cst}.$$

The element of W^{cst} with the indices r, j is given by $\sum_{k,s} \alpha_{kj}^{sr} \iota_{kj}^{sr}(t_{kj}^{sr} > 0)$. The indicator variable is now equal to 1 if the trade cost associated with the value stream is positive, otherwise the indicator is 0.

Finally, the average nominal trading costs across all value stream with trading costs ($\overline{T}^{nom}$), the fourth indicator, are by definition equal to:

$$\bar{T}_j^{r,nom} = TCI_j^{r,u} / D_j^{r,cst},$$

where $\overline{T}_j^{r,nom}$ and $D_j^{r,cst}$ are the country-industry average nominal trade costs and the country-industry number of taxed trade flows, respectively. With these definitions $d_j^{r,int} = D_j^{r,int} / D_j^{r,lng}$ and $d_j^{r,cst} = D_j^{r,cst} / D_j^{r,int}$ the decomposition by country-industry combination results in:

$$TCI_j^{r,u} = \bar{T}_j^{r,nom} \cdot D_j^{r,lng} \cdot d_j^{r,int} \cdot d_j^{r,cst}.$$

The trade cost index for a country-industry combination results from the average nominal trade cost ($\bar{T}_j^{r,nom}$), the length of the value chain ($D_j^{r,lng}$), number of country border crossings in each country-industry combination ($d_j^{r,int}$) and the taxed trade flows relative to free trade flows ($d_j^{r,cst}$).

6.2 Data

6.2.1 World input- output table

The main data source for the structure and size of value chains is a world input-output table, also called Multi-Regional Input-Output (MRIO) table. For the various countries and industries, this table contains the value of all intermediate-use deliveries between them, i.e. from one country-industry combination to another country-industry combination. In addition, it includes the value of gross production, final demand (consumption, investment) and value added of each country-industry combination. For final demand, the products and/or services of a country-industry combination are broken down by country of destination. For example: the table may include a value for delivery of agricultural products from the Netherlands for final use in China. This is then an export for the Netherlands and an import for China. Another example is a delivery from the machinery industry in Germany to the automotive industry in the US. International trade is thus an integral part of an MRIO.

The data in an MRIO satisfy two accounting identities. The gross production value of a country-industry is equal to the value of all intermediate deliveries to all country-industry combinations (including to itself) plus deliveries to all countries for final use (including in-country). In addition, the value added of a country-industry is always equal to the gross production value minus the value of all intermediate supplies of all country-industry combinations.

The MRIO we use is Eurostat's FIGARO.[23] The countries in FIGARO are the 27 EU member states, the UK, the US, Japan, China, 13 other countries and a Rest-of-the-World category, i.e. the table contains data on all world production and world trade (see table 6.2). The dataset includes 64 industries (see table 6.3) and is available from 2010 to 2020. We use the 2019 data for the analysis.[24]

6.2.2 Data rates and distances

The source for the tariff data is the World Integrated Trade Solution (WITS) of the World Bank. This dataset contains bilaterally levied tariffs at a very detailed product level. In total, we can distinguish more than 6,500 products for almost 200 trading partners. We aggregate tariffs to the level of industries and the set of countries from FIGARO, including a Rest-of-the-World *category*, which is an average of all non-FIGARO countries. Tariffs are only available for goods, as imports of services are generally not subject to tariffs.

To aggregate products to industries, we use World Bank translation tables (concordances). These translation tables allow us to link different products to the industry of production. With this, we aggregate tariffs on products unweighted to industry level. We refrain from applying weights in this context, as doing so

[23] We use the 2022 release. For further details on the FIGARO database, see Rémond-Tiedrez and Rueda-Cantuche (2019) and the Eurostat website (link).
[24] Note that with 46 countries and 64 industries, more than 8 mln intermediate supplies can be identified (46 x 64 x 46 x 64 = 2944 x 2944 = 8,667,136).

would potentially distort the representation, given our anticipation that countries are likely to engage in more trade of specific products when tariffs on those products are low.

Given that tariffs are aggregated to industry level, we can link them to FIGARO trade data. Tariffs vary across importers, exporters and the exporting industry (or product). Tariffs are logically constant across importing industries within a country: it does not matter who in a country imports a particular good for the level of the tariff. We link tariff data with three dimensions to the four dimensions of the FIGARO data, so tariffs do not vary across importing industries or type of use (intermediate or final use).

The dataset with distances between countries comes from the CEPII GeoDist dataset.[25] These data show the physical distances (in km) between countries. The dataset is broader and also includes variables such as common language between two trading partners or colonial pasts. We only use distance in our distance index.

6.3 Results

6.3.1 Variations between industries in the EU

European industries differ significantly from their Dutch counterparts. For the Netherlands, the upstream and downstream value chains of industries are structured differently from the EU average. Thus, products made in these value chains may face higher tariffs or, on the contrary, longer, more international chains. For instance, Dutch food processing (C10T12) has significantly higher tariff cost indices both upstream and downstream than the EU average.

Goods

The upstream tariff cost index for goods shows large differences between industries (see figure 6.1 (left)). In particular, the upstream value chain for the textile industry (C13T15) is an outlier. This is caused by the relatively high tariffs in this value chain that apply to relatively many stages. For other industries (not shown), the index is actually lower. This is especially true for agriculture and mining with relatively short upstream value chains. Figure 6.7 in the annex illustrates the decomposition.

The downstream tariff cost index has less variation, particularly within the top 10 (see figure 6.1 (right)). The highest downstream tariff cost index is for the chemical industry (C20). This industry is part of long downstream value chains that are highly internationalised. As a result, the chemical industry has an average high index despite relatively low tariffs. The electrical appliances industry (c27) also has a high index, although its downstream value chain exhibits distinct characteristics. It is less internationalised, but has higher average tariffs. See also figure 6.8.

[25] See Mayer and Zignago, 2011

Figure 6.1 Average upstream and downstream EU-27 tariff cost index for different goods industries

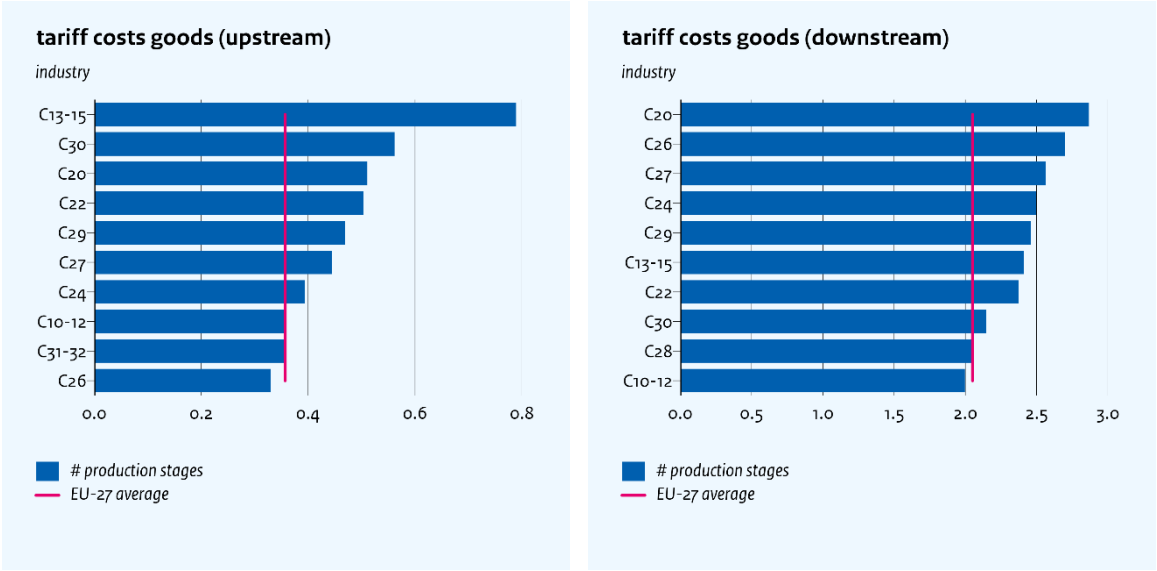


Figure note: Ten industries with the highest tariff cost index. Average for EU-27 shows the weighted average across all industries of the 27 EU countries with the value added of each country-industry combination as weight. Figures are for 2019.
Note (in alphabetical order): **C10-12** Food industry; **C13-15** Textile industry; **C20** Chemical industry; **C22** Plastics industry; **C24** Basic metal industry; **C26** Electrical industry; **C27** Electrical equipment industry; **C28** Machinery industry; **C29** Automotive industry; **C30** Other transport equipment industry; **C31-32** Furniture industry.

Services

Air and water transport services (H50 and H51) has the highest upstream tariff cost index. Despite this, the index is still lower than the average of the index for goods industries. These service industries have relatively goods-intensive (i.e. transport goods) supply chains. Moreover, the value chains are long and international, so tariffs are levied in a large part of the value chain (see figure 6.9 in this appendix for illustration). However, among the industries with the lowest index (not shown) are the employment activities, education and insurance activities. These have mainly short value chains, which are mostly domestic.

On the contrary, the downstream index is the highest among services for the employment activities (N78). This is because the downstream value chain for this industry is long, crosses international borders relatively often and is burdened by tariffs. This is related to the type of services of this industry, which end up at various companies. The lowest downstream index applies to health care, which has a relatively high upstream index. Since the vast majority of health care services end up directly with consumers and the downstream value chain is thus very short and low in tariffs, this is no surprise.

Figure 6.2 Average upstream and downstream EU-27 tariff cost index for different service industries

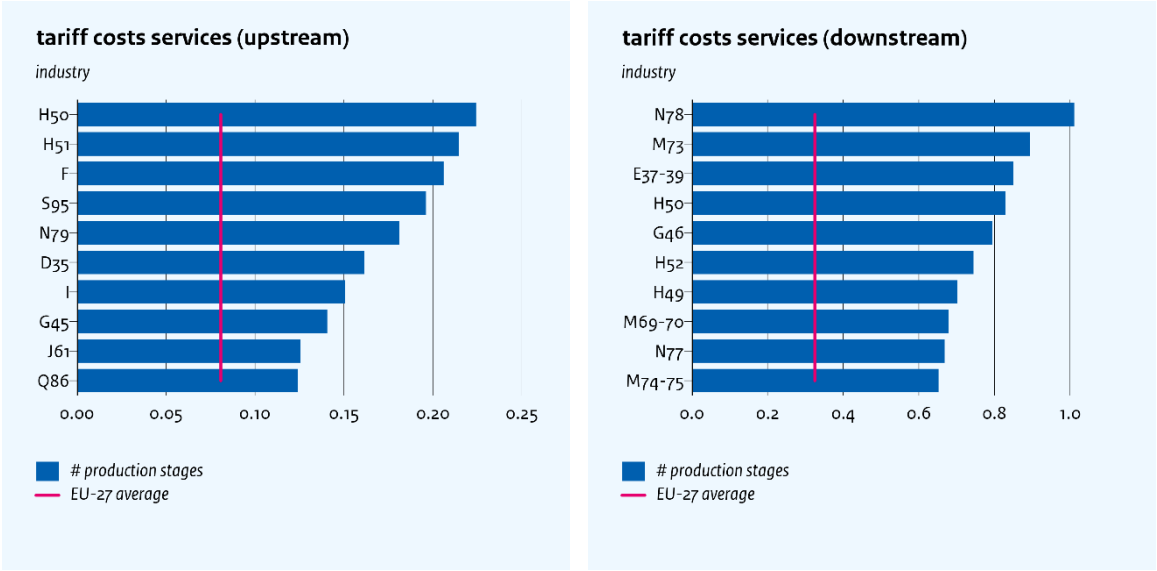


Figure note: Ten industries with the highest tariff cost index. Average for EU-27 shows the weighted average across all industries of the 27 EU countries with the value added of each country-industry combination as weight. Figures are for 2019.
Note (in alphabetical order): **D35** Energy; **E37-39** Waste; **F** Construction; **G45** Wholesale and retail sales of motor vehicles; **G46** Other wholesale trade; **H49** Land transport services; **H50** Water transport services; **H51** Air transport services; **H52** Warehousing; **I** Hotels and restaurants; **J61** Telecommunications; **M69-70** Lawyers and accountants; **M73** Advertising services; **M74-75** Other business services; **N77** Rental and leasing; **N78** Temporary employment agencies; **N79** Travel; **Q86** Health services; **S95** Repair of computers, household goods.

6.3.2 Decomposition of the tariff cost index of the Netherlands

Goods

Figure 6.3 Upstream tariff cost index of The Netherlands for goods: decomposition

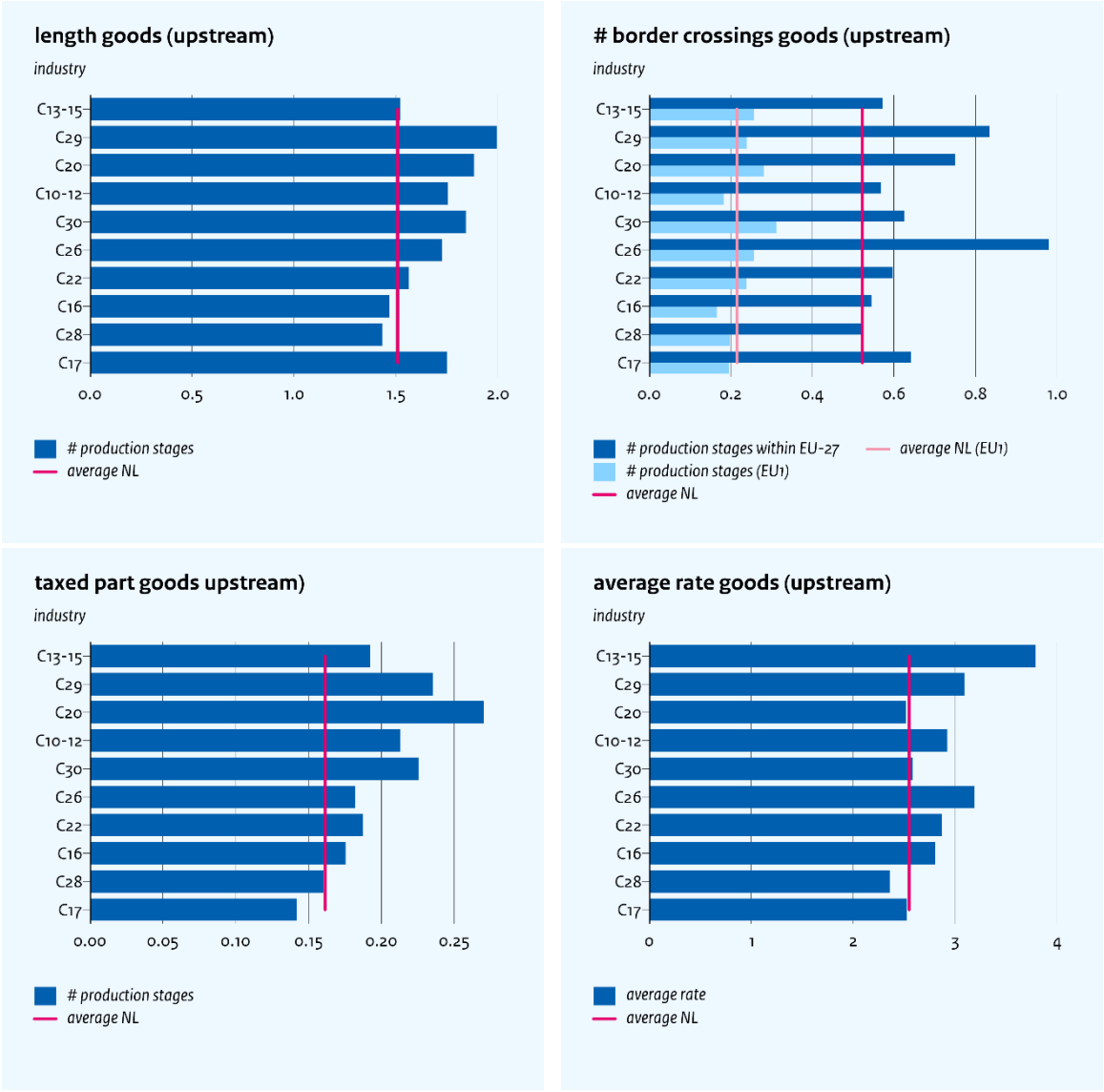


Figure note: Ten industries with the highest tariff cost index. Average for the Netherlands shows the weighted average across all Dutch industries with each industry's value added as a weight. See table 6.1 for an explanation of the terms. Figures are for 2019.
Note (in alphabetical order): **C10-12** Food industry; **C13-15** Textile industry; **C16** Wood industry; **C17** Paper industry; **C20** Chemical industry; **C22** Plastic industry; **C26** Electrical industry; **C28** Machinery industry; **C29** Automotive industry; **C30** Other transport equipment industry.

Figure 6.4 Downstream tariff cost index of the Netherlands for goods: decomposition

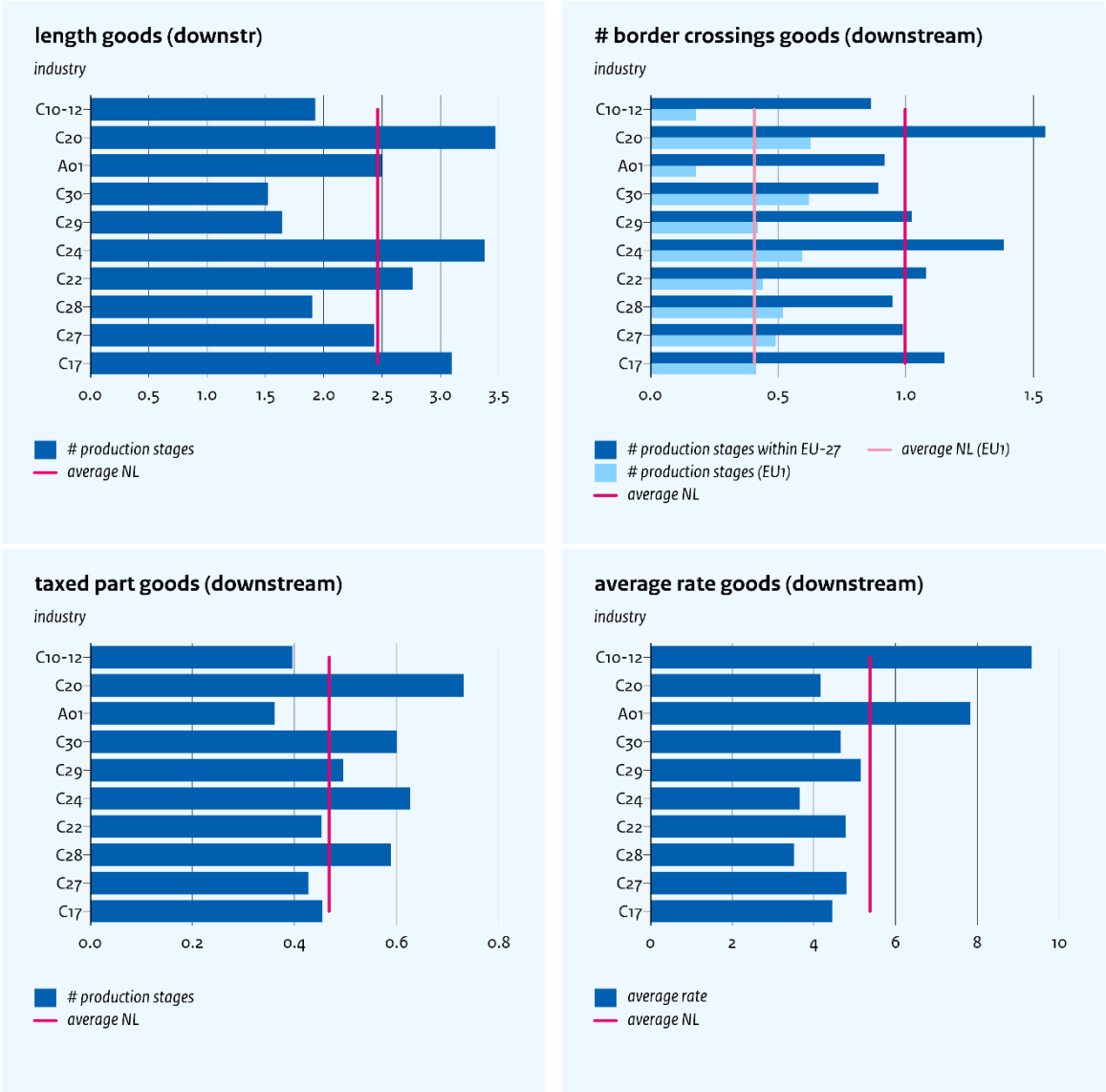


Figure note: Ten industries with the highest tariff cost index. Average for the Netherlands shows the weighted average across all Dutch industries with each industry's value added as a weight. See table 6.1 for an explanation of the terms. Figures are for 2019.
Note (in alphabetical order): **A01** Agriculture; **C10-12** Food industry; **C17** Paper industry; **C20** Chemical industry; **C22** Plastics industry; **C24** Basic metal production; **C27** Electrical equipment industry; **C28** Machinery industry; **C29** Automotive industry; **C30** Other transport equipment industry.

Services

Figure 6.5 Upstream tariff cost index of the Netherlands for services: decomposition

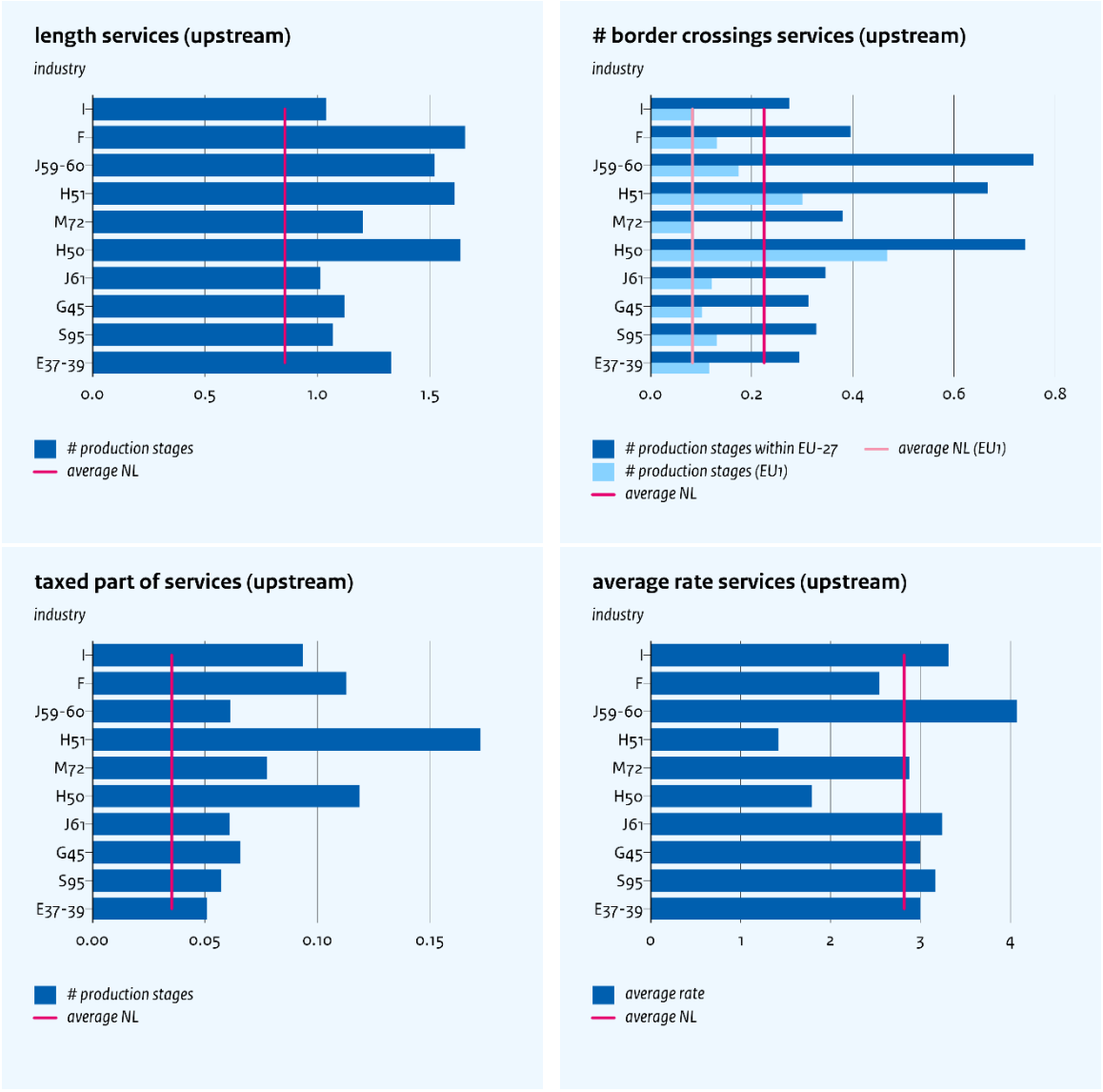


Figure note: Ten industries with the highest tariff cost index. Average for the Netherlands shows the weighted average across all Dutch industries with each industry's value added as a weight. See table 6.1 for an explanation of the terms. Figures are for 2019.
NB (in alphabetical order): **E37-39** Waste; **F** Construction; **G45** Wholesale and retail sale of motor vehicles; **H50** Water transport services; **H51** Air transport services; **I** Hospitality; **J59-60** Film and TV; **J61** Telecommunications; **M72** R&D; **S95** Repair of computer, household goods.

Figure 6.6 Downstream tariff cost index of the Netherlands for services: decomposition

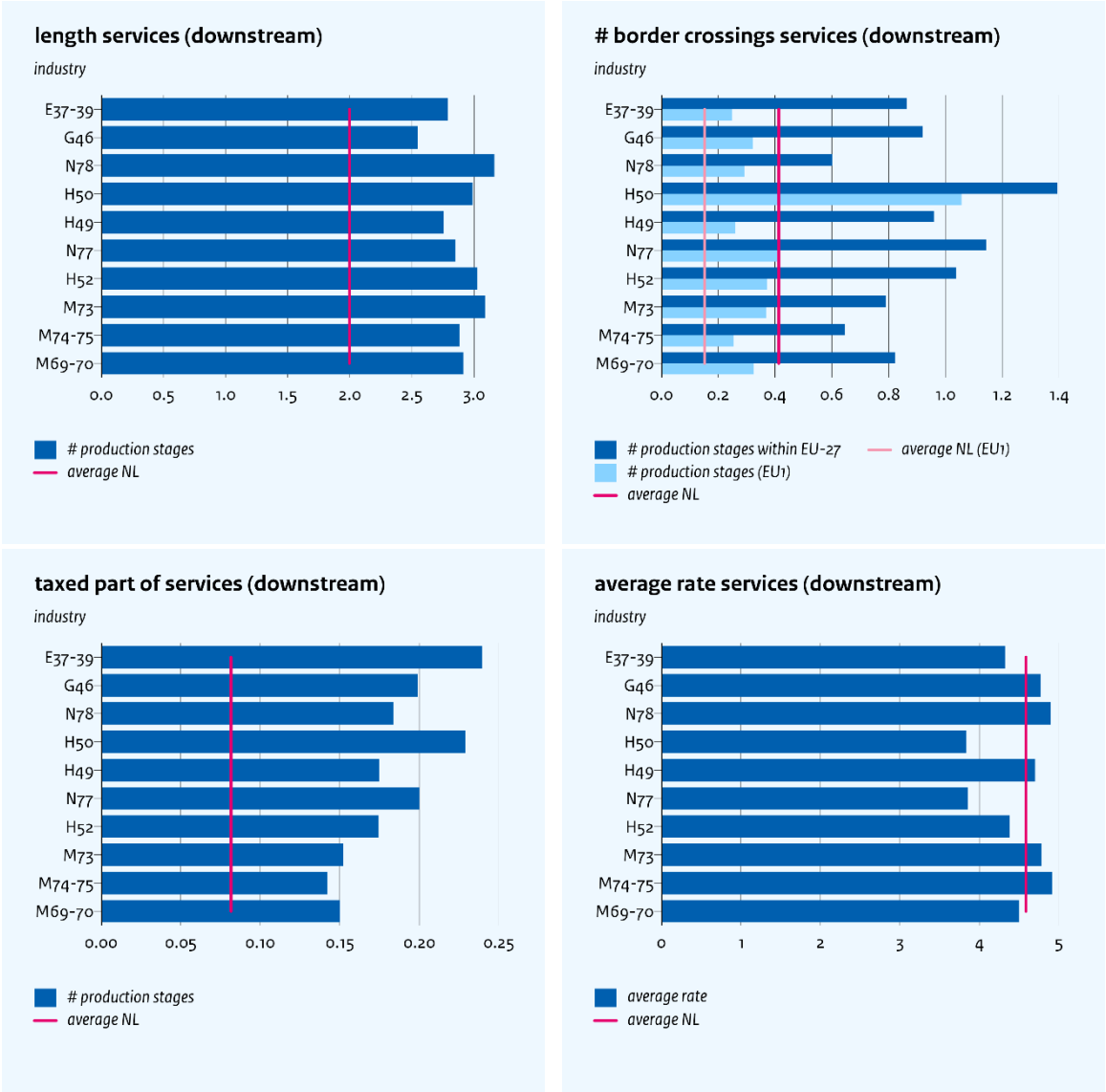


Figure note: Ten industries with the highest tariff cost index. Average for the Netherlands shows the weighted average across all Dutch industries with each industry's value added as a weight. See table 6.1 for an explanation of the terms. Figures are for 2019.
Note (in alphabetical order): **E37-39** Waste; **G46** Wholesale trade other; **H49** Land transport services; **H50** Water transport services; **H52** Warehousing; **M69-70** Lawyers and accountants; **M73** Advertising services; **M74-75** Other business services; **N77** Rental and leasing; **N78** Temporary employment agencies.

6.3.3 Decomposition of EU-27 tariff cost index

Goods

Figure 6.7 EU-27 upstream tariff cost index for goods: decomposition

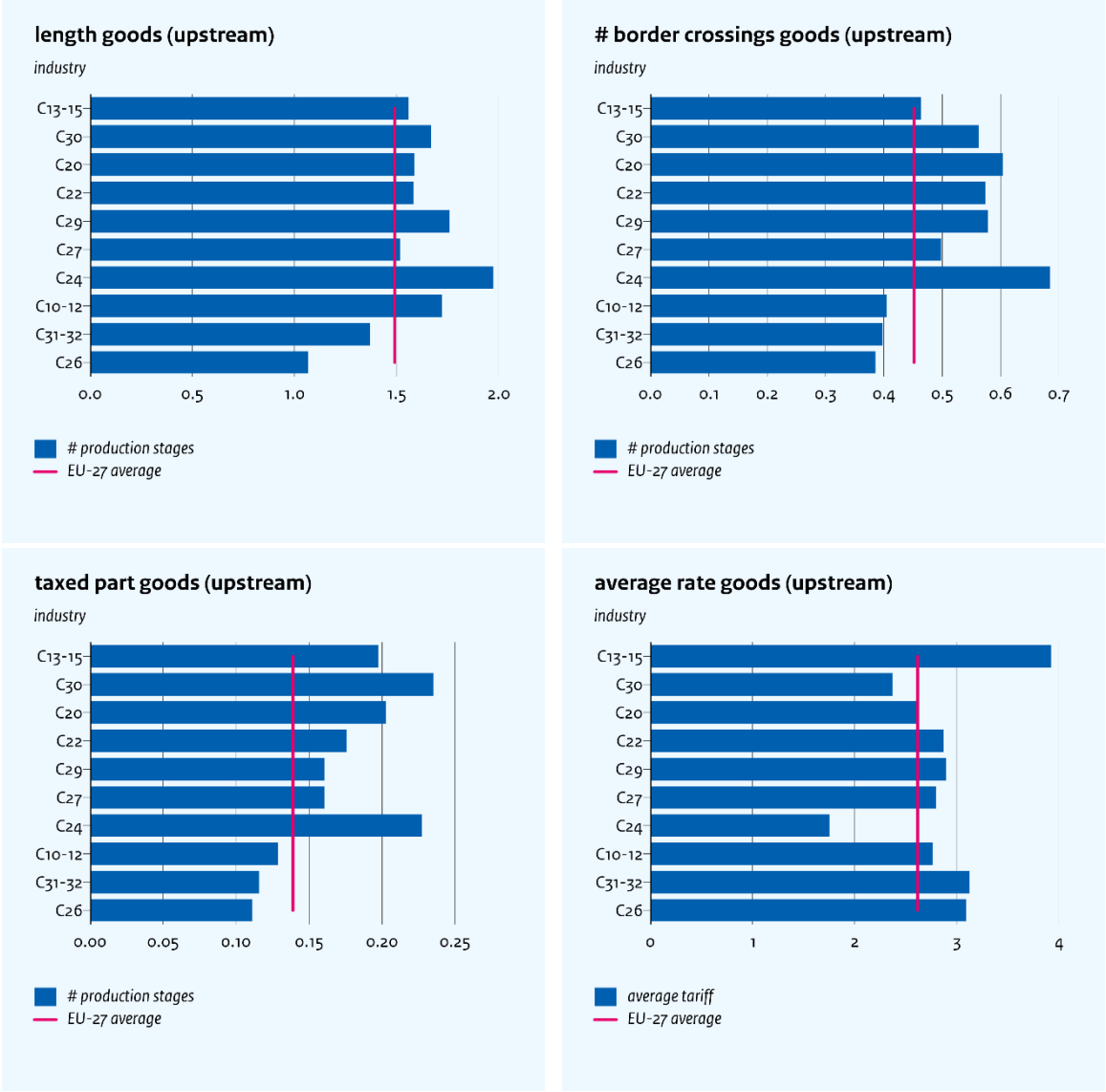


Figure note: Ten industries with the highest tariff cost index. Average for EU-27 shows the weighted average across all industries of the 27 EU countries with the value added of each country-industry combination as weight. See table 6.1 for an explanation of the terms. Figures are for 2019.
Note (in alphabetical order): **C10-12** Food industry; **C13-15** Textile industry; **C20** Chemical industry; **C22** Plastic industry; **C24** Basic metal production; **C26** Electrical industry; **C27** Electrical appliance industry; **C29** Automotive industry; **C30** Other transport equipment industry; **C31-32** Furniture industry.

Figure 6.8 EU-27 downstream tariff cost index for goods: decomposition

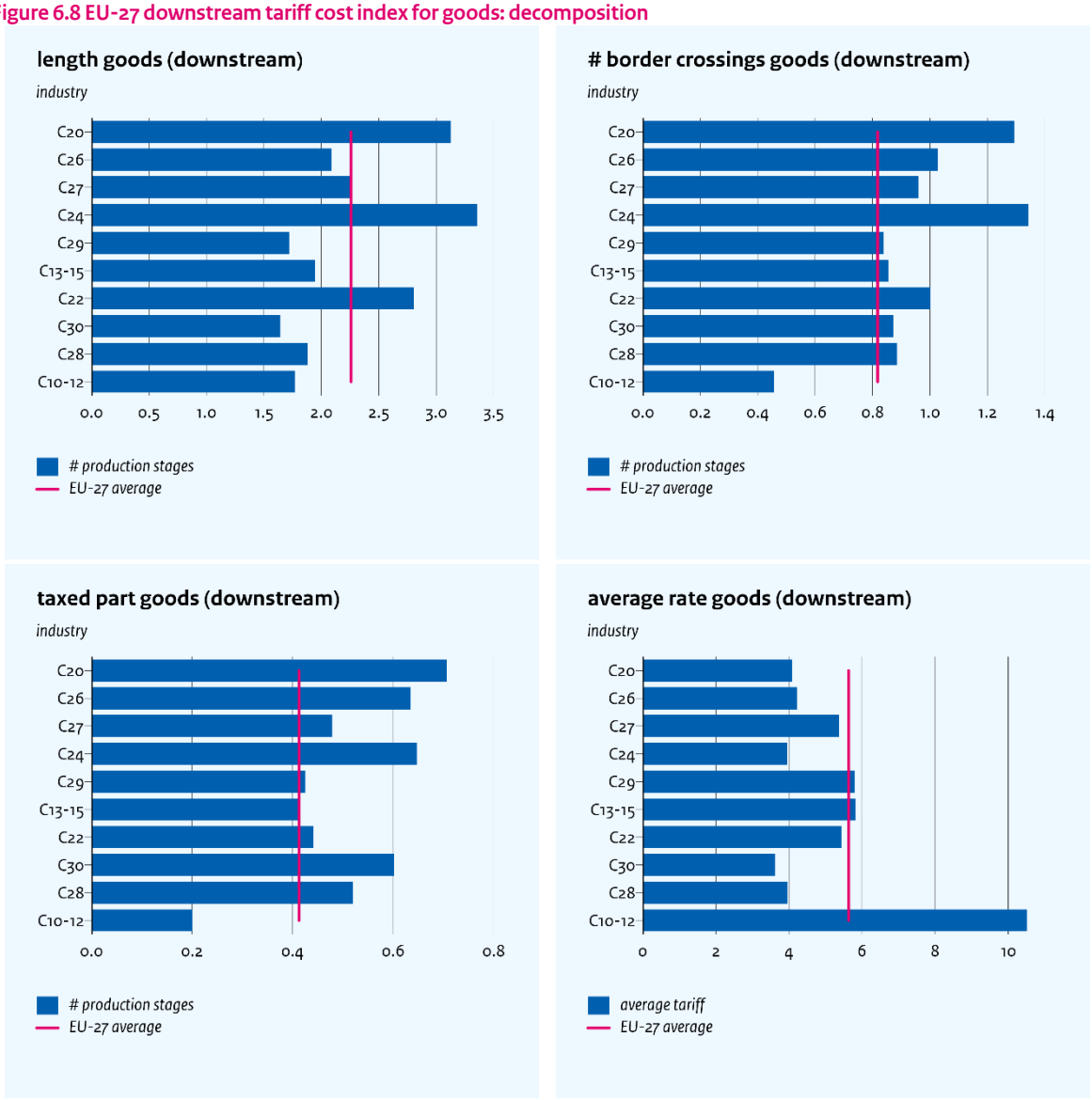


Figure note: Ten industries with the highest tariff cost index. Average for EU-27 shows the weighted average across all industries of the 27 EU countries with the value added of each country-industry combination as weight. See table 6.1 for an explanation of the terms. Figures are for 2019.
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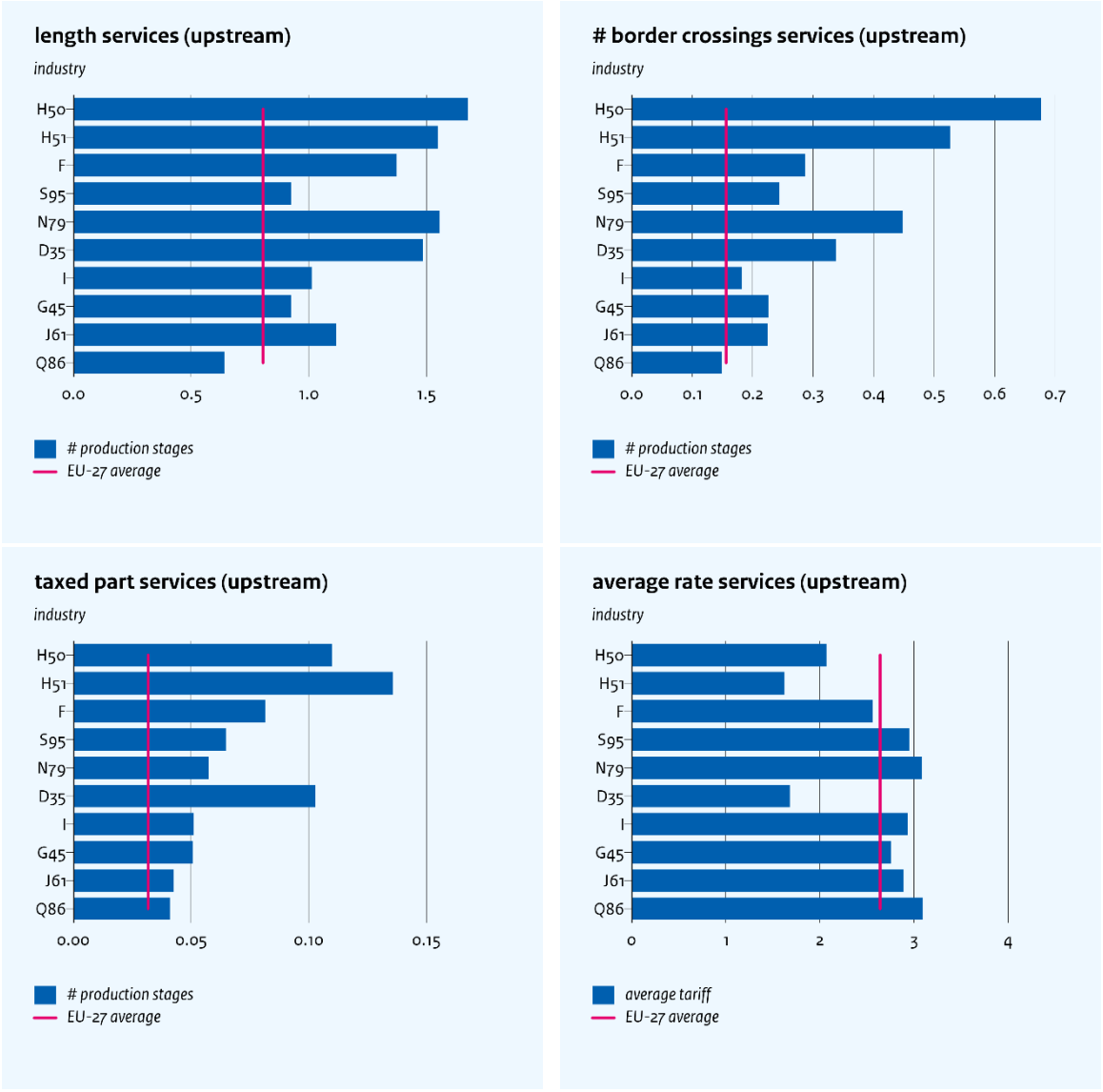
Services

Figure 6.9 EU-27 upstream tariff cost index for services: decomposition



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NB (in alphabetical order): **D35** Energy; **F** Construction; **G45** Wholesale and retail motor vehicles; **H50** Water transport services; **H51** Air transport services; **I** Hospitality; **J61** Telecommunications; **N79** Travel; **Q86** Healthcare; **S95** Repair of computer, household goods.

Figure 6.10 EU-27 downstream tariff cost index for services: decomposition

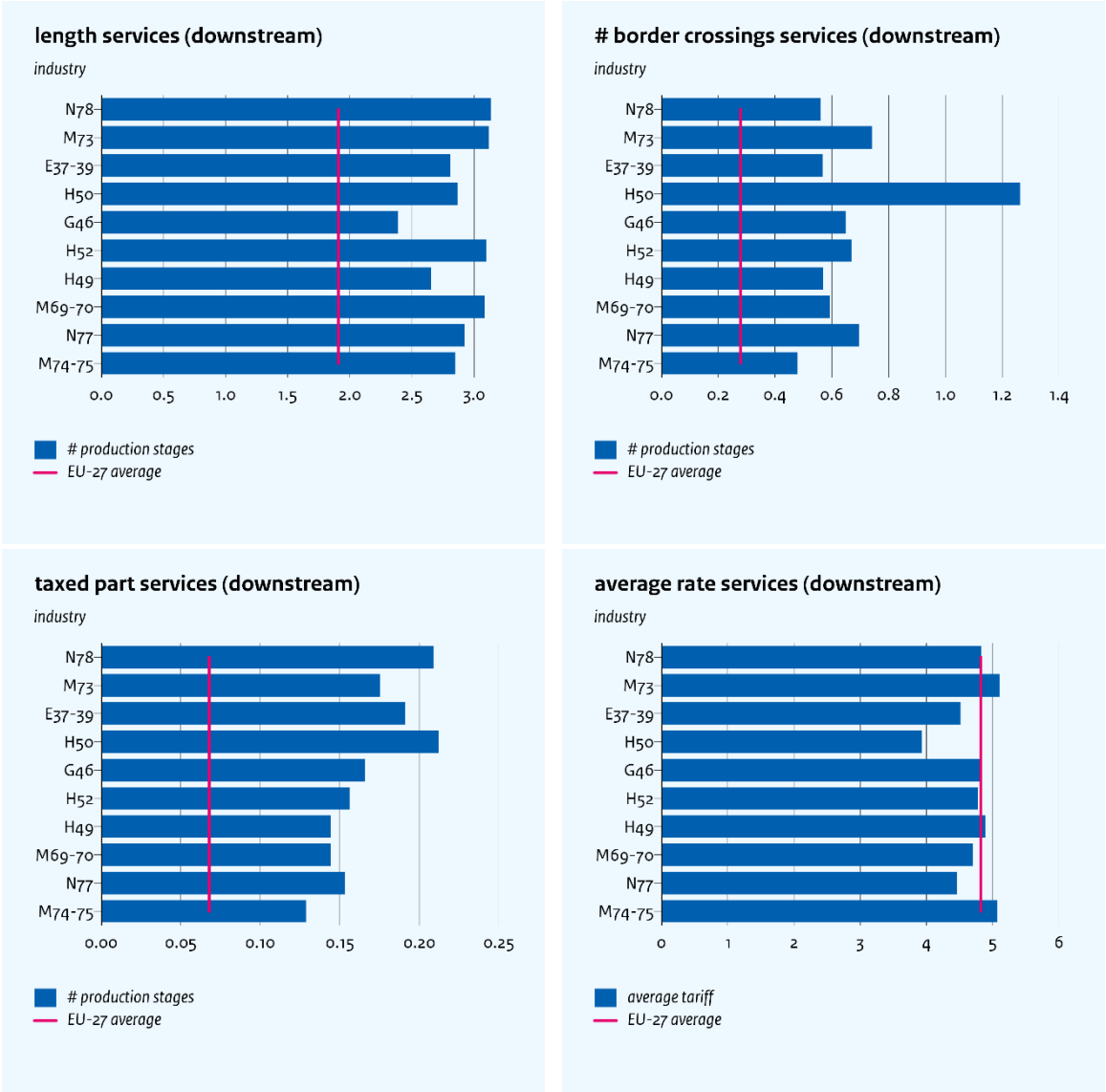

Figure note: Ten industries with the highest tariff cost index. Average for EU-27 shows the weighted average across all industries of the 27 EU countries with the value added of each country-industry combination as weight. See table 6.1 for an explanation of the terms. Figures are for 2019.
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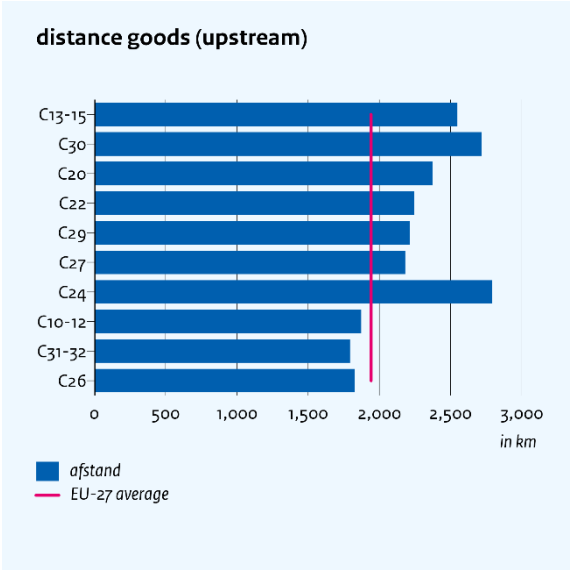
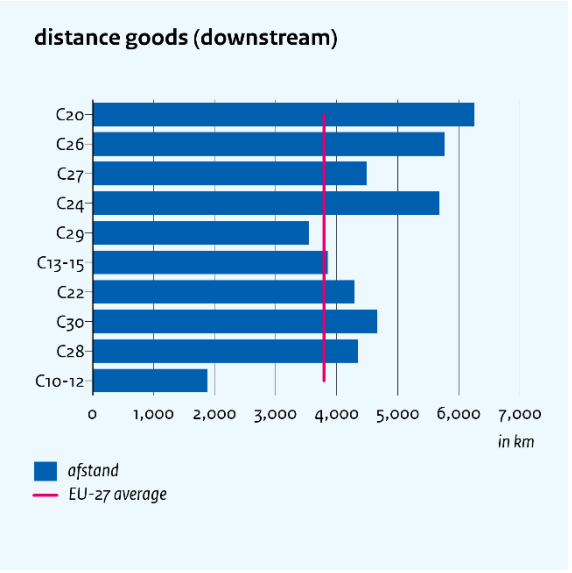
6.3.4 Industry-level distances

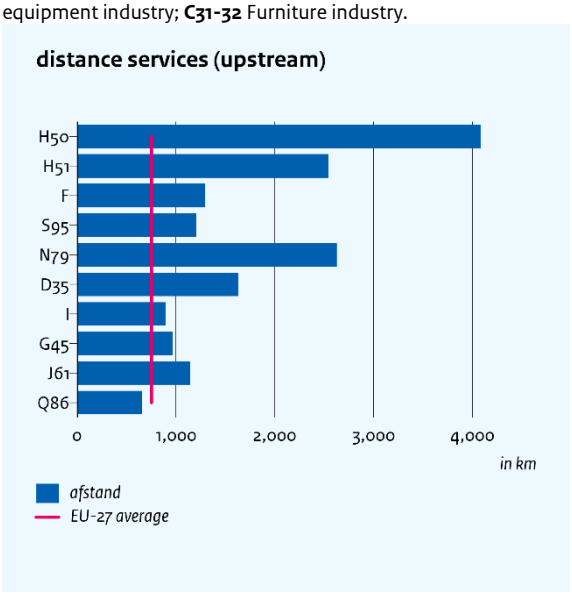
Figure 6.11 Distance index for the average of different industries across all EU-27 countries



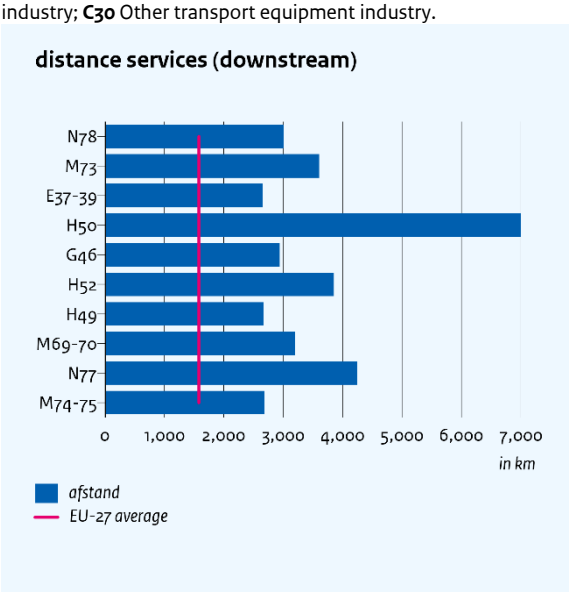
Note (in alphabetical order): **C10-12** Food industry; **C13-15** Textile industry; **C20** Chemical industry; **C22** Plastic industry; **C24** Basic metal production; **C26** Electrical industry; **C27** Electrical appliance industry; **C29** Automotive industry; **C30** Other transport equipment industry; **C31-32** Furniture industry.



Note (in alphabetical order): **C10-12** Food industry; **C13-15** Textile industry; **C20** Chemical industry; **C22** Plastic industry; **C24** Basic metal production; **C26** Electrical industry; **C27** Electrical equipment industry; **C28** Machinery industry; **C29** Automotive industry; **C30** Other transport equipment industry.



NB (in alphabetical order): **D35** Energy; **F** Construction; **G45** Wholesale and retail motor vehicles; **H50** Water transport services; **H51** Air transport services; **I** Hospitality; **J61** Telecommunications; **N79** Travel; **Q86** Healthcare; **S95** Repair of computer, household goods.



Note (in alphabetical order): **E37-39** Waste; **G46** Wholesale trade other; **H49** Land transport services; **H50** Water transport services; **H52** Warehousing; **M69-70** Lawyers and accountants; **M73** Advertising services; **M74-75** Other business services; **N77** Rental and leasing; **N78** Temporary employment agencies.

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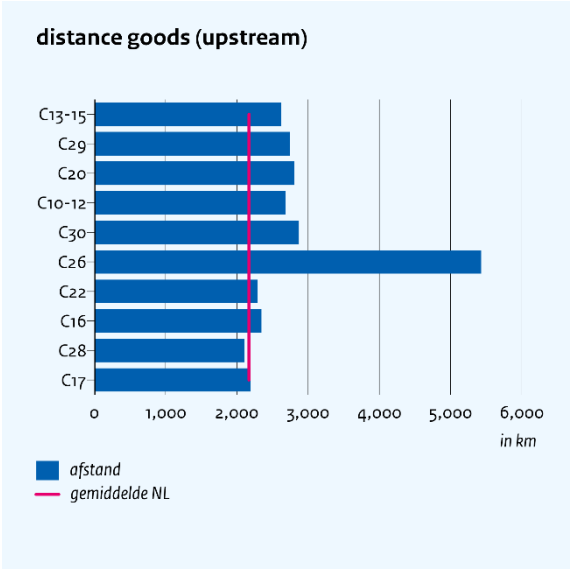
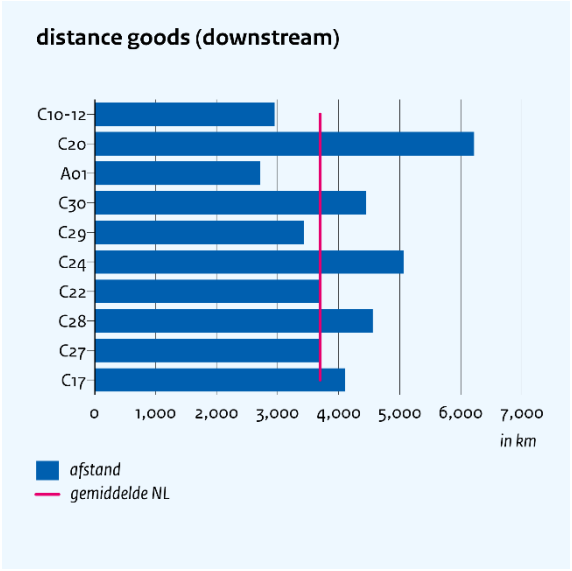
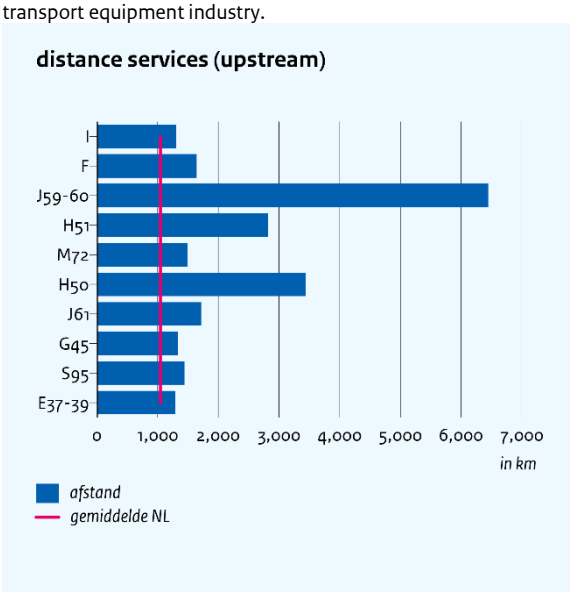
Figure 6.12 Distance index for different industries in the Netherlands



