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**Research Report**

## Global value chains and tariffs: Insights from theory and model-based analysis

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# Global value chains and tariffs: Insights from theory and model-based analysis

Changing trade patterns, higher tariffs and increased geoeconomic fragmentation are increasingly shaping the global economy. It is important for Danmarks Nationalbank to have the tools to analyse and assess the consequences of these trends to ensure a robust Danish economy. This memo presents insights from theoretical trade literature and reviews the mechanisms captured by an advanced general equilibrium model used by Danmarks Nationalbank.

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## The literature suggests that tariffs lead to global losses, but unilateral tariffs can theoretically benefit individual countries

Tariffs cause efficiency losses because resources are allocated less efficiently. However, classical trade theory suggests that a country with sufficient market power can improve its terms of trade by imposing import tariffs. The net effect depends on the size of these opposing effects. However, the potential gain comes at the expense of other countries and results in global losses. Further, there is a risk of retaliation, which would reduce the gains from the improved terms of trade and amplify global losses.



## Global value chains add to the complexity of economic analyses of trade policy

When production is spread across countries, the effects of tariffs propagate through global value chains. Measures aimed at protecting domestic production can also raise costs for firms that rely on imported inputs. Third countries may experience both negative and positive spillover effects as trade flows are redirected. This complexity makes it difficult to assess the impact of trade policy measures such as tariffs on individual countries.



## Model-based calculations can address much of the complexity but do not capture all channels

Newer trade models can quantify changes in terms of trade and efficiency losses, while accounting for global value chains and differences in country-specific goods. Therefore, they provide a solid basis for understanding the aggregate effects of tariffs. However, certain economic channels require separate analysis outside the models. In the short term, uncertainty, increased savings and postponed consumption can amplify the negative consequences of tariffs.

## Why is it important?

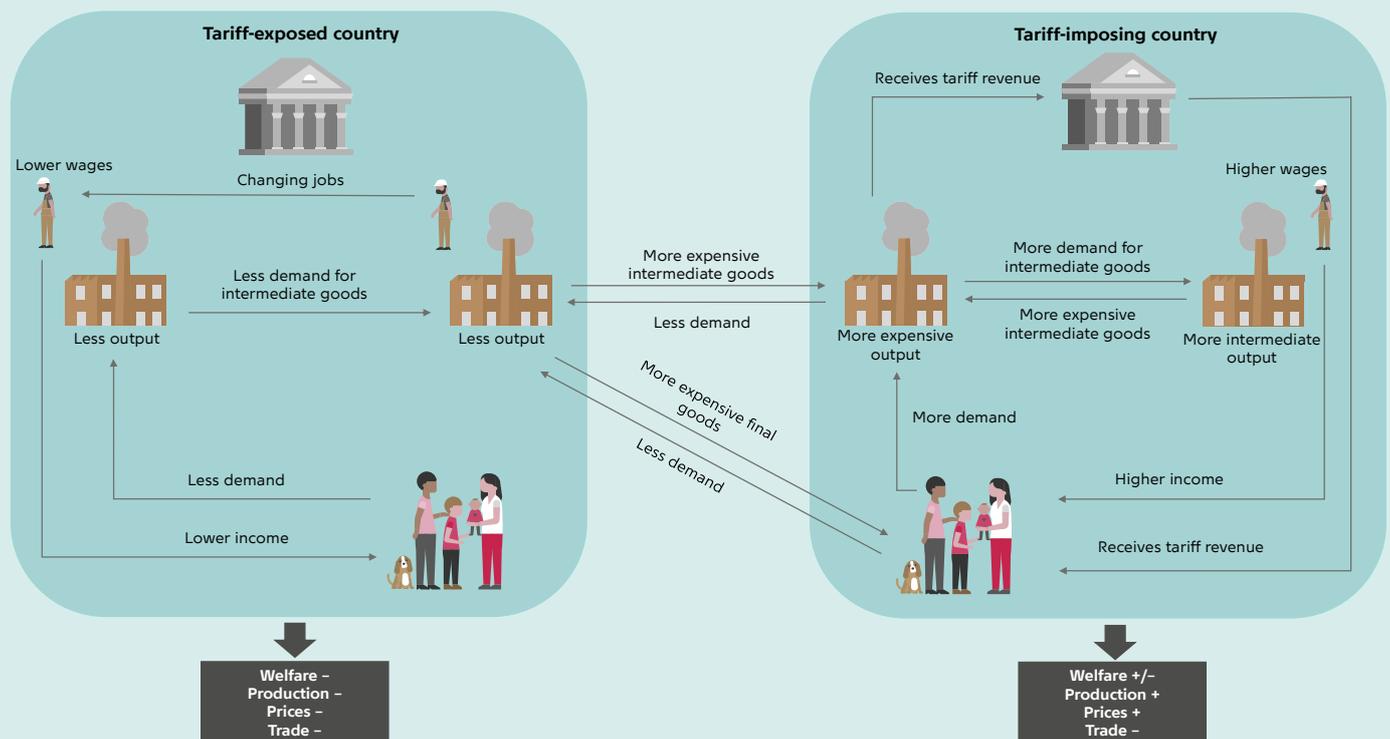
How should changes in trade barriers, increased tariffs and the impact of global value chains be understood and analysed? The economic literature on international trade has long addressed with these questions. In light of growing signs of geoeconomic fragmentation, recent US tariff increases, and shifts in global trade patterns, these issues have once again become key to assessing both the global and Danish economies, and thus to Danmarks Nationalbank.



**For decades, globalisation and increased global trade have been taken for granted. But now we face an increasingly polarised world.**

— Christian Kettel Thomsen,  
Governor of Danmarks  
Nationalbank

## Main chart: Adjustments in a trade model following a tariff shock



Note: A simplified illustration of the adjustments following a tariff shock in both the tariff-imposed and the tariff-exposed country in an advanced static general equilibrium model developed by Baqaee and Farhi, which is used by Danmarks Nationalbank, among others.

