Impact of US tariffs on the Spanish economy: An analysis based on the "exposure" indicator and FIGARO data

Juan Cervigón and Sixto Muriel. INE (Spain)

Introduction

In recent years, US trade policy has shifted toward marked protectionism, using tariffs not only as economic tools but also as instruments of international policy that transcend conventional financial criteria. This trend creates an environment of high uncertainty, making medium-term planning difficult for open economies like Spain's

In a context of growing protectionism and reconfiguration of international trade relations, the United States' tariff policy has become a source of uncertainty for the global economy, prompting the central question of this analysis: What is the real impact of an increase in US tariffs on a particular economy (in this case in the Spanish economy) in terms of added value and employment, considering not only direct trade but also its integration into Global Value Chains?

Unlike traditional analyses based on gross flows, this analysis focuses on the impact on Value Added and employment. This involves investigating direct and indirect economic flows. The analysis of direct flows measures the Spanish value added contained in Spanish exports to the US (for example, lower exports of manufactured goods to the US result in lower value added in the services sector). Indirect flows measure the Spanish value added that, through other countries, ends up being imported by the US (for example, lower exports of automobiles from Germany to the US result in a loss of Spanish value added due to reduced activity in the production of automotive components).

For Spain, understanding this impact is a vital necessity that requires going beyond the analysis of gross exports; the real risk lies in how the Added Value and Employment that depend on North American demand are affected.

This indicator is a core component of the Macroeconomic Global Indicators (MGI) published by Eurostat, utilizing the FIGARO database to trace how value moves across borders.

The originality of this work lies in the convergence of a high-fidelity database with an advanced exposure metric. The model allows for the quantification of tariff policy impacts by assuming a set of reasonable hypotheses that are easily adaptable to analyse different scenarios. Furthermore, all the calculations are implemented in Python, so no proprietary software is required for its use.

The paper is structured in the following steps:

1. Data: The analysis is based on data from FIGARO (Full International and Global Accounts) for Research in Input-Output analysis), published by Eurostat. FIGARO has become a standard database that allows the development of macroeconomic models considering the interaction between economies.
2. Leontief Model and the TiVA indicators: The classic multi-regional *input-output* analysis structure is used. The core of the calculation is the Inverse Leontief Matrix, which allows capturing the direct and indirect effects of a change in final demand.
3. "Exposure" Indicator: The TiVA indicator of one economy's exposure to another is used. This indicator is broken down into the value added generated in Spain contained in Spanish exports to the US (differentiating between final use in the US as intermediate consumption for final demand in US or other countries) