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The Effect of Tariffs in Global Value Chains

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ABSTRACT: This paper empirically investigates the impact of tariffs when production is organized in global value chains. Using global input-output matrices, we construct four different tariff measures that capture the direct and indirect exposure to tariffs at different stages of the production chain for a broad set of countries and industries. Our results suggest that tariffs have significant effects on economic outcomes, including on countries and sectors not directly targeted. We find that tariffs higher up and further down in the value chain depress value added, employment, labor productivity and total factor productivity to varying degrees. We find no benefits for the sector that enjoys additional protection, yet there is some evidence of economic activity being diverted, i.e. positive effects on value added and employment from tariffs imposed on competitors. Our paper relates to recent innovations in theoretical gravity models and provides an empirical assessment of possible long-term effects of recent trade tensions.

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WORKING PAPERS

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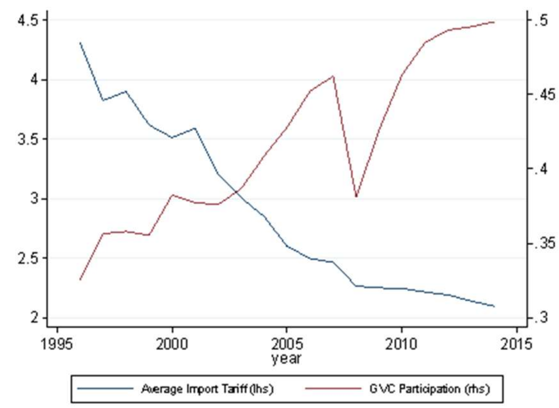
Contents

1. Introduction

Starting April 2017, trade tensions escalated, particularly between the US and China. Until the signature of a "phase-one deal" in January 2020, average bilateral tariffs between the US and China increased to above 21%, from 8% and 3% before 2018, respectively on Chinese imports from the US and US imports from China (Brown, 2021).

This episode reversed a decades-long trend in trade policy. Among mostly OECD countries, average tariff levels had declined from roughly 4.5% in the mid-1990s to about 2% in 2015, with substantially more pronounced declines in cases such as India, China and many countries in Eastern Europe (Figure 1)[1]. By 2008-09, when progress in trade liberalization slowed, tariffs generally constituted a very small share of the costs of international trade (e.g. Hummel, 2007; Escaith, 2017). Falling tariffs, together with improved transportation and communication technologies have contributed to an increasingly tight integration of production, illustrated in Figure 1 by an increase in average global value chain (GVC) participation rate[2]. Final goods often combine value added from multiple locations and components that cross borders several times on their way to the eventual consumer. In such a world, exporters from different countries not only compete with each other and with domestic producers, they also supply intermediate inputs, which may be further processed and re-exported to the rest of the world.

Figure 1: GVC Participation and Tariffs



Note: Weighted averages of tariffs and global value chain (GVC) participation (forward + backward). Value added weights were used for aggregation from country-sector level. Based on manufacturing sectors only and the 35 countries in our regression sample. Source: OECD, Tiva, author calculations.

The increases in bilateral tariffs between the US and China applied to goods at different places in the value chain (e.g., from steel to washing machines), while tariffs on and among other countries were much less affected. This raises the question to what extent countries and sectors not directly targeted by US and Chinese tariffs would also be affected, either through lower demand for their intermediate exports, which for instance were assembled in China, higher costs for intermediate inputs or lower competition in export markets. Several theoretical contributions have investigated this question and stressed that while China and the US are hurt the most by higher bilateral tariffs, other countries may either benefit or suffer depending on their sectoral composition (see IMF 2019 and references therein).

This paper attempts to answer the question empirically with the help of a three-dimensional panel. For each country-sector and year, we calculate four different tariff measures that capture respectively: (a) average tariffs on competing imports, i.e. the degree of domestic protection from foreign competition; (b) tariffs higher up in the

[1] For example, between 1995 and 2015 value added weighted tariffs on manufacturing goods declined from 32% to 11% in the case of India, from 20% to 7% for China and from 14% to 0.7% for Romania.

[2] Global value chain (GVC) participation is defined as the sum of forward- and backward GVC participation, where backward GVC participation refers to the share of foreign value added in gross exports and forward GVC participation is the ratio of domestic value added contained in inputs sent to third economies for further processing and export, over the country's total gross exports.

value chain, which increase the cost of inputs; (c) tariffs further down in the value chain, which increase the costs of the own output for the eventual consumer; and (d) the ease of access to export markets compared to other international competitors. Our empirical model then estimates the effect of the respective tariff measures on value added, employment and productivity. Illustrative simulations provide a sense of the relative magnitudes of the effects.

Our paper finds that upstream and downstream tariffs generally hurt economic activity. Coefficients are negative and significant for value added, labor productivity as well total factor productivity. Higher domestic protection however is generally found to be insignificant, bar a borderline-significant negative effect on employment. Higher tariffs on competitors are associated with higher value added and employment, not however improved productivity.

Our paper builds on recent conceptual innovations of how tariffs can affect trade in a globally integrated economy. A first set of papers has emphasized that the effect of tariffs increases as the eventual good crosses international borders at several stages of production. Yi (2003, 2010), Koopman, Wang, and Wei (2014), Rouzet and Miroudot (2013) and others emphasized that in such a situation there is an accumulation of tariffs (tariff on inputs at each border crossing) as well as a magnification, as the value that is added to a product in the exporting country may only be a share of the good's total value, on which the tariff is applied.

Recent theoretical innovations have incorporated the idea that tariffs can accumulate, providing much of the theoretical foundation for our empirical analysis. Key to tariff accumulation and magnification is the recognition that an important share of international trade is done in intermediate inputs, rather than final consumer goods. Theoretical papers that have studied the influence of trade in intermediates include Arkolakis, Costinot and Rodriguez-Clare (2012), Eaton, Kortum, Neiman and Romalis (2016), Hsieh and Ossa (2016), and Shikher (2011). Caliendo and Parro (2015) allow for particularly rich heterogeneity across sectors and linkages between them. Vandenbussche, Connell and Simons (2019) go into a similar direction, but also relax the Ricardian assumption that every input is sourced from only one country. In their model, what matters for a given sector is the extent to which its output will be taxed either directly or indirectly, once processed, incorporated in other products and re-exported. The principle of accumulation thus derives naturally from their setup.[3] In addition, Vandenbussche et al. (2019) also highlights that a bilateral tariff will not only destroy, but also divert trade.

The empirical literature has only partially followed suit, focusing mostly on the effects of tariffs imposed by the importing country itself, the "domestic" effects of tariffs. Much of the focus has also been on the effect on productivity. The literature has generally found productivity enhancing effects from tariff reductions both through an increase in competition as well as cheaper and higher-quality inputs. For example, Amiti and Konings (2007) and Topalova and Khandelwal (2010) have estimated the productivity effects on firm level data, while Ahn, Dabla-Norris, Duval, Hu and Njie (2016) and Furceri, Hannan, Ostry and Rose (2021) perform a similar exercise with international samples at the industry level. One way we extend the existing literature is by looking at a larger set of dependent variables, one that includes not only productivity measures, but also value added and employment. Since the motivation for our paper is less the potential benefits from further liberalization, but the medium-term costs of tariffs being raised, looking at the likely more palpable and politically sensitive value added and employment effects seems important.

[3] In their model, production technology is given, which implies that the relevant accumulation happens downstream in the value chain. This partially contrasts the abundant empirical literature, which focuses on *input tariffs*, i.e. tariffs imposed higher up in the value chain.

The second contribution of our paper is that we investigate a richer set of possible effects from specific tariffs. The above-mentioned papers have distinguished the tariffs a country imposes on imports competing with a firm's (or sector's) output (generally called output tariffs) from the ones imposed on its imported intermediate inputs (input tariffs). They have found that while both input- and output tariffs have negative effects on productivity, input tariffs tend to be quantitatively more important. We take the analysis one step further. To our knowledge, we are the first paper to estimate jointly not only the effects of domestic protection and tariffs on inputs, but also of tariffs that are further down in the value chain or imposed on competitors. This is particularly relevant in the current context. Given China's role as a global production hub, higher tariffs on its exports may indirectly affect firms all over the world. However, our paper also highlights a general issue, as omitting the additional tariff measures potentially biases the estimated effects of included tariffs and underestimates spillovers to parts of the economy not directly targeted.[4]

Yet, while we extend the existing literature in some ways, our paper remains partial in others. For one, we focus on the effects of tariffs and abstract from other trade costs. This is done both for practical and conceptual reasons. Since most tariffs are bilateral, goods-specific and ad-valorem (i.e., proportional to the value of imports), they combine easily with the logic of input-output matrices. This is less the case for example for non-tariff barriers, which are generally not bilateral and whose costs may be partly fixed (e.g., administrative hurdles) or more a function of weight or volume (e.g., transportation costs). The extent to which some of our conclusions – for example that tariffs affect prospects at different stages of the production chain – also apply to other types of trade costs, is left for further research.

The rest of the paper is structured as follows. The next section will present the data and the empirical strategy and explain the construction of the different tariff measures. Section 3 will present the main results. Section 4 will discuss to what extent they change if important elements of the baseline specification are altered. Finally, section 5 concludes.

2. Data, Tariff Measures and Empirical Strategy

This section will explain the empirical approach. It will start by highlighting some of the key data sources before explaining how the various tariff measures are constructed. The section concludes with a brief discussion of the empirical model.

2.1 Data

Our paper studies the effects of tariffs on sectoral economic prospects at various stages in the production chain. For this, three types of data are key.

- **Input-output matrices**: One of the key ingredients for our tariff measures are global input-output matrices. For each country and sector, these report what kind of inputs are used and how the sector's own output is absorbed, i.e. either processed as an intermediate input or consumed, domestically or

[4] Studying the effects of domestic protection in isolation can bias the effect of a tariff due to omitted variables. When looking at a particular sector for example, the estimated effects of reduced domestic protection could be exaggerated if the tariff reduction is part of a reciprocal international agreement. In such a context, the effect of easier access to the market of the partner country (captured in our downstream tariff) could provide additional benefits but may also be offset if competitors enjoy similar benefits (captured by our diversion tariff). This issue becomes more complex when studying the effects beyond a particular sector, as the sectoral interaction can lead to spillovers, including to *a priori* non-tradable sectors.

abroad. We use the 2016 version of the OECD Inter-Country Input-Output (ICIO) Tables, which relies on the ISIC REV.3 sectoral classification.

- **Bilateral tariffs**: The other ingredient for the tariff measures are bilateral tariffs, taken from the "World Integrated Trade Solution Platform". To match these with the input-output tables, we aggregate HS6 goods-level tariffs (simple averages of more detailed tariffs) to the sector-level using constant average import-shares as weight. When bilateral tariffs at the goods level are not reported every year, we linearly interpolate them.[5] Given that in a currency union, countries no longer have independent trade policies, the EU tariffs are used for all member countries, while tariffs among them are assumed to be zero.

- **Real economic variables**: The dependent variables in our empirical model are respectively real value added, employment and labor- and total factor productivity at the sectoral level. In our baseline specification, we use the gross value added per hour worked to proxy for labor productivity. Since the lack of hours worked constrains our sample, we use as an alternative definition the ratio of gross value added divided by employment. The series are taken from the various KLEMs databases (EU-KLEMs, World- KLEMs and Asia- KLEMs, see Jäger 2018 and Jorgenson 2017). The estimation uses the natural logarithms of the outcome variables.

Whenever we aggregate disaggregated data, we use constant weights. This applies to both import- and export weights as well as the input-output tables. The rationale for this choice is that we want the dynamics of the tariff measures to be a function of active trade policy decisions, not of the composition of trade flows. The latter would be particularly concerning if trade patterns react to trade policies, potentially offsetting a change in nominal tariffs. While we generally use averages over the available time span, we will show in our robustness section that conclusions do not change significantly when different weights are chosen.

While the input-output tables include 34 sectors for 65 countries[6], and tariff data is nearly universal, data availability is more limited for the dependent variable. As a result, only roughly half of the countries are part of the eventual sample for value added, employment and labor productivity, and 22 for the specifications using TFP.[7] In addition, to match the eventual tariff measures with the outcome variables, some sectors of the input-output tables had to be aggregated to the next higher level. How these tariff measures are constructed will be explained next.

2.2 The Construction of the Tariff Measures

Our paper constructs four different tariff measures. We call these (i) *domestic protection*, (ii) *upstream tariffs*, (iii) *downstream tariffs* and (iv) *diversion tariffs.*

[5] At the end (beginning) of the sample, we use the last (earliest) reported value for the missing observations.

[6] In the case of Mexico and China, the OECD's ICIO tables distinguish three, respectively four, different values for each sector and partner country, depending on the type of manufacturing or service provision the sector is involved in (e.g., manufacturing for domestic sales, exports that rely on the processing of goods without change of ownership , etc). The motivation for such a distinction is that an average for a given country-sector can hide substantial variation across different types of companies. To keep things tractable, our exercise aggregates the different observations for Mexico and China to get one observation for each sector.

[7] For TFP, the eventual sample includes AUS, AUT, BEL, CAN, CZE, DEU, DNK, ESP, FIN, FRA, GBR, HUN, IRL, ITA, JPN, NLD, SVK, SVN, SWE and USA. Regressions of employment and labor productivity additionally include CYP, EST, GRC, HRV, KOR, LTU, LUX, LVA, MLT, POL, PRT, and ROU. Regression of value added further include China and India.

Domestic Protection: This is the most simple and intuitive of the four tariff measures. It captures the degree of protection producers in country c and sector s enjoy from international competition. The domestic protection tariff is calculated as the weighted average of bilateral tariffs $\tau_{c,s,i,t}$ applied by country c to imports from partner countries i that are directly competing with sector s in a given year t.

$$\tau_{c,s,t}^{dp} = \sum_i \overline{\omega}_{c,s,i}^{M} \, \tau_{c,s,i,t}$$

$$\overline{\omega}_{c,s,i}^{M} = \frac{1}{T} \sum_T \frac{M_{c,s,i,t}}{\sum_{j \neq c} M_{c,s,j,t}}$$

Where $\overline{\omega}_{c,s,i}^{M}$ is the average share in country c's imports of products from sector s ($\sum_{j \neq c} M_{c,s,j,t}$) that comes from partner country i. In some other studies[8], the domestic protection tariff has been called "output tariff", a term we believe could create confusion in our context, given the simultaneous inclusion of the downstream tariff discussed below. A higher degree of domestic protection is expected to support domestic demand.

Upstream: The other tariff measure that has been studied extensively is the upstream tariff, called "input tariffs" in many other studies. Amiti and Konings (2007), Topalova and Khandelwal (2007) and Furceri et al. (2021) use a *first degree* input tariff, by which we mean the weighted average of tariffs applied on intermediate inputs that are imported directly (the first sum in the equation below). Ahn et al. (2019) recognize that inputs may be imported indirectly, i.e. sourced domestically but containing imported components. Following Rouzet and Miroudot (2013), we take the measure one step further and include the cumulative effect of tariffs on the cost of inputs, independently of whether these are imposed at the last border crossing or before. It thus includes (i) the tariff imposed by country c on inputs that are imported directly by sector s (the first term in the equation below) and (ii) the tariffs applied at previous production steps to inputs sourced either domestically or from abroad. A higher upstream tariff thus makes inputs more expensive, to the extent that higher costs are not absorbed by the producer. They can be thought of as a negative supply shock.

We follow the methodology proposed by Rouzet and Miroudot (2013) to calculate the upstream tariffs. To simplify notation in the equations below, we use one subscript for each country-sector, so that $\tau_{h,j}$ is the tariff imposed by country-sector h on country-sector j. Equivalently $\bar{a}_{h,j}$ – the individual element of the input-output matrix $\bar{A}$[9] – stands for the average inputs used by the country-sector h, supplied by country-sector j and scaled by total output of h.[10] The scaling by output allows for the straightforward accumulation of tariffs over different production stages. For example, the product $\bar{a}_{h,j} \, \bar{a}_{j,k} \tau_{j,k,t}$ in the second sum of the equation below illustrates simply that the tariff imposed by j on country-sector k is only relevant for h as far as the output from k sourced through j are important inputs for h, the product $\bar{a}_{h,j} \, \bar{a}_{j,k}$. The influence of tariffs thus generally declines rapidly with additional steps in the value chain. X and M are the export and import matrices with dimensions CS × C (where C and S are respectively the number of countries and sectors). The vector e has dimension 1 × CS.

[8] "*Output tariff*" has been used as label for our degree of domestic protection e.g. by Amiti et Konings 2007, Topalova and Khandelwal (2007), Furceri et al. (2021), Ahn et al. (2019)

[9] For matrix invertibility purposes, the household sectors are omitted. We use averages in trade-weights to rule out that changing trade relationships create additional variation in the tariff measures.

[10] As explained below, the upstream and downstream tariffs are scaled respectively by the share of imported or exported inputs in a country-sector's output. This results in their magnitudes being substantially smaller than the (unscaled) nominal tariff rates.

$$= \sum_j \bar{a}_{h,j}\tau_{h,j,t} + \sum_j\sum_k \bar{a}_{h,j}\,\bar{a}_{j,k}\,\tau_{j,k,t} + \sum_j\sum_k\sum_q \bar{a}_{h,j}\,\bar{a}_{j,k}\,\bar{a}_{k,q}\,\tau_{k,q,t}\ \dots$$

Fortunately, the sums simplify substantially when using matrix multiplications.

$$\tau^{up}_{h,t} = (\,e^{up}\,B^{up}\,(I - \bar{A})^{-1}\,)$$

Where e^{up} is a vector of ones of dimension 1 × CS and $B^{up} = \bar{A} \circ \tau$, i.e. the element-by-element multiplications of the input-output matrix (of dimension CS × CS) and the tariff matrix τ[11].

Downstream: The downstream tariff is simply the mirror image of the upstream tariff. It captures the cumulative tariff that the output of a given sector faces downstream in the value chain. This includes the tariffs that a country-sector faces when exporting directly (the first sum $\sum_j \bar{a}_{j,h}\tau_{j,h,t}$) as well as when value added is exported indirectly, for example when output is further processed by the direct customer and eventually exported to yet another country-sector. A higher downstream tariff makes a country-sector's output more expensive and is thus expected to reduce demand.

$$\tau^{down}_{h,t} = \sum_j \bar{a}_{j,h}\tau_{j,h,t} + \sum_j\sum_k \bar{a}_{j,h}\,\bar{a}_{k,j}\,\tau_{k,j,t} + \sum_j\sum_k\sum_q \bar{a}_{j,h}\,\bar{a}_{k,j}\,\bar{a}_{q,k}\,\tau_{q,k,t}\ \dots$$

$$\tau^{down}_{h,t} = (I - \bar{A})^{-1}\,B^{down}\,e^{down}$$

Where e^{down} is a vector of ones of dimension C ×1 and $B^{down} = \bar{X} \circ \tau$ is the element-by-element multiplication of a tariff matrix τ (of dimension CS ×C) with a matrix $\bar{X}$ of nominal exports scaled by GDP.

Diversion: The diversion tariff captures the advantage the sector i in country j enjoys when exporting to country p, relative to its competitors. Our diversion tariff is constructed in two steps. A first step calculates for each partner country p and sector i, the average tariff imposed on all other countries than home country c, weighted by the imports of country p (the term $\sum_{s\neq c} \varpi^{M}_{p,i,s}\,\tau_{p,i,s,t}$). The second step then averages for the home country c the tariffs the partner countries p impose on others, using export shares $\varpi^{X}_{c,i,p}$ as weights. Given that the diversion tariff captures trade restrictions on the competitors, an increase in the tariff measure should support demand for the country-sector in question.

$$\tau^{div}_{c,i,t} = \sum_{p\neq c} \varpi^{X}_{c,i,p} \sum_{s\neq c} \varpi^{M}_{p,i,s}\,\tau_{p,i,s,t}$$

where

$$\varpi^{X}_{c,i,p} = \frac{1}{T}\sum_t \frac{X_{c,i,p,t}}{\sum_{j\neq c} X_{c,i,j,t}}$$

$$\varpi^{M}_{p,i,s} = \frac{1}{T}\sum_t \frac{M_{p,i,s,t}}{\sum_{j\neq s} M_{p,i,j,t}}$$

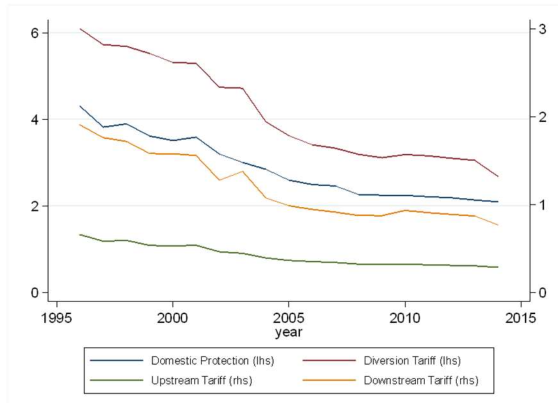
[11] Since tariffs are independent of which particular sector absorbs the goods, the tariff matrix τ can be written in dimension CS × C (as for the calculation of the downstream tariffs) or with dimension CS × CS (as for the calculation of the upstream tariffs), depending on dimension of the matrix it is multiplied with.

2.3 Description and Illustration of Tariff Measures

Having explained how the tariffs are constructed, this subsection briefly illustrates their respective magnitudes and evolution. Three broad patterns stand out.

- On aggregate, upstream and downstream tariffs have come down in line with domestic protection, i.e. nominal tariff rates (Figure 2**Error! Reference source not found.**). While the dynamics are similar, the tariff measures differ significantly in size, due to their different scaling. Upstream and downstream tariffs (associated with the right-hand scale in the graph) are substantially smaller than the diversion and import tariffs (which are not scaled by output or exports). The differences in the relative weights also leads to a significant difference between the larger downstream tariff and the smaller upstream tariffs. Downstream tariffs tend to be larger as they use the shares of total output that is exported as weights, while the upstream tariff relies on the shares of imported inputs in total outputs, which combines a trade- and an input criteria in the numerator.

Figure 2: Common Trend among Tariffs Measures



Note: The figure shows the evolution of the average upstream-downstream-, and diversion tariffs as well as of the degree of domestic protection, in percent. Value added weights are used for the aggregation from the country-sector level. Based on manufacturing sectors of the countries in the regression sample.

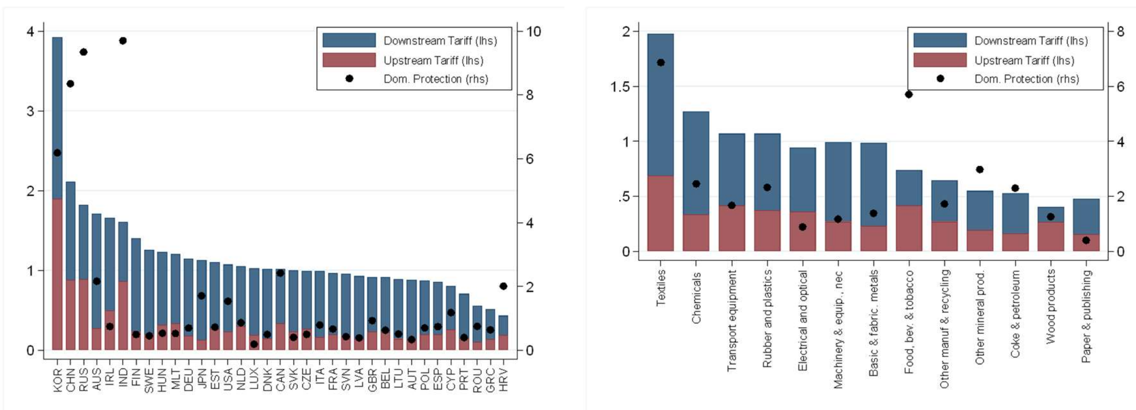
- There is a significant cross-sectional correlation between upstream and downstream tariffs as well as with the degree of domestic protection. Figure 3 shows the averages for the three types of tariffs, respectively across countries and sectors. Countries and sectors that are affected by high upstream tariffs also tend to see high downstream tariffs. In part, this is also true when compared to domestic protection, yet the correlation is slightly lower and more sensitive to outliers, particularly in the case of downstream tariffs.[12]

- Despite the positive correlation among the different tariff measures, there is substantial variation in their relative importance, which is partly a function of the sectors' and countries' positions in global value chains. Downstream tariffs are relatively more important for sectors such as *basic and fabricated metals* or *chemicals*, but relatively less important for sectors that rely on heavily taxed intermediate inputs, such as the *food beverage and tobacco* industry (Figure 3, right). Similarly, upstream tariffs are relatively more important for countries that assemble intermediate inputs from elsewhere, such as Korea and China, than for countries that have significant exports of raw material, such as Australia and Finland (Figure 3, left).

[12] The correlation coefficient between upstream and downstream tariffs is 0.85 across sectors (0.62 when the textile sector is dropped) and 0.68 across countries. The correlations between upstream tariffs and domestic protection are 0.77 across countries and 0.73 across sectors; for downstream tariffs, they are respectively 0.35 and 0.56 and highly insignificant if either the textile sector or Korea is excluded.

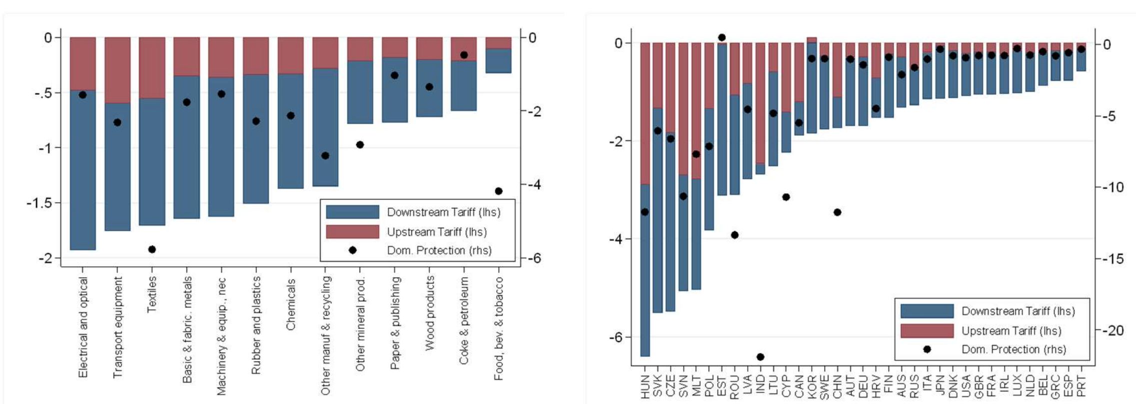
- Finally, countries have seen their upstream and downstream tariffs decline, also independently of their own domestic protection. Figure 4 illustrates the changes in the three tariff measures between 1995 and 2010. The correlation between the declines in downstream (blue) and upstream (red) tariffs again appears pronounced, yet the link with domestic production (black dot) is weak and sensitive to outliers.[13] This provides a key source of largely exogenous variation: countries and sectors saw their indirect tariff exposure reduced, largely independently of domestic trade policy.

Figure 3: Relative Importance of Upstream and Downstream Tariffs, 2010



Note: The figure shows respectively the country- and sector averages of 2010 upstream and downstream tariffs (stacked) as well as of the degree of domestic protection, in percent. Value added weights are used for the aggregation from the country-sector level. Based on manufacturing sectors of the countries in the regression sample.

Figure 4: Changes in Tariff Measures between 1995 and 2010



Note: The figure shows respectively the change in the country- and sector averages of upstream and downstream tariffs between 1995- and 2010 (stacked) as well as in the degree of domestic protection, in percent. Value added weights are used for the aggregation from the country-sector level. Based on manufacturing sectors of the countries in the regression sample.

A concrete example may help illustrate the roles of the different tariff measures: a US tariff increase on semiconductor imports from China. Abstracting from everything else, what are the likely effects for the US, China and the other countries? A priori, an increase in import tariffs (i.e. domestic protection) makes production in the US more lucrative, as companies can charge a higher price to the consumer. By consequence, industries relying

[13] Correlation coefficients between the changes in upstream and downstream tariffs are 0.46 across countries and 0.80 accross sectors. The correlations with the change in domestic protection are for the upstream tariff 0.83 across country, but an insignificant 0.25 across sectors. For downstream tariffs, the correlations 0.20 across countries and 0.02 across sectors, both highly insignificant.

either directly or indirectly on microchips would see prices for their inputs increase. This would be reflected in an increase in their upstream tariff. The tariff imposed on microchips from Mainland China can also make exports from other economies – such as Taiwan Province of China or South Korea – more competitive, captured by an increase in their diversion tariff. Finally, it likely affects the Chinese demand for intermediate inputs. From the perspective of the (domestic or international) silicon suppliers, a tariff on Chinese microchips increases their downstream tariffs.

This example is not entirely hypothetical, as integrated circuits or semiconductors were part of a June-2018 list of Chinese imports on which a 25% tariff was to be levied, published by the US administration. Rather than investigating whether the expected effects materialized in this concrete episode, we study whether the predicted patterns can be generally replicated with historical data. This approach is driven in part by data availability (particularly the production of input-output matrices are updated infrequently), in part by the desire to attain broader external validity. The rise of trade barriers between the US and China was exceptional among major economies, both in its speed and scope. Unless we believe similar trade policy adjustments will be the norm going forward, the study of the more gradual historical adjustments may actually be more informative for understanding the plausible effects of trade policy going forward, particularly if one cannot exclude non-linearities in the effects[14]. Finally, relying on multiple countries and sectors helps us distinguish the effects of tariffs from other macro-economic drivers and sectoral particularities. How our empirical strategy does this will be discussed in the next subsection.

2.4 Empirical Strategy

Our empirical model estimates the effects of the just-presented tariff measures on economic outcome variables at the sectoral level, along the lines of the following model:

$$ln(y_{c,s,t}) = \alpha + \beta_1 T^{up}_{c,s,t-1} + \beta_2 T^{down}_{c,s,t-1} + \beta_3 T^{dp}_{c,s,t-1} + \beta_4 T^{div}_{c,s,t-1} + \gamma_{c,t} + \delta_{c,s} + \varepsilon_{c,s,t}$$

The dependent variable $ln(y_{c,s,t})$, representing the log of real value added, employment, labor productivity or total factor productivity, is regressed on the various tariff measures and two types of fixed effects. Country-sector fixed effects ($\delta_{c,s}$) absorb structural and time-invariant aspects of the given country-sector, and country-time fixed effects ($\gamma_{c,t}$) control for any time-varying macro-economic drivers of economic prospects.

The inclusion of the fixed effects implies that the coefficients are estimated based on the variation across industries over time within a given country, yet are unaffected for instance by the country's business cycle, the exchange rate, or the effect of global financial cycles. This makes the identification of the coefficients more precise. The related drawback is that it becomes impossible to determine aggregate or general equilibrium effects of tariffs (including effects on the exchange rate). This also complicates the comparison of our results to studies that have highlighted the global costs of the recent trade tensions, such as Caceres, Cerdeiro and Mano (2019) or IMF (2019).

[14] To what extent our results are informative to assess the effects of trade wars depends on asymmetries and non-linearities in the effects of tariffs. While we are not aware of convincing evidence on non-linear effects, there is some evidence on asymmetry. Furceri et al (2021) suggest that the dynamic effects of a tariff increase are more harmful for productivity and output than tariff decreases are beneficial. Irwin (2014) finds a similar effects when looking at US sugar imports between 1890 and 1930, attributing the asymmetry to front-running prior to tariffs increase followed by a collapse in demand once the tariff is in place. Their findings suggests that our estimates, based on tariffs levels which generally declined, may actually underestimate the damage done by a tariff increase.

The baseline estimation generally includes 13 manufacturing sectors for up to 35 countries.[15] We follow the existing literature in lagging tariffs generally by one year, to avoid results being contaminated by front running, i.e. companies adjusting activity just before tariffs come into effects. We estimate the model with the linear estimator for high-dimensional fixed effects developed by Correia (2017).

3. Results

This section presents the main results, starting with a discussion of the baseline estimates. Since significant differences in the size of the tariff measures complicate the comparison of their effects, the second subsection puts a particular emphasis on their relative magnitude. Besides rescaling the tariff measure to have a comparable variation, illustrative simulations highlight their relative importance in situations resembling the recent US-China trade tensions.

Table 1: The Effect of Tariffs on Economic Outcome Variables

	(1)	(2)	(3)	(4)
	VA	Empl.	L-Prod.	TFP
T upstream	-19.41***	-10.24***	-6.53*	-11.52**
	(6.810)	(3.853)	(3.847)	(4.696)
T dom. protection	0.02	-0.88*	0.92	0.37
	(0.646)	(0.487)	(0.885)	(0.383)
T downstream	-14.47**	-0.50	-12.61***	-13.19**
	(6.027)	(3.790)	(4.672)	(6.394)
T diversion	5.14*	3.50*	1.29	-2.70
	(2.792)	(1.836)	(2.100)	(4.188)
Country-Year FE	Yes	Yes	Yes	Yes
Country-Ind. FE	Yes	Yes	Yes	Yes
N	6774	6776	6144	4112
R2	0.733	0.995	0.734	0.693

Note: Effect of a 1 ppt increase in the respective tariffs measures. VA = real value added; Empl. = number of persons engaged; L-Prod. = labor productivity and TFP = total factor productivity. Dependent variables are expressed in natural logarithm. Tariff measures are lagged by one year. Residuals are clustered at the country-sector level. SE in parentheses; * p<0.10** p<0.05 *** p<0.01

3.1 Baseline Estimates

Our baseline specification estimates the regression model outlined in equation (1), using respectively real value added, employment, labor productivity and total factor productivity as the dependent variable $y_{c,s,t}$.

Column 1 of Table 1 shows the effects of a one percentage-point increase in the respective tariff measures on real value added. Results suggest that tariffs higher up as well as further down in the value chain are drags on activity, illustrated by the negative and significant coefficients on the *Upstream* and *Downstream* tariffs. Relatively

[15] The sectors of mining and agriculture are not included, as their value added and productivity measures have been disproportionally volatile, likely due to the volatility of commodity prices.

lower tariff barriers compared to competitors (captured by a higher *diversion tariff*) tends to support it. However, we find no effect of domestic protection against foreign competition.

The estimated effect on value added broadly extend to employment and productivity. Employment also suffers under higher upstream tariffs and similarly benefits from higher diversion tariffs (column 2). In both cases, the coefficients are however slightly smaller, consistent with the idea that employment often does not change one-for-one with value added.[16] Unlike value added however, employment seems to be unaffected by downstream tariffs. Another difference is that the coefficients on domestic protection are negative and borderline statistically significant. Our confidence in the validity of the employment results is slightly reduced by the limited degree of variation on which coefficients are identified. Separate regressions (not reported) show that country-sector fixed effects alone explain 96% of the variation and that the addition of country-year fixed effects brings the R2 to 0.9945[17]. This implies that the four tariff coefficients are identified on only 0.05% of the variation, the difference with the R2 in column (2).[18]

The flip side of the differences between value added and employment are similarities between value added and labor productivity[19]. Labor productivity seems most strongly affected by the upstream and downstream tariffs, whose coefficients are negative and statistically significant (column 3). In the case of the upstream tariff, the point estimate is somewhat smaller than the one for value added; in the case of the downstream tariff – consistent with a negligible effect on employment – it is very similar in size. The effects of domestic protection and diversion tariffs are far from being statistically different from zero. Results for total factor productivity follow the ones for labor productivity quite closely.

We find our results largely in line with the existing literature and economic intuition. For example, our results confirm the findings of much of other papers that upstream tariffs tend to be more relevant than domestic protection for productivity. Amiti and Konings (2007), Topolova & Khandelwal (2011) and Ahn et al. (2018) have all found significantly larger productivity gains from a reduction of tariffs on intermediate inputs (their *input tariffs*) than from reducing tariffs on domestic protection (their *output tariff*). Similar to our results, Ahn et al. (2018) finds output tariffs to have a statistically insignificant effect in almost all specifications.

Empirical evidence on the effects of tariffs on value added and employment is more limited and more diverse. While recent theoretical work has studied the decomposition of gross trade into value added components,[20] our study is to our knowledge the first that empirically studies the effect on value added in a cross-country setup.

Micro studies of the effect of tariffs on labor markets have found negative, neutral and positive effects, depending on the setup or context. Various papers have highlighted that such differences in effects are not surprising. They have argued that the effect of both input and output tariffs depend on the extent a firm (or sector) is confronted with foreign competition or uses imported intermediate inputs (Amiti and Davis, 2011), the differentiation of output

[16] For example, Vandenbusche et al. (2019) use employment elasticities of just above 0.5 for the manufacturing sector when calibrating their model to assess the employment effects of Brexit.

[17] For the other variables analyzed, the combination of country-time and country-sector fixed effects explain respectively 73% (value added), 74% labor productivity and 69% (total factor productivity), predominantly driven by country-sector fixed effects.

[18] This implies that the cross-sectoral variation, the type of variation our estimation relies upon, is significantly lower for employment than either for value added or productivity. This could be a sign of very rigid labor markets, so that employment does not vary much with prospects. Alternatively, this may be related to the way data is collected.

[19] The link between the estimated effects on value added, employment and labor productivity is not exact, as the latter is calculated as the ratio of value added over hours worked. Not only does this differ somewhat from the "persons engaged" (the definition of employment), it is also available for a slightly smaller number of countries.

[20] See e.g. Hummels, Ishii, and Yi (2001), Koopman, Wang, and Wei (2014) and Foster-McGregor and Stehrer (2013).

(Luong, 2011) or intermediate inputs (Tuan, 2011) and the precise labor market rigidities (Helpman and Itskhoki, 2010). The most comparable results to ours probably come from Feenstra and Sasahara (2018) and Barattieri and Cacciatore (2020). In Barattieri and Cacciatore (2020), temporary trade barriers have insignificant effects on the protected sector but hurt industries further down in the value chain, consistent with our insignificant effects of domestic protection and negative effects of upstream tariffs. Feenstra and Sasahara (2018) however partly disagree. Their results suggest that tariffs can increase employment in the protected sector at the expense of foreign exporter, conclusions which are not fully consistent with our results or the ones from Barattieri and Cacciatore (2020).[21]

Few empirical studies have investigated trade diversion explicitly, despite the close conceptual link to the "multilateral resistance term" in trade gravity equations, whose importance has been recognized by the seminal contributions by Anderson (1979) and Anderson and van Wincoop (2003).[22] The inclusion of a multilateral tariff in Feenstra and Sasahara (2018) is one attempt to study tariff-induced diversion of employment, which has produced results consistent with our estimated employment effects of diversion tariffs. Other studies have looked at trade diversion mostly in the context of free-trade agreements. Magee (2004), Carter and Steinbach (2018) and Mattoo, Mulabdic and Ruta (2017) all find some, but generally weak, trade diversion from different discriminatory trade policies, broadly consistent with our results for value added.

3.2 The Magnitude of the Effects

Our baseline estimates in Table 1 have shown the effects of a one-percentage point change in the respective tariff measures. However, as we have shown earlier, the tariff measures differ considerably in size. This complicates the comparison of their effects.

We address this issue in two ways. In the first approach, we standardize all tariff measures. Regression coefficients thus no longer show the effect of a one-percentage-point increase in the respective tariff, but the effect of a one-standard deviation change. Table 2 shows the results. Relative to Table 1, the coefficients of the upstream and downstream tariffs decline somewhat, while the ones of domestic protection and the diversion tariff increase. For value added for example, one-standard deviation changes in the upstream or downstream tariffs have roughly comparable effects to trading partners reducing tariffs imposed on competitors by the same extent.

While looking at the effects of a one-standard deviation change helps make the effects more comparable, the procedure ignores that the various tariffs are closely connected. A tariff increase by one country can affect one or several tariff measures for all the countries in the sample, yet potentially to very different degrees. For example, a discriminatory tariff will likely affect the domestic protection of the home country or the downstream tariff of the targeted one more strongly than it affects the trade diversion tariff of the untargeted. We thus use simulations to illustrate how a given tariff change would likely affect the respective tariffs and eventually the economic prospects of the various countries concerned.

[21] The results by Feenstra and Sasahara (2018) attribute a small but statistically significant positive employment effect of domestic protection as well as a negative effect of downstream tariffs, which our results fail to reproduce. Conditional on the bilateral tariff, they also find a positive effect of the multilateral tariff, the tariff imposed on everybody else, consistent with our results for the diversion tariff.

[22] Vandenbussche, Connell and Simons (2019) illustrate the importance of trade diversion at the sectoral level. In their model, a tariff hike creates trade diversion both through a redirection of trade by the targeted exporter towards countries with lower tariffs (given an increase in the outward MRT) and a redirection of trade by the importer towards those not affected by the new tariff (given an increase in the importers' inward MRT). Our diversion tariff defined as the weighted average tariff imposed by the partner countries on all other suppliers cannot distinguish between the two channels.