Source: Baqaee and Farhi (2024) and own illustration.



## Keywords

International economy

Models

Danish foreign trade

# 01

## According to theory, tariffs can affect terms of trade and lead to efficiency losses

After decades of increased trade integration and the expansion of global value chains, trade policy interventions that restrict trade are now becoming more prevalent. Instruments such as state subsidies for local production, export restrictions and tariffs have been used in recent years to an extent not seen since the 1980s.<sup>1</sup> The trend has prompted the International Monetary Fund, IMF, to warn that the world is entering a new reality characterised by geoeconomic fragmentation – a politically driven reversal of global economic integration.<sup>2</sup> Most recently, increases in US import tariffs have sparked renewed attention to the effects of geoeconomic fragmentation.

Fragmentation of international trade weakens global welfares by limiting the significant benefits of free trade. When countries trade freely, they can specialise according to comparative advantage, promoting efficient global resource allocation, higher productivity and economic growth, as well as numerous spill-over effects.<sup>3</sup> By contrast, trade barriers will reduce these gains and reduce overall welfare. Although tariffs cause global losses, theory suggests that under certain circumstances, they may benefit some countries at the expense of others.

### **According to classical trade theory, tariffs affect the tariff-imposing economy through positive terms of trade gains and negative efficiency losses**

In classical trade theory, the introduction of moderate import tariffs has both positive and negative effects for the tariff-imposing country. In the long run, two mechanisms are highlighted: an improvement in the country's terms of trade and a distortion in the allocation of resources and production.

The terms of trade refers to the ratio of the country's export prices to its import prices. When tariffs are raised, demand for foreign goods declines, which can pressure exporters in tariff-exposed countries to lower their prices. This means that the tariff-imposing country may experience gains if it succeeds in paying less for its imports. Additionally, tariffs can also increase demand for domestic goods and shield domestic production from foreign competition. Large countries, which typically have market power over a range of products, can therefore, in principle, achieve welfare gains by imposing tariffs – provided they are not met with retaliatory measures from the tariff-exposed countries, as discussed later. Moreover, the government collects a tariff revenue, which can be used to compensate producers and consumers.

The second mechanism is that tariffs create market distortions and a less efficient allocation of production.<sup>4</sup> When imports become more expensive, incentives arise to substitute away from foreign goods – not because domestic alternatives are more productive, but because they are relatively cheaper after tariffs are imposed. This will distort the efficient allocation of resources and reduce the

<sup>1</sup> See Branner et al. (2023).

<sup>2</sup> See Aiyar et al. (2023).

<sup>3</sup> For example, economies of scale, increased competition, innovation, knowledge diffusion and access to a wider and cheaper range of goods for consumers and producers.

<sup>4</sup> See Baqaee and Malmberg (2025).

aggregate productivity of the economy. Furthermore, consumers in the tariff-imposing country are worse off as they either pay higher prices for imported goods or buy more expensive domestic goods, although this can be partly offset if the tariff revenue is redistributed to consumers and wages rise.

The trade-off between terms-of-trade gains and efficiency losses has given rise to the literature on *optimal tariff*, which suggests that for every country there exists a welfare-optimising import tariff rate that is either zero or positive.<sup>5</sup>

From a global perspective, however, imposing tariffs is almost always ineffective and reduces overall welfare.<sup>6</sup> Tariff-exposed countries face lower demand, which can depress prices and wages and worsen their terms of trade. A key concern for the tariff-imposing country is therefore the risk of retaliation. Retaliatory tariffs will partially erode the terms-of-trade gains for the tariff-imposing country and may lead to a welfare loss for that country.<sup>7</sup> For the tariff-exposed countries, on the other hand, retaliatory tariffs can restore their terms of trade somewhat, leaving them slightly better off than if they had not retaliated. However, retaliation will lead to further efficiency losses and thus greater global welfare losses. This reflects a classic Prisoner's Dilemma situation, which international trade agreements seek to prevent.<sup>8</sup>

### **The growing integration of global value chains makes it more complex to assess the effects of trade policy changes**

In a globalised world, it is not only the tariff-imposing and tariff-exposed countries that are affected by trade policy measures. Modern production of goods is characterised by complex global value chains, where production is divided into steps that often take place across several countries before the final good is used for consumption or export. This means that measures such as tariffs not only affect the countries directly involved but also third countries that participate in the same value chains.

The incorporation of global value chains in economic trade theory is a relatively new and still expanding branch of the literature.<sup>9</sup> Whereas classical trade theory focuses on trade in final goods between two parties, the newer literature emphasises the importance of intermediate goods – goods that enters in the production of other goods. Trade in intermediate goods enables access to specialised inputs that may not be efficiently produced domestically.

Chart 1 illustrates how a tariff shock between two countries alters trade flows and affects both the countries involved and third countries through global value chains. When production is spread across multiple countries and depends on imported inputs, tariffs affect not only consumption and terms of trade, but also

<sup>5</sup> The classic result originates from Edgeworth (1894), who argued that tariffs could benefit a country if import demand is not perfectly elastic. Bickerdike (1907) builds on this, formulating in a partial equilibrium model the conditions under which a tariff can improve a country's terms of trade and thus its welfare. Since then, several contributions have further developed the optimal tariff theory, including Kaldor (1940), who argues that import tariffs below a certain level will always increase the welfare of the tariff-imposing country if there are no retaliatory measures. Subsequently, Kahn (1947), Johnson (1953), de V. Graaff (1949), and Mundell (1960a) each analysed how tariffs affect welfare in both small and large open economies. For a recent and comprehensive review of optimal tariffs in modern trade models – including the importance of intermediate goods, sector heterogeneity and global value chains – see Caliendo and Parro (2021).

<sup>6</sup> There are, however, arguments that industrial policies, including the introduction of tariffs, can have positive global impact. One of them is the 'infant industry' argument, which emphasises that strategic tariffs on some sectors in some countries can benefit aggregate world welfare. The idea is that if a country protects a particular sector in its early stages, the producers in that sector can achieve economies of scale, which can benefit more countries than just the tariff-imposing country.

<sup>7</sup> Scitovsky (1942) discusses this outcome; by contrast, Johnson (1953) finds that under the right conditions, it is possible for a country to make gains even through retaliation.

<sup>8</sup> See Ignatenko, Lashkaripour, Macedoni and Simonovska (2025), who argue that while imposing unilateral tariffs may make one country better off, it will always lead to global economic losses.

<sup>9</sup> See, for example, Johnson (2017), Antràs and Chor (2021) and Antràs (2020) for an overview of recent literature on global value chains and global trade. For earlier contributions, see Ruffin (1969), Casas (1973), and Das (1983), who point out differences between tariffs on final and intermediate goods.

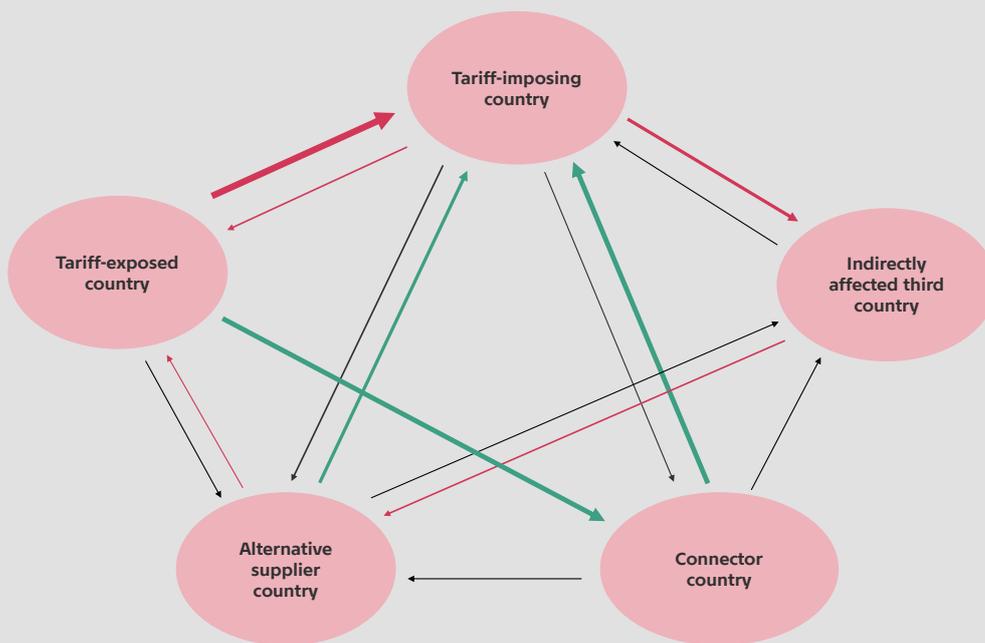
production costs throughout the value chain. For the tariff-imposing country, on the one hand, this can mean that higher tariffs increase costs for domestic producers and thereby reduce production, counteracting the intent to protect domestic production.<sup>10,11</sup> On the other hand, the higher costs of imported intermediate goods can in some cases be passed on to foreign consumers and producers through higher export prices, which can improve the terms of trade.<sup>12</sup>

The chart also illustrates that the effects are not limited to the two countries. Third countries may either face higher costs or experience increased demand. Producers in third countries may encounter higher import prices or supply disruptions if tariffs are raised upstream in the value chain, which could reduce their production and exports. Conversely, tariffs between other parties can increase demand for intermediates and final goods from alternative suppliers in third countries that are not subject to tariffs. Finally, third countries can act as connector-countries through which trade flows are redirected to circumvent tariffs, see chart 1.<sup>13</sup>

**CHART 1**

**The effects of tariffs spread to third countries through global value chains**

Change in trade flows relative to the baseline due to the introduction of import tariffs between the two countries.



Note: The graph shows trade flows between countries, where red arrows indicate a decrease in trade flows, green arrows indicate an increase in trade flows, and black arrows indicate neutral or unchanged trade flows. The thickness of the arrow reflects the strength of the effect – the thicker the arrow, the greater the change in trade flow.

Source: Own illustration.

<sup>10</sup> Grubel and Johnson (1971) introduce the concept of the "effective rate of protection", which measures the actual protection a domestic producer obtains through tariffs, taking both tariffs on final goods and on the imported intermediate goods used in production into account. They also show that tariffs on intermediate goods can offset the effect of tariff protection on final goods.

<sup>11</sup> Cavallo et al. (2021) showed that in 2018, US tariffs were primarily paid by US producers and consumers as imported inputs were difficult to substitute, thereby increasing the production cost. By contrast, American producers absorbed the cost of China's retaliation as Chinese goods were easier to replace. See also Fajgelbaum et al. (2019) and Amiti et al. (2019).

<sup>12</sup> See, for example, Baqaee and Farhi (2024) and Gunella and Quaglietti (2019).

<sup>13</sup> See Attinasi et al. (2023a).

The presence of third countries can therefore both dampen and amplify the effects of tariffs for individual countries and globally. Alternative trade links can maintain exports for the tariff-exposed country, but distortions in global value chains can also spread and amplify the negative consequences, ultimately affecting imports and exports in multiple countries. The prevalence of global value chains in global trade makes the assessment of trade policy significantly more complex and reinforces the need for models that can quantify the direct and indirect effects of trade policy changes.

### **Country-specific goods allow even small countries to achieve terms-of-trade gains from higher tariffs**

Global value chains have made trade patterns more complex and created the need for models that can handle countries importing and exporting within the same product category – a phenomenon that classical trade models typically cannot explain. A common solution in newer trade models is to build on the Armington assumption, which implies that goods are differentiated by country of origin.<sup>14</sup> This means that the same type of good from different countries are considered similar but not fully interchangeable.<sup>15</sup> Specifically, an elasticity of substitution is assigned to each good, indicating how easily it can be replaced by foreign alternatives.