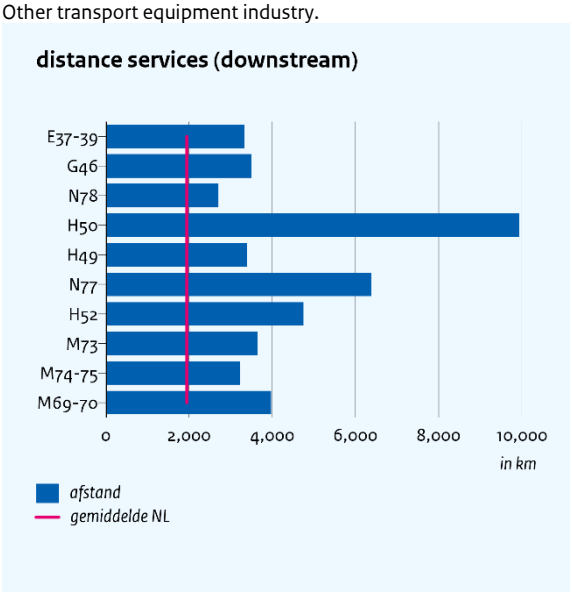
Note (in alphabetical order): **C10-12** Food industry; **C13-15** Textile industry; **C16** Wood industry; **C17** Paper industry; **C20** Chemical industry; **C22** Plastic industry; **C26** Electrical industry; **C28** Machinery industry; **C29** Automotive industry; **C30** Other transport equipment industry.



Note (in alphabetical order): **A01** Agriculture; **C10-12** Food industry; **C17** Paper industry; **C20** Chemical industry; **C22** Plastic industry; **C24** Basic metal production; **C27** Electrical equipment industry; **C28** Machinery industry; **C29** Automotive industry; **C30** Other transport equipment industry.



NB (in alphabetical order): **E37-39** Waste; **F** Construction; **G45** Wholesale and retail sale of motor vehicles; **H50** Water transport services; **H51** Air transport services; **I** Hospitality; **J59-60** Film and TV; **J61** Telecommunications; **M72** R&D; **S95** Repair of computer, household goods.



Note (in alphabetical order): **E37-39** Waste; **G46** Wholesale trade other; **H49** Land transport services; **H50** Water transport services; **H52** Warehousing; **M69-70** Lawyers and accountants; **M73** Advertising services; **M74-75** Other business services; **N77** Rental and leasing; **N78** Temporary employment agencies.

Figure note: Ten industries with the highest tariff cost index. Average for the Netherlands shows the weighted average across all Dutch industries with each industry's value added as a weight. See table 6.1 for an explanation of the terms. Figures are for 2019.

6.4 List of abbreviations and terms

Table 6.1 List of abbreviations and terms

Concept	Description
Length of value chain	Weighted total number of production stages in a value chain
Border crossings	Weighted number of international border crossings in a value chain
Taxed part of the chain	Weighted number of border passes with a tariff
Average rate	Average rate for border crossings with a rate
Upstream	From a country-industry combination all intermediate supplies that are part of a value chain up to the first point of production (raw materials)
Downstream	From a country-industry combination the sale of its own intermediate or final products that are part of a value chain running to the end user
Distance between countries	In kilometres
	Dates/other
FIGARO	Full International and Global Accounts for Research in input-output analysis (Eurostat's MRIO)
MRIO	Multi Regional Input-Output table (world-IO table)
NTM	Non-tariff measures
WIOD	World Input-Output Database (MRIO from the University of Groningen)
WITS	World Integrated Trade Solution (World Bank trade data)
WTO	World Trade Organisation
	Country groups
BRICS	Brazil, Russia, India, China and South Africa
EU	European Union
EU1	EU aggregated, as a whole (see figure 6.3 tofigure 6.6)
EU-27	EU average, across the 27 member states
NAFTA	North American Free Trade Agreement

Table 6.2 List of countries and codes in the FIGARO World Input-Output table

Countries in the analysis			
Country	**Code**	**Country**	**Code**
Argentina	AR	Ireland	IE
Austria	AT	India	IN
Australia	AU	Italy	IT
Belgium	BE	Japan	JP
Bulgaria	BG	South Korea	KR
Brazil	BR	Lithuania	LT
Canada	CA	Luxembourg	LU
Switzerland	CH	Latvia	LV
China	CN	Malta	MT
Cyprus	CY	Mexico	MX
Czech Republic	CZ	Netherlands	EN
Germany	THE	Norway	NO
Denmark	DK	Poland	PL
Estonia	EE	Portugal	PT
Spain	ES	Romania	RO
Finland	FI	Russia	RU
Rest of the world	RoW	Saudi Arabia	SA
France	FR	Sweden	SE
United Kingdom	GB	Slovenia	SI
Greece	GR	Slovakia	SK
Croatia	HR	Turkey	TR
Hungary	HU	United States	US
Indonesia	ID	South Africa	ZA

Table 6.3 Industry codes and names for goods and services

Goods		Services	
Code	**Industry name**	**Code**	**Industry name**
A01	Agriculture	D35	Electricity, gas, steam and air conditioning supply
A02	Forestry	E36	Water collection, treatment and supply
A03	Fisheries	E37-39	Waste
B	Mineral extraction	F	Construction
C10-12	Food industry	G45	Wholesale and retail motor vehicles
C13-15	Textile industry	G46	Wholesale trade
C16	Wood Industry	G47	Retail trade
C17	Paper industry	H49	Land transport
C18	Graphics industry	H50	Water transport
C19	Coke and refined petroleum products	H51	Air transport
C20	Chemical industry	H52	Warehousing
C21	Pharmaceutical industry	H53	Postal and courier services
C22	Plastics industry	I	Accommodation and food service activities
C23	Other minerals	J58	Publishing activites
C24	Basic metal industry	J59-60	Film and TV
C25	Metal products industry	J61	Telecommunications
C26	Electrical industry	J62-63	IT and information services
C27	Electrical appliance industry	K64	Financial services
C28	Machinery industry	K65	Insurance
C29	Car and trailer industry	K66	Other financial services
C30	Other transport equipment industry	L	Real estate
C31-32	Furniture industry	M69-70	Lawyers and accountants
C33	Other industry and repair	M71	Architects and engineers
		M72	R&D
		M73	Advertising services
		M74-75	Other business services
		N77	Rental and leasing
		N78	Employment activities
		N79	Travel activities
		N80-82	Security & investigative activities
		O84	Public administration and government
		P85	Education
		Q86	Human health activities
		Q87-88	Care services
		R90-92	Culture and recreation
		R93	Sports and entertainment
		S94	Activities of membership organisations
		S95	Repair computer, household goods
		S96	Other personal service activities
		T	Activities of households as employers

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