Table 2: Effect of One Standard Deviation Changes

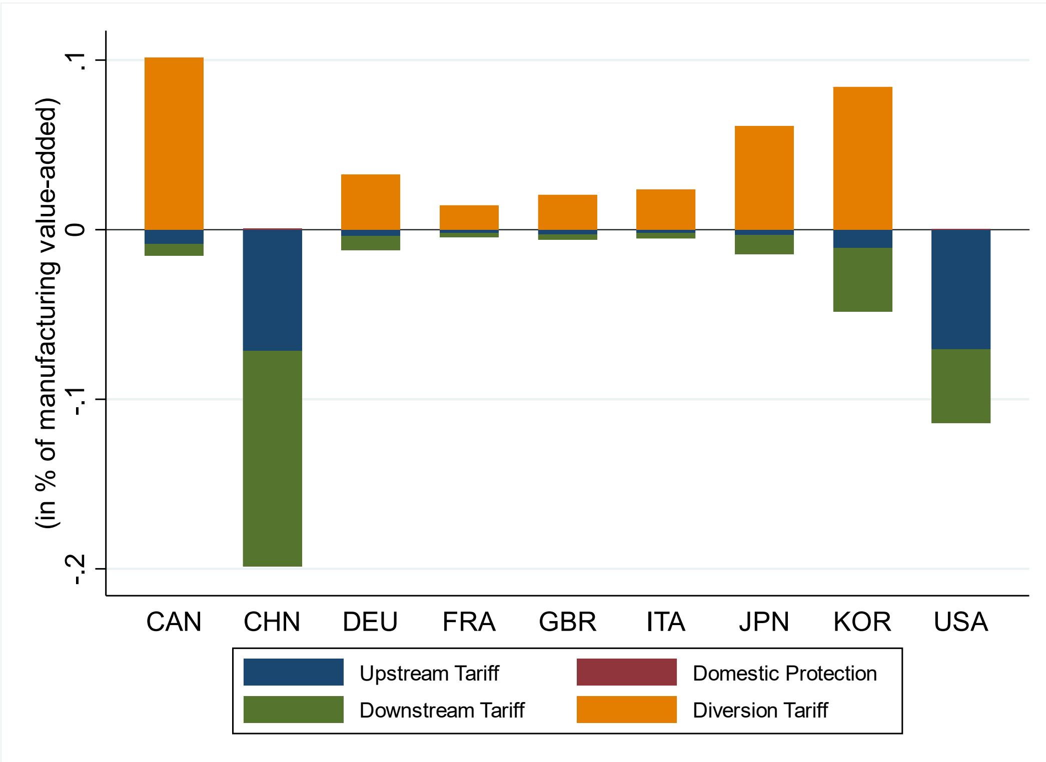
	(1) VA	(2) Empl.	(3) L-Prod.	(4) TFP
T upstream	-16.18***	-8.55***	-5.45*	-9.60**
	(5.68)	(3.21)	(3.21)	(3.91)
T dom. protection	0.10	-5.17*	5.42	2.17
	(3.80)	(2.86)	(5.20)	(2.25)
T downstream	-11.93**	-0.41	-10.40***	-10.87**
	(4.97)	(3.12)	(3.85)	(5.27)
T diversion	10.98*	7.45*	2.75	-5.76
	(5.96)	(3.92)	(4.48)	(8.94)
Country-Year FE	Yes	Yes	Yes	Yes
Country-Ind. FE	Yes	Yes	Yes	Yes
N	6774	6768	6144	4112
R2	0.733	0.995	0.734	0.693

Note: Effect of a 1 standard-deviation increase in the respective tariffs measures. VA = real value added; Empl. = number of persons engaged; L-Prod. = labor productivity and TFP = total factor productivity. Dependent variables are expressed in natural logarithm. Tariff measures are lagged by one year. Residuals are clustered at the country-sector level. SE in parentheses; * p<0.10** p<0.05 *** p<0.01

Figure 5 shows the simulated effect of a reciprocal uniform 1ppt tariff increase between the US and China on their value added and that of some of their main trading partners. The effects are most negative for China and the US themselves, driven by the significant changes in the upstream and downstream tariffs and the large coefficients associated with them. Domestic protection also increases but given a coefficient very close to zero, it barely shows up in the graph. Other countries generally benefit from significant trade diversion, but downstream tariffs – and to a lesser extent – upstream tariffs partly offset these gains in value added. This is particularly the case for countries such as Korea, Japan and Canada.

In terms of magnitude, our estimated effects are significantly larger than those from theoretical general-equilibrium models. For example, according to our coefficients a reciprocal and uniform increase in bilateral tariff by 25 percentage points between the US and China would reduce Chinese value added by roughly 5½ % in the long run and US value added by roughly 3%. Model simulations published in IMF (2019) suggest that the likely effects on GDP may only be a fraction of this. Part of this difference is likely due to general equilibrium effects being absorbed in our framework by the country-year fixed effects. Changes in the exchange rate or in the costs of factors of production likely attenuate the macro-economic impact of tariffs. An additional plausible driver of our bigger effects is the fact that our tariff elasticities are estimated on a sample of manufacturing sectors only, which are likely particularly sensitive to tariffs.

Figure 5: Effects on Manufacturing Value Added of a US-China Tariff War



Note: Simulated effect of a reciprocal and uniform 1 ppt-tariff increase between China and the US on value added, based on coefficients reported in column (1) of Table 1. Bars show the total contributions of the different tariff measures, summed over individual sectors, in percent of manufacturing value added.

4. Robustness

The previous section has shown that tariffs tend to have wide-ranging effects throughout the value chain. The effects are consistent with the theoretical literature but have been largely neglected by existing empirical studies. The objective of this section is to show that many of our results are surprisingly robust, including to different specifications, different weights or changing lag-length. We briefly discuss the various robustness checks here but refer to the appendix for most of the additional results.

A. Individual Effects of Tariff Measures

We have argued in the introduction that using a richer set of tariff measures is not only relevant in the current context but may also influence the estimated effects of tariffs studied more abundantly by the existing literature. Our first robustness check thus investigates how the inclusion of a broader set of tariffs alters their individual effects estimated with a univariate regression (plus the various FEs).

Table 3: Individual vs Jointly Estimated Effects on Value Added

	(1)	(2)	(3)	(4)	(5)
	VA	VA	VA	VA	VA
T upstream	-19.41***	-22.30***			
	(6.810)	(7.464)			
T dom. protection	0.02		-0.58		
	(0.646)		(0.699)		
T downstream	-14.47**			-14.20**	
	(6.027)			(6.724)	
T diversion	5.14*				2.33
	(2.792)				(2.171)
Country-Year FE	Yes	Yes	Yes	Yes	Yes
Country-Ind. FE	Yes	Yes	Yes	Yes	Yes
N	6774	6774	6774	6774	6774
R2	0.733	0.730	0.722	0.725	0.722

Note: Effect of a 1 ppt increase in the respective tariffs measures. VA = real value added; The dependent variable (value added) is expressed in natural logarithm. Tariff measures are lagged by one year. Residuals are clustered at the country-sector level. SE in parentheses; * p<0.10** p<0.05 *** p<0.01

Table 3: Individual vs Jointly Estimated Effects on Value Added compares for value added the jointly estimated effects of the various tariffs (column 1) with the ones estimated individually (columns 2 to 5). The difference between individually and jointly estimated coefficients are generally statistically insignificant yet point estimates do vary somewhat. Across value added and the other dependent variable (for which equivalent tables are reported in the Appendix), we observe that individually estimated coefficients tend to be somewhat larger (in absolute values) for the upstream tariff, quite similar for the downstream tariff and somewhat smaller for the diversion tariff. This suggests that in our sample the inclusion of additional tariff measures mostly helps to broaden the studied impact of tariffs (including on non-targeted countries and sectors), but only marginally alters the estimated effects of the individual tariffs.

B. Alternative Weights for Tariff Aggregation

For the construction of our tariff measures, we used averages of imports and exports or the input-output tables. These have the advantage of being constant and broadly representative for the sample period. Yet, the structure of the global economy changed substantially since the mid-1990s. This raises the question whether and how results change when different weights are chosen.

Table 4: Effect on Value Added with Alternative Weights

	(1)	(2)	(3)
Weights based on	1995-2010	1995	2010
T upstream	-19.41***	-20.63***	-17.18**
	(6.81)	(7.11)	(8.01)
T dom. protection	0.02	0.31	0.06
	(0.65)	(0.48)	(0.67)
T downstream	-14.47**	-15.84**	-11.99***
	(6.03)	(7.53)	(4.63)
T diversion	5.14*	2.19	4.46**
	(2.79)	(2.67)	(2.01)
Country-Year FE	Yes	Yes	Yes
Country-Ind. FE	Yes	Yes	Yes
N	6774	6774	6774
R2	0.733	0.733	0.731

Note: Effect of a 1 ppt increase in the respective tariffs measures, when respectively 1995 and 2010-weights are used for their calculations. Dependent variable (value added) is the natural logarithm of value added. Tariff measures are lagged by one year. Residuals are clustered at the country-sector level. SE in parentheses; * p<0.10** p<0.05 *** p<0.01

Table 4 compares the baseline results for value added in column (1) with the ones when the tariff measures are calculated using either 1995 or 2010 weights. Equivalent tables for the other variables are again reported in the Appendix. While we find results broadly robust to the alternative weighting schemes, some results weaken when relying on trade and production links from the beginning of the sample. For example, the coefficient of the diversion tariff for value added is not distinguishable from zero with 1995 weights (column 2). The same is true for the effect of upstream tariffs on labor productivity (Table 11, column 2). Given that trade patterns have changed significantly since 1995, we find this neither particularly surprising nor concerning.