Good differentiation using the Armington assumption makes trade models better equipped to handle global value chains because it explains why the production of a final good is rarely centralised in one country. When goods have country-specific characteristics, it can be more efficient to locate different stages of production in different countries to leverage specialisation and access to unique inputs.<sup>16</sup>

The Armington assumption has significant implications for understanding the effects of tariffs. When goods are not fully substitutable, a country will continue to buy from a trade partner even if the price increases. This gives all countries a degree of market power due to their specialised place in global value chains. For some countries, this is because they produce specialised goods that they are the sole supplier of and therefore cannot be easily replaced. For other countries, the reason is that they are the only buyers of very specific goods. This opens the possibility that terms-of-trade effects to occur through both import and export prices. Even small countries can therefore, in theory, gain from imposing tariffs if the rates are carefully targeted and there are no retaliatory measures.<sup>17,18</sup>

Differentiating goods by country of origin enables trade models to capture the nuances that arise in global trade, where trade patterns are driven not only by price differences, but also by preferences, production methods and other characteristics associated with the country of origin. This means that distortions in resource allocation due to tariff changes are typically larger in models that incorporate global value chains and build on the Armington assumption.<sup>19</sup>

<sup>14</sup> See Armington (1969).

<sup>15</sup> For example, coffee beans from Brazil and coffee beans from Vietnam are two distinct goods. This means that relative demand depends on relative prices, but the goods are not perfect substitutes. An increase in Brazilian coffee prices will only partially lead to increased demand for Vietnamese coffee.

<sup>16</sup> As pointed out by Alvarez and Lucas (2007), Costinot and Rodríguez-Clare (2014) and Caliendo and Parro (2021), in a Ricardian economy with heterogeneous goods, as in Eaton and Kortum (2002), every economy – regardless of size – has certain goods that it produces particularly efficiently.

<sup>17</sup> See, for example, Gros (1987), Alvarez and Lucas (2007) and Demidova and Rodríguez-Clare (2009).

<sup>18</sup> However, the risk of retaliation is typically higher for small countries, as large countries can retaliate without significant costs to themselves. This is because large economies often have more substitution possibilities domestically and can more easily absorb the consequences of their own retaliatory measures.

<sup>19</sup> See, for example, Antràs and Chor (2021) and Caliendo and Parro (2021). See also Blanchard et al. (2016), who show in a specific-factor model that global value chains reduce the gains a country can achieve from an import tariff due to effects on export demand and input dependence.

# 02

## Introduction to a trade model used in Danmarks Nationalbank's analyses

To analyse the effects of trade policy measures, Danmarks Nationalbank uses, among other tools, a trade model developed by Baqaee and Farhi (the BF model), which incorporates global value chains and good differentiation.<sup>20,21</sup>

The BF model is an advanced, static general equilibrium model that describes the world economy as a network of sectors and countries connected through trade.<sup>22</sup> It is calibrated using input-output data; see box 1 for a detailed description. The model can analyse the effects of trade policy changes by quantifying changes in terms of trade and the negative consequences of less efficient production allocation. In addition, it can capture that tariffs between two countries also affect third countries through global value chains. Furthermore, the model has a high degree of flexibility and can accommodate specially designed shocks for individual sectors and countries.

### **The model is based on optimising agents and market equilibrium in a static economy with frictions**

The BF model describes a world consisting of several countries, each containing producers, factors of production – labour and capital – and a representative consumer. Production uses the two factors of production, which are assumed to be exogenously given, as well as intermediates that can be sourced domestically and abroad.<sup>23</sup> Producers minimise their costs and set prices equal to marginal costs multiplied by a factor that reflects market distortions such as tariffs, mark-ups, price rigidity or other frictions.

The representative consumer has homothetic preferences<sup>24</sup> and a consumption basket consisting of several final goods, where an elasticity determines the degree of substitution between goods. The consumer receives income from the ownership of production factors, as well as from any tariff revenue.<sup>25</sup> In the model, the representative consumer specifies the total final demand in the domestic economy, including private and public consumption and investment,

<sup>20</sup> For Danmarks Nationalbank's applications of the model, see Branner et al. (2024), Bentsen et al. (2025) and box 1 in Danmarks Nationalbank (2025). The model is introduced by Baqaee and Farhi (2024).

<sup>21</sup> The BF model has also been widely used in trade policy analyses by institutions other than Danmarks Nationalbank. The authors themselves have used the model to examine a complete trade shutdown between Germany and China as well as German energy imports from Russia, see Bachmann et al. (2022) and Baqaee et al. (2024). The European Central Bank, ECB, and the Bank of Italy, like Danmarks Nationalbank, have used the model to analyse geoeconomic fragmentation, see Attinasi et al. (2023a), Attinasi et al. (2023b), and Conteduca et al. (2025). The central banks of Canada and Italy have also used it to assess the hypothetical and enacted US tariff policies; see Banque du Canada (2025) and Conteduca, Mancini and Borin (2025).

<sup>22</sup> The model does not include migration or capital movements across countries.

<sup>23</sup> Production is based on a constant-scale production function, where the inputs and factors are combined via a nested CES structure, see chart 3.

<sup>24</sup> Homothetic preferences mean that income changes do not affect the relative composition of consumption.

<sup>25</sup> Although households are compensated for paid tariffs through lump-sum transfers, they do not internalise this effect – that is, a transfer only affects their budget constraint and not their marginal choices.

and maximises utility subject to a budget constraint that reflects observed prices.<sup>26</sup>

Equilibrium in the economy occurs when producers and consumers have made their optimal choices and all markets – for goods, services and factors – clear so that supply equals demand. The model is static and does not describe the transition to the new equilibrium.

#### BOX 1

##### **A detailed and comprehensive input-output database enables analysis of trade shocks in global value chains**

In Danmarks Nationalbank's work, the calibration of the BF model is based on the Asian Development Bank Multi-Region Input-Output database, ADB MRIO. The database covers 73 countries and contains detailed input-output tables that map the links between 35 sectors domestically and internationally. A key strength of ADB MRIO is the coverage of emerging market economies, particularly in Southeast Asia and Latin America, which provides a more balanced and realistic representation of the world economy compared to other databases, such as the World Input-Output Database, WIOD, which focuses primarily on European countries. This broader coverage is particularly important for analyses where changes in global value chains are a significant factor.

The database is used to calibrate links between inputs and outputs across all countries and sectors. The multi-regional input-output tables show final demand, input use and value added for each sector in each country. Each cell indicates how much value is created in one country in one sector as part of the production of a final good in another country in one sector. The columns show the demand for output, while the rows show the contribution to value added. This makes it possible to map global value chains and the tables can be used to analyse how countries and sectors contribute to each other's production and where final consumption takes place.

For the model to capture producers' reactions to a tariff shock, data on production factors (capital and labour) are required. As such data is not available in ADB's MRIO tables, data from WIOD Socio Economic Accounts (WIOD SEA, 2016) is used instead. However, WIOD SEA only covers 43 countries. For countries included in ADB MRIO but not in WIOD SEA, average sector intensities based on WIOD SEA, are used. This approach follows Attinasi (2023a) and is supported by the literature, which shows that capital and labour inputs typically change slowly, see, for example, Sáenz (2022).

##### **The BF model describes how a trade shock propagates through global value chains and creates broad economic consequences**

A trade shock, such as a tariff increase, moves the economy out of its initial equilibrium. Tariffs raise the prices of imported goods and change relative prices in the economy, which affects producers' and consumers' choices depending on their price sensitivity. The BF model provides a framework for analysing how the economy responds endogenously to a trade shock by modelling it as a price shock, and makes it possible to trace the impact of the shock throughout the economy, see chart 2.<sup>27</sup>

Producers respond to higher import prices by shifting demand towards alternative intermediate goods from the domestic markets or other countries. Some sectors and countries experience production gains, while others become less competitive. This changes the demand for production factors, which affects factor prices. Producers adjust their choices of input – both factors and intermediate goods – as well as output level, in response to changes in relative prices and demand.

<sup>26</sup> As the model is static and does not distinguish between consumption and investment, investments are included as part of total consumption when calibrating based on input-output tables, see box 1.

<sup>27</sup> In the BF model, a shock can be simulated through both trade barriers and tariffs. This is useful, as many interventions take the form of non-tariff trade barriers such as import quotas, export restrictions, differences in product standards, as well as government support and subsidies that provide competitive advantages to domestic producers. An important distinction between shocks to trade barriers and to tariffs is that tariffs generate revenue for a country, whereas trade barriers do not.

Consumers also change their demand patterns as relative prices changes. Further, their income is also affected through two channels: changed factor income and the redistributed tariff revenue. If income rises, demand increases, which feeds back to producers.

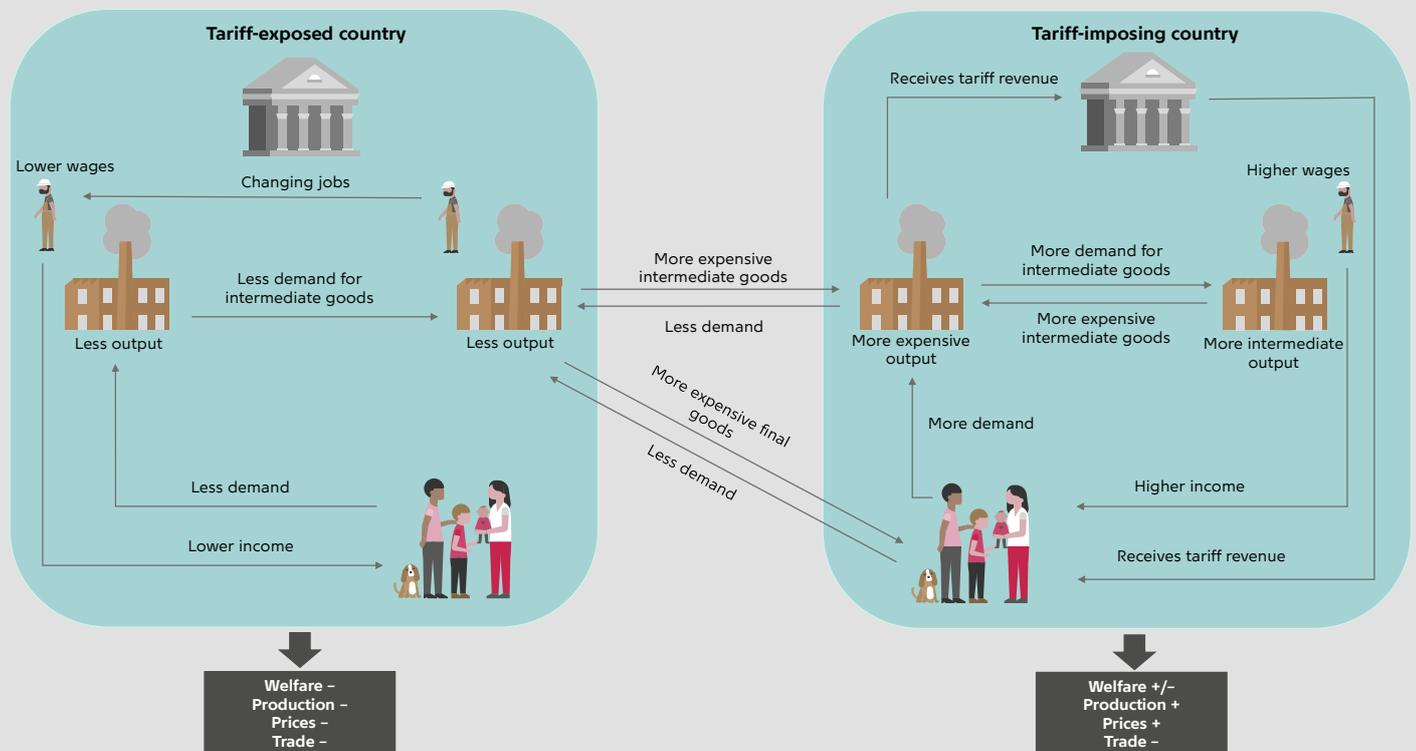
The initial price shock has broad implications across the global value chains due to producers' and consumers' adjustments and higher marginal costs. When one sector is affected, for example, by rising tariffs on steel, its customers are affected, which in turn affects their customers, thus the original sector and all sectors that use its inputs are impacted. Ultimately, consumers face higher prices for final goods that use steel as an input. If the price change is sufficiently large, consumers will reduce their demand for the good and producers will have to scale back production. This illustrates that the effect of a tariff spreads upstream and downstream in the value chain, and the extent of the adjustments depends on the position and substitution possibilities of the affected sectors. Market distortions can thus reinforce each other and create systemic disruptions in global value chains.