C. Robustness to Lag Order

Our last sensitivity test investigates how increasing the lag length between the tariffs and the dependent variables affects the results. Table 5 compares our baseline result using a lag of one year (column 2) with the contemporaneous effect (column 1) and the ones using longer lags. While effects decline with increasing lag length, the conclusions remain broadly unchanged, as the point estimates decline only slowly. This is also the case for the other dependent variables, for which equivalent tables are reported in the Appendix. Some coefficients, which are only marginally significant in the baseline, however become statistically indistinguishable from zero with longer lag lengths.

Table 5: Effect on Value Added with Increasing Lag Length

	(1) Contemp.	(2) L1	(3) L2	(4) L3
LX. T upstream	-20.85***	-19.41***	-18.53***	-17.18***
	(7.04)	(6.81)	(6.62)	(6.18)
LX. T dom. protection	0.05	0.02	-0.02	-0.00
	(0.66)	(0.65)	(0.64)	(0.58)
LX. T downstream	-15.37**	-14.47**	-12.75**	-11.43**
	(6.37)	(6.03)	(5.64)	(5.25)
LX. T diversion	5.87**	5.14*	4.37	3.73
	(2.81)	(2.79)	(2.68)	(2.54)
Country-Year FE	Yes	Yes	Yes	Yes
Country-Ind. FE	Yes	Yes	Yes	Yes
N	7187	6774	6361	5948
R2	0.744	0.733	0.719	0.709

Note: Effect of a 1 ppt increase in the respective tariffs measures, with increasing lag length from zero to three years. The dependent variable (value added) is expressed in natural logarithm. L is the lag operator. Residuals are clustered at the country-sector level. SE in parentheses; * p<0.10** p<0.05 *** p<0.01

5. Conclusion

This paper empirically investigates the effects of tariffs when production is organized in global value chains. We use global input-output matrices to construct four different tariff measures that allow us to study richer spillovers from tariffs than the existing literature has looked at. Our results suggest that tariffs can have wide-ranging effects, including on countries and sectors that are not directly targeted. We find economically and statistically significant negative effects on economic outcomes from tariffs that are imposed higher up as well as further down in the value chain. We also find positive effects from tariffs imposed on competitors.

Our findings have important policy implications, in line with much of the existing literature. First, domestic protection generally does not improve economic prospects in the protectionist country. This is due to the combination of negligible or even negative effects on the sector that benefits from protection and the fact that the home country tends to suffer most from more expensive intermediate inputs. Second, tariffs can have wide-ranging consequences on sectors and countries not directly targeted. While some countries and sectors may benefit from the effects of tariffs imposed on competitors, others see their demand suppressed even if their goods or services are not exported directly. Third, bilateral tariff wars hurt the two parties involved the most, with third countries sometimes benefiting on net from trade diversion. Even if a bilateral tariff was not met with a reciprocal tariff from the targeted country, it often does not benefit the country imposing the tariff. Instead, imports from the targeted country are likely to be replaced by imports from elsewhere. Related, Eugster et al. (2020) discuss how bilateral tariffs and trade balances are largely irrelevant for macroeconomic performance.

We believe our results significantly extend the empirical literature on the effects of tariffs, while being in line with recent theoretical studies. One of our key contributions to the literature is the construction of a richer set of tariff measures. While upstream tariffs have been analyzed before – in various forms and with different names – we believe we are the first cross-country study to empirically investigate the effects of downstream tariffs and tariff-induced diversion of value added. Our study builds on and complements recently developed theoretical gravity models, which focus on trade linkages at the sectoral level and emphasize trade in value added (e.g., Vandenbusche et al. 2019, Caliendo and Parro 2015, Noguera 2012). Our results also fit well with recent evidence from higher-frequency studies of the recent US-China trade tensions, which generally confirm that the negative effects of tariffs confronted further down in the value chain outweigh potentially positive effects of domestic protection.[23]

The contribution of our paper to the discussion of the effects of trade policy is based on historical tariff data. While this has many advantages, it also has important limitations. First, the focus on tariffs likely underestimates the overall effect of trade tensions. Non-tariff barriers, including higher administrative hurdles, appear to have risen in tandem and the increased uncertainty is likely a further deterrent to trade and investment. While it seems plausible that the effects of tariffs highlighted in our paper also apply to other types of trade barriers, we are unable to either support or refute this hypothesis based on our results.

A second limit of our analysis is the historical data itself. Historically, tariffs declined rather gradually. It is not clear whether the effect of a tariff increase is the mirror image of a tariff decline or whether there are relevant asymmetries. It is also not clear whether and to what extent effects are linear, i.e. whether effects increase proportionally with the change in the tariff. Finally, global value chains adapt, which itself may also have non-negligible consequences. All these important questions are left for further research.

[23] For example, Flaaen and Pierce (2019) finds that in the US, industries more exposed to tariff increases suffered more from the recent tariff hikes, as a potentially positive effect from domestic protection was more than offset by higher input costs and an increase in tariffs on their exports. Similarly, Chor and Li (2021) find concentrated negative effects on income per capita in Chinese locations particularly exposed to US tariffs (equivalent to a higher downstream tariff in our framework), but little effects from domestic protection.

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Appendix

1. Data

Table 6: Country- and Industry Sample

iso3 code	Country Name	Isic3 Code	Manufacturing Sectors
AUS	Australia	C15T16	Food, bev. & tobacco
AUT	Austria	C17T19	Textiles
BEL	Belgium	C20	Wood products
CAN	Canada	C21T22	Paper & publishing
CHN	China	C23	Coke & petroleum
CYP	Cyprus	C24	Chemicals
CZE	Czechia	C25	Rubber and plastics
DEU	Germany	C26	Other mineral prod.
DNK	Denmark	C27T28	Basic & fabric. metals
ESP	Spain	C29	Machinery & equip., nec
EST	Estonia	C30T33	Electrical and optical
FIN	Finland	C34T35	Transport equipment
FRA	France	C36T37	Other manuf & recycling
GBR	United Kingdom		
GRC	Greece		Service Sectors
HRV	Croatia	C40T41	Electr., gas & water
HUN	Hungary	C45	Construction
IND	India	C50T52	Wholesale & retail
IRL	Ireland	C55	Hotels and restaurants
ITA	Italy	C60T63	Transport and storage
JPN	Japan	C64	Post & telecom
KOR	South Korea	C65T67	Financial intermed.
LTU	Lithuania	C70	Real estate
LUX	Luxembourg	C71T74	Business Serv.
LVA	Latvia	C75	Public admin, defence
MLT	Malta	C80	Education
NLD	Netherlands	C85	Health & social work
POL	Poland	C90T93	Other comm., soc & pers.
PRT	Portugal		
ROU	Romania		
RUS	Russia		
SVK	Slovakia		
SVN	Slovenia		
SWE	Sweden		
USA	United States		

2. Additional Results Table

2.1 Differences between Individually and jointly estimated Tariff Effects

The tables below compare the effects of the tariff measures on employment, labor productivity and total factor productivity when these are estimated jointly or individually (i.e. without controlling for all others tariffs). Similar to Table 3 for value added, the Tables below show that the two estimations do not produce statistically different estimates.

Table 7: Individual vs Jointly Estimated Effects on Employment

	(1) Empl.	(2) Empl.	(3) Empl.	(4) Empl.	(5) Empl.
T upstream	-10.24***	-12.63***			
	(3.853)	(4.049)			
T dom. protection	-0.88*		-0.99**		
	(0.487)		(0.439)		
T downstream	-0.50			-1.13	
	(3.790)			(3.855)	
T diversion	3.50*				2.01
	(1.836)				(1.385)
Country-Year FE	Yes	Yes	Yes	Yes	Yes
Country-Ind. FE	Yes	Yes	Yes	Yes	Yes
N	6776	6776	6776	6776	6776
R2	0.995	0.995	0.995	0.995	0.995

Note: Effect of a 1 ppt increase in the respective tariffs measures. The dependent variable (number of persons engaged) is expressed in natural logarithm. Tariff measures are lagged by one year. Residuals are clustered at the country-sector level. SE in parentheses; * p<0.10** p<0.05 *** p<0.01

Table 8: Individual vs Jointly Estimated Effects on Labor Productivity

	(1) L-Prod.	(2) L-Prod.	(3) L-Prod.	(4) L-Prod.	(5) L-Prod.
T upstream	-6.53*	-7.12*			
	(3.847)	(4.154)			
T dom. protection	0.92		0.36		
	(0.885)		(0.758)		
T downstream	-12.61***			-11.64**	
	(4.672)			(4.678)	
T diversion	1.29				-0.10
	(2.100)				(1.871)
Country-Year FE	Yes	Yes	Yes	Yes	Yes
Country-Ind. FE	Yes	Yes	Yes	Yes	Yes
N	6144	6144	6144	6144	6144
R2	0.734	0.730	0.729	0.732	0.729