The model captures these cascading effects and the general equilibrium effects on prices, good choices and factor allocation. The new equilibrium reflects the changed relative prices, but is typically less efficient. Limited substitution capacity and market distortions can lead to inefficiencies and production losses, ultimately resulting in welfare loss.

CHART 2

Adjustments in a trade model following a tariff shock

A simplified illustration of the adjustments following a tariff shock in both the tariff-imposed and the tariff-exposed country in the BF model.



Source: Own illustration.

### The effects of trade shocks are assessed by considering changes in welfare

The key variable in the model is the change in welfare, which is approximated by the change in the country's real gross national income, GNI.<sup>28</sup> GNI measures the country's total income, which, in the model, is equivalent to its total demand for final goods. Static trade models typically focus on changes in welfare rather than GDP.<sup>29</sup> This is because GDP only measures the value of domestic production and can therefore give a misleading picture of economic gain, for example, if a large share of factor income accrues to foreign consumers or if the consumption consists largely of imported goods. In addition, GDP does not necessarily capture the effects of changes in the terms of trade, which can be significant.<sup>30</sup>

### Elasticities determine the economy's response to trade policy changes

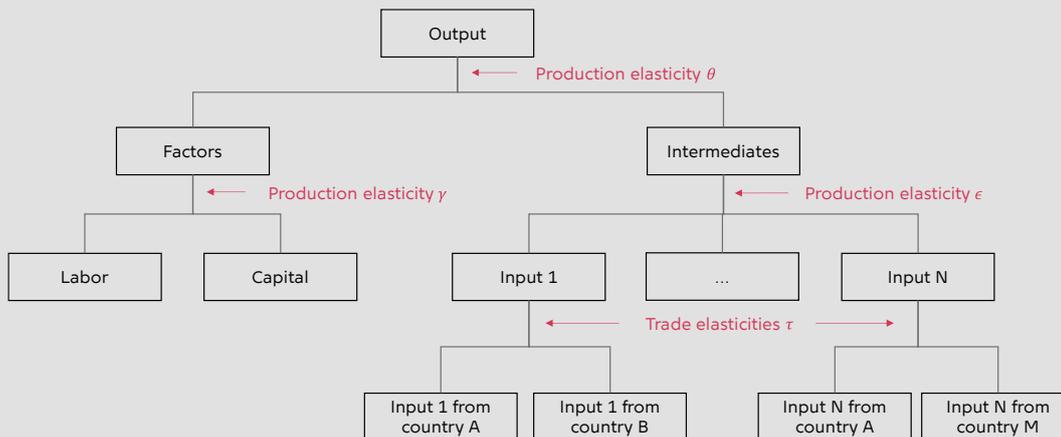
Central to the model's results are the assumptions about elasticities, which measure the sensitivity of demand to changes in relative prices. Production elasticities indicate how easily consumers or producers switch between different goods and inputs, while trade elasticities describe how easily they can choose between country-specific varieties of the same good.

In the model, the production decision is structured hierarchically, where factors are combined with different intermediate goods to produce an output, and each of these stages has an associated production elasticity, see chart 3. Production elasticities are constant across sectors and countries and are calibrated based on the literature.<sup>31</sup>

CHART 3

### Production involves a number of choices that are influenced by different elasticities

The production structure in the model is a hierarchical nested CES function where different inputs are combined in the production of the final output.



Source: Own illustration.

<sup>28</sup> According to Shepard's lemma, the change in real *gross domestic consumption*, defined as a country's total demand for final goods (which in the BF model equals real gross national income), is equivalent to the change in welfare, as the utility functions used in the BF model are homothetic.

<sup>29</sup> Gross domestic product, GDP, in the model is defined as the total value of value added produced in the domestic economy, with imports subtracted in the GDP calculation.

<sup>30</sup> See Baqaee et al. (2024).

<sup>31</sup> Production elasticities are taken from Baqaee and Farhi (2024) and derived from Atalay (2017).

What distinguishes the BF model from classic trade models is the inclusion of the decision on which country to import intermediate goods from. This is done using Armington elasticities, which determine the degree of substitution between country-specific varieties of the same good. These Armington trade elasticities vary between sectors and are based on empirical estimates from the literature.<sup>32,33</sup> The same elasticities are also used to model consumers' choice of country-specific final goods.

Trade elasticities with considerable sector variation are used in the BF model. This means that trade patterns respond strongly to price changes in sectors with easily substitutable goods, such as agricultural goods and textiles, whereas the response is weaker in sectors where substitution possibilities are more limited, such as machinery and electronics. Further, the production elasticities used in the model imply that inputs are used in fixed proportions and can be replaced only to a limited extent.<sup>34</sup> The interaction between these elasticities determines the overall response of production and consumption patterns to price changes. In general, a more rigid structure reduces economic losses due to market distortions, but at the same time leads to a greater increase in price levels and higher tariff revenue for the tariff-imposing country.<sup>35</sup>

### **Short-term effects are approximated by lower elasticities and fixed wages**

Although the model is set up to estimate long run effects, several studies approximate the short run by adjusting two key assumptions: lower elasticities and fixed wages in the short run.<sup>36,37</sup> In these studies, the short run equilibrium corresponds to the effects after about one year, while the long run effects occur after about six years.

The elasticities are assumed to be lower, as empirical evidence shows that substitution is more difficult in the short run. This is due to a lack of alternative goods and suppliers, contractual obligations and adjustment costs.<sup>38</sup> Wages are also assumed to be fixed in local currency in line with the literature<sup>39</sup>, which means that employment adjusts to changes in demand.<sup>40,41</sup>

<sup>32</sup> In Danmarks Nationalbank's model calibration, trade elasticities are taken from the model setup in Baqaee and Farhi (2024), where the estimates come from Caliendo and Parro (2015). Other studies using the BF model have also used these trade elasticities, see, for example, Attinasi et al. (2023c). There is generally considerable variation in the literature in empirical estimates of trade elasticities due to differences in estimation methods, data sources, time periods and the degree of sector disaggregation, see Ahmad et al. (2021).

<sup>33</sup> Sectors with standardised goods, such as agriculture and textiles, have high trade elasticities as the goods are easily substituted. By contrast, technically complex sectors such as machinery and electronics have lower elasticities due to specialised and complex value chains.

<sup>34</sup> This is in line with standard assumptions in the literature and means that the production structure reacts relatively weakly to price changes.

<sup>35</sup> By contrast, a more flexible structure would lead to significant market distortions, but smaller price increases and lower tariff revenue.

<sup>36</sup> Baqaee and Farhi (2024) introduce fixed wages in the model. Attinasi et al. (2023c) use fixed wages and add low production elasticities to their model calibration of the BF model, which approximates the short run. Baqaee et al. (2022) vary both production and trade elasticities in the BF model to model different time horizons.

<sup>37</sup> For other mechanisms that affect the short run effects of tariffs, see chapter 4.

<sup>38</sup> Empirical studies show that elasticities are smaller in the short run. For example, Boehm et al. (2020) show that elasticities are typically two to three times larger in the long run than in the short run. The model uses production elasticities from the lower 10 per cent range from Atalay (2017), and sector-specific trade elasticities are halved in the short run calculations to reflect this fact. This approach aligns with other analyses investigating short run effects on trade flows.

<sup>39</sup> See, for example, Heckel et al. (2008) and Kahn (1997).

<sup>40</sup> See Autor et al. (2012) for evidence of the impact of increased international trade on local labour markets, and Rodríguez-Clare et al. (2020) for the correlation to fixed wages.

<sup>41</sup> To model nominal rigidities such as fixed wages, the BF model includes a simple monetary policy framework necessary to close the model. The central bank is assumed to stabilise the price level while the exchange rate acts as a technical variable to ensure equilibrium. The role of the central bank is a modelling technique and not a realistic description of monetary policy behaviour. The model does not operate with bilateral exchange rates, but expresses all prices in relation to a numéraire, in this instance USD. It therefore does not explicitly account for currency unions or fixed exchange rate policies, including the Danish fixed exchange rate policy, making it most consistent to assume that the central bank focuses on the price level alone. However, it is possible in the model that central banks stabilise a weighting between technical exchange rates and the price level. See Baqaee and Farhi (2024).

# 03

## Limitations of the BF model and alternative modelling approaches for trade analysis

Although the BF model captures many key aspects of international trade, it is a static model that assumes the economy is in equilibrium and is designed to estimate long run effects. Short run effects can be approximated by adjusting certain assumptions, but genuine dynamic adjustment processes are not captured. In addition, there are several mechanisms, particularly in the short run, that can in principle be modelled but are not included in this framework. These mechanisms can significantly affect how the economy responds to trade barriers, either amplifying or dampening the effects. Finally, some factors cannot be modelled in this type of framework, including the risk of retaliation, which is therefore not addressed here, although it will greatly influence the net effect. The following focuses on selected mechanisms, both in the short and long run, that can be modelled but are not included in the BF model and their theoretical implications.

### Short run mechanisms outside the model

Five channels are particularly relevant to the short-run effect: uncertainty, foreign direct investment, exchange rate movements, consumption postponement and the monetary policy response.

#### *Uncertainty*

Increased uncertainty can in itself be detrimental to the economy, independent of tariffs.<sup>42</sup> This is because uncertainty among firms and consumers can dampen business investment and private consumption in the tariff-imposing and tariff-exposed countries.<sup>43</sup> However, uncertainty can also lead to a temporary surge in trade if firms accelerate purchases and production in anticipation of future restrictions. In addition, uncertainty can also create volatility in financial markets, which may spill over to the real economy through tighter financial conditions.

#### *Foreign direct investment*

According to the literature, tariffs can both increase and decrease foreign direct investment in the tariff-imposing country. On the one hand, some foreign firms may choose to increase their investments in the tariff-imposing country to circumvent the tariffs by establishing production there.<sup>44</sup> On the other hand, recent research suggests that tariffs can deter investment, especially when multinationals rely on imports from their headquarters, as tariffs increase the costs and risks of producing in the tariff-imposing country.<sup>45</sup>

#### *Exchange rate movements*

According to trade theory, import tariffs can reduce the demand for foreign goods and thus for foreign currency. This will push up the value of the domestic

<sup>42</sup> See, for example, Bloom (2009).

<sup>43</sup> See, for example, Altig et al. (2018) and Boer and Rieth (2024).

<sup>44</sup> See, for example, Chahinea et al. (2021).

<sup>45</sup> See, for example, Roeger and Welfens (2022).

currency in the tariff-imposing country, leading to an appreciation.<sup>46</sup> Such an appreciation can partially offset the substitution towards domestic goods induced by the import tariffs and may therefore make the net GDP effect negative.<sup>47,48</sup>

The opposite may apply for tariff-exposed countries. If demand for their exports drops significantly, it could lead to a weakening of their currencies. A weaker currency can make exports more competitive while making imports relatively more expensive for consumers and producers. The exchange rate response can thus partially offset the decline in production.