Note: Effect of a 1 ppt increase in the respective tariffs measures. The dependent variables (labor-productivity) is expressed in natural logarithm. Tariff measures are lagged by one year. Residuals are clustered at the country-sector level. SE in parentheses; * p<0.10** p<0.05 *** p<0.01

Table 9: Individual vs Jointly Estimated Effects on Total Factor Productivity

	(1) TFP	(2) TFP	(3) TFP	(4) TFP	(5) TFP
T upstream	-11.52**	-13.55***			
	(4.696)	(4.671)			
T dom. protection	0.37		-0.19		
	(0.383)		(0.450)		
T downstream	-13.19**			-16.68**	
	(6.394)			(7.007)	
T diversion	-2.70				-4.88
	(4.188)				(4.317)
Country-Year FE	Yes	Yes	Yes	Yes	Yes
Country-Ind. FE	Yes	Yes	Yes	Yes	Yes
N	4112	4112	4112	4112	4112
R2	0.693	0.688	0.685	0.691	0.687

Note: Effect of a 1 ppt increase in the respective tariffs measures. The dependent variable (total factor productivity) is expressed in natural logarithm. Tariff measures are lagged by one year. Residuals are clustered at the country-sector level. SE in parentheses; * p<0.10** p<0.05 *** p<0.01

2.2 Alternative Weights for the Calculation of Tariffs

The tables below compare for employment, labor productivity and total factor productivity the effects of the baseline tariffs, which rely on 1995-2010 averages as weights, with those using either 1995 or 2010 values for aggregation. Similar to Table 4 for value added, the tables below show that the effects are broadly robust.

Table 10: Effect on Employment with Alternative Weights

Weights based on	(1) 1995-2010	(2) 1995	(3) 2010
T upstream	-10.24***	-13.27***	-10.88**
	(3.85)	(4.36)	(4.92)
T dom. protection	-0.88*	-0.52*	-0.70
	(0.49)	(0.31)	(0.45)
T downstream	-0.50	-0.86	2.50
	(3.79)	(6.14)	(3.83)
T diversion	3.50*	3.22*	1.16
	(1.84)	(1.73)	(1.45)
Country-Year FE	Yes	Yes	Yes
Country-Ind. FE	Yes	Yes	Yes
N	6776	6776	6776
R2	0.995	0.995	0.995

Note: Effect of a 1 ppt increase in the respective tariffs measures, when using respectively 1995 and 2010-weights for their calculations. Dependent variable (number of persons engaged) is the natural logarithm of employment. Tariff measures are lagged by one year. Residuals are clustered at the country-sector level. SE in parentheses; * p<0.10** p<0.05 *** p<0.01

Table 11: Effect on Labor Productivity with Alternative Weights

Weights based on	(1) 1995-2010	(2) 1995	(3) 2010
T upstream	-6.53*	-2.86	-9.73*
	(3.85)	(3.31)	(5.40)
T dom. protection	0.92	0.79	0.93
	(0.89)	(0.79)	(0.88)
T downstream	-12.61***	-15.21***	-10.45***
	(4.67)	(4.65)	(3.73)
T diversion	1.29	-0.13	2.00
	(2.10)	(2.43)	(1.48)
Country-Year FE	Yes	Yes	Yes
Country-Ind. FE	Yes	Yes	Yes
N	6144	6144	6144
R2	0.734	0.734	0.734

Note: Effect of a 1 ppt increase in the respective tariffs measures, when using respectively 1995 and 2010-weights for their calculations. Dependent variable (labor productivity) is the natural logarithm of labor productivity. Tariff measures are lagged by one year. Residuals are clustered at the country-sector level. SE in parentheses; * p<0.10** p<0.05 *** p<0.01

Table 12: Effect on Total Factor Productivity with Alternative Weights

Weights based on	1995-2010	1995	2010
T upstream	-11.52**	-12.78**	-15.04***
	(4.70)	(5.41)	(5.25)
T dom. protection	0.37	0.32	0.52
	(0.38)	(0.36)	(0.39)
T downstream	-13.19**	-18.04**	-7.77*
	(6.39)	(7.57)	(4.26)
T diversion	-2.70	-2.55	-1.60
	(4.19)	(3.71)	(2.72)
Country-Year FE	Yes	Yes	Yes
Country-Ind. FE	Yes	Yes	Yes
N	4112	4112	4112
R2	0.693	0.693	0.692

Note: Effect of a 1 ppt increase in the respective tariffs measures, when using respectively 1995 and 2010-weights for their calculations. The dependent variable (total factor productivity) is the natural logarithm of total factor productivity. Tariff measures are lagged by one year. Residuals are clustered at the country-sector level. SE in parentheses; * p<0.10** p<0.05 *** p<0.01

2.3 Increasing Lag Lengths

The tables below compare the effects of the tariff measures on employment, labor productivity and total factor productivity when these enter the equation with increasing lag length. Similar to **Error! Reference source not found.** for value added, the tables below show that the size of the effects generally decline as lag length are increased.

Table 13: Effect on Employment with Increasing Lag Length

	(1) Contemp.	(2) L1	(3) L2	(4) L3
LX.T_upstream	-10.77***	-10.24***	-9.43**	-8.71**
	(3.89)	(3.85)	(3.89)	(3.68)
LX.T_D_protect	-0.83*	-0.88*	-0.92*	-0.85*
	(0.48)	(0.49)	(0.49)	(0.46)
LX.T_downstream	-1.39	-0.50	0.47	1.21
	(4.00)	(3.79)	(3.57)	(3.29)
LX.T_diversion	3.93**	3.50*	3.16*	2.53
	(1.84)	(1.84)	(1.83)	(1.79)
Country-Year FE	Yes	Yes	Yes	Yes
Country-Ind. FE	Yes	Yes	Yes	Yes
N	7183	6776	6369	5962
R2	0.995	0.995	0.995	0.996

Note: Effect of a 1 ppt increase in the respective tariffs measures, with increasing lag length from zero to three years. The dependent variable (number of persons engaged) is expressed in natural logarithm. L is the lag operator. Residuals are clustered at the country-sector level. SE in parentheses; * p<0.10** p<0.05 *** p<0.01

Table 14: Effect on Labor Productivity with Increasing Lag Length

	(1) Contemp.	(2) L1	(3) L2	(4) L3
LX.T_upstream	-7.81*	-6.53*	-6.88*	-7.03*
	(3.99)	(3.85)	(3.82)	(3.92)
LX.T_D_protect	0.87	0.92	0.83	0.74
	(0.88)	(0.89)	(0.91)	(0.87)
LX.T_downstream	-12.77***	-12.61***	-11.71**	-11.00**
	(4.72)	(4.67)	(4.60)	(4.47)
LX.T_diversion	1.77	1.29	0.94	0.81
	(2.03)	(2.10)	(2.12)	(2.11)
Country-Year FE	Yes	Yes	Yes	Yes
Country-Ind. FE	Yes	Yes	Yes	Yes
N	6524	6144	5764	5384
R2	0.747	0.734	0.717	0.703

Note: Effect of a 1 ppt increase in the respective tariffs measures, with increasing lag length from zero to three years. The dependent variable (labor productivity) is expressed in natural logarithm. L is the lag operator. Residuals are clustered at the country-sector level. SE in parentheses; * p<0.10** p<0.05 *** p<0.01

Table 15: Effect on Total Factor Productivity with Increasing Lag Length

	(1) Contemp.	(2) L1	(3) L2	(4) L3
LX.T_upstream	-14.32***	-11.52**	-9.54*	-5.47
	(5.35)	(4.70)	(4.93)	(6.73)
LX.T_D_protect	0.43	0.37	0.34	0.33
	(0.42)	(0.38)	(0.36)	(0.34)
LX.T_downstream	-14.53**	-13.19**	-9.76	-7.26
	(6.59)	(6.39)	(6.00)	(5.71)
LX.T_diversion	-1.94	-2.70	-2.41	-1.42
	(3.80)	(4.19)	(3.85)	(3.61)
Country-Year FE	Yes	Yes	Yes	Yes
Country-Ind. FE	Yes	Yes	Yes	Yes
N	4365	4112	3859	3606
R2	0.698	0.693	0.686	0.683

Note: Effect of a 1 ppt increase in the respective tariffs measures, with increasing lag length from zero to three years. The dependent variable (total factor productivity) is expressed in natural logarithm. L is the lag operator. Residuals are clustered at the country-sector level. SE in parentheses; * p<0.10** p<0.05 *** p<0.01

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