Recent literature also focuses on how exchange rate movements affect the value of a country's external financial position. If the tariff-imposing country primarily has liabilities in its own currency and assets in other currencies, an appreciation of the domestic currency will reduce net wealth. Conversely, assets denominated in the currency of the tariff-imposing country can serve as a form of hedge for the tariff-exposed countries.<sup>49</sup>

#### *Consumption postponement*

If consumers expect tariffs to be temporary, they may choose to postpone consumption of goods that have become more expensive and instead increase their savings. This intertemporal substitution can affect domestic demand and lead to lower GDP in the short run.<sup>50</sup> In line with this, some studies find that temporary, unilateral tariffs can lead to recession if the drop in demand exceeds the potential substitution towards domestic goods.<sup>51</sup>

#### *Monetary policy response*

Imposing import tariffs on final goods will increase consumer prices in the tariff-imposing country. If the central bank assesses that it will affect inflation expectations in the economy, it may respond by raising interest rates. This can have a contractionary effect that, in some cases, partly or fully offsets the potential terms-of-trade gains from import tariffs.<sup>52</sup> The BF model does not take into account that monetary policy affects the economy through a number of transmission mechanisms, such as financial channels and expectation formation, and can therefore not shed light on how different monetary policy responses change the effect of trade policy measures.<sup>53</sup>

### **Long run mechanisms outside the model**

Although the model is designed to estimate the long run effects of tariffs and other trade measures, some long run mechanisms – including capital accumulation and knowledge diffusion – are not included in its calculations.

#### *Capital accumulation and investment*

Capital adjustment is an important long run mechanism that the BF model does not capture.<sup>54</sup> When import tariffs are imposed on capital goods and their inputs, the relative price of capital to labour increases. This can dampen the demand for capital and reduce the long run capital stock. Studies show that

<sup>46</sup> See, for example, Mundell (1960b), Eichengreen (1981) or Krugman (1982).

<sup>47</sup> Imposing import tariffs under floating exchange rates can be contractionary because it leads to exchange rate appreciation and increased savings, see, for example, Mundell (1960b) or Krugman (1982). For example, Barattieri et al. (2021) found that a permanent import tariff of 10 per cent could lead to a significant real appreciation.

<sup>48</sup> The effect is less pronounced if the country has the world's currency, because global prices are more likely to be set in their own currency.

<sup>49</sup> See Itskhoki and Mukhin (2025).

<sup>50</sup> See, for example, Barattieri et al. (2021).

<sup>51</sup> See Auclert et al. (2025).

<sup>52</sup> See, for example, Monacelli (2025).

<sup>53</sup> The role of the central bank in the model is purely a technical construct to close the model under the assumption of fixed wages. See footnote 41 for more information.

<sup>54</sup> Note that there is investment data, which in the model is included in consumption, but the model does not include capital accumulation or depreciation over time.

when the capital stock can adjust in dynamic models, the long run consequences of trade barriers become larger and more negative.<sup>55</sup>

#### *Innovation and knowledge diffusion*

Trade can support productivity growth through greater access to foreign knowledge and technology, more competition and incentives for innovation.<sup>56</sup> Empirical studies show, for example, that technology transfer from China following its WTO accession in 2001 contributed significantly to productivity growth in Europe in the 2000s.<sup>57</sup> Trade fragmentation and increased tariffs can therefore have more significant and lasting adverse effects on productivity than what is captured by most trade models, including the BF model.<sup>58</sup>

#### **Several models can estimate the effects of trade policy, but none capture all aspects**

In addition to the BF model, there are several alternative modelling approaches that can shed light on different aspects of trade policy changes. The choice of model should reflect the focus and time horizon of the analysis, as each model has distinct strengths and limitations.

One type of model is modern computable general equilibrium (CGE) models, which are typically static and focus on long run effects – including the BF model.<sup>59</sup> They assume that the economy reaches a new equilibrium after a trade policy intervention and are suitable for analysing structural changes in global trade and production. Several newer CGE models are dynamic and can include adjustment mechanisms such as capital accumulation and consumption postponement.<sup>60</sup>

Another type of model is dynamic stochastic general equilibrium (DSGE) models, which are better suited for analysing short run effects and transition dynamics.<sup>61</sup> They can include factors such as uncertainty, savings, investments and labour market frictions, depending on the model design. On the other hand, DSGE models generally have a lower level of detail regarding global value chains and are less flexible in modelling sector-specific shocks.

Finally, macroeconomic models can be used to estimate the effects of trade policy changes.<sup>62</sup> They focus on short run dynamics, making them useful for analysing cyclical effects. However, they rarely account for the role of global value chains and therefore cannot shed light on how trade structures adjust. In addition, they are typically not micro-founded, which makes them less suitable for conducting scenario analyses.

<sup>55</sup> Baqaee and MalMBERG (2025) make this comparison and argue that capital stock adjustment is a dominant driver of long run effects – more important than standard mechanisms such as terms-of-trade effects and inefficient allocation of production.

<sup>56</sup> The idea that trade can generate positive spillover effects through knowledge diffusion became widespread with the new wave of endogenous growth models in the 1990s, including Grossman and Helpman (1991), who theoretically demonstrate that such mechanisms not only create level effects on GDP but also ensure long run growth effects.

<sup>57</sup> See Bloom et al. (2016) for an empirical study of the effect of China's entry into the WTO on Europe's productivity growth.

<sup>58</sup> See, for example, GóES and Bekkers (2022) for a trade model that takes knowledge diffusion into account in a CGE model.

<sup>59</sup> In addition, the model in Caliendo and Parro (2015) has helped to set the standard for how input-output networks are linked to estimates of sectoral comparative advantage and serves as a common foundation for applied and theoretical contributions in the literature.

<sup>60</sup> For example, Baqaee and MalMBERG (2025) introduce a dynamic CGE model that takes capital accumulation into account.

<sup>61</sup> For example, IMF's Global Integrated Monetary and Fiscal Model, GIMF.

<sup>62</sup> For example, the National Institute Global Econometric Model, NiGEM, which is used by the IMF and OECD, among others.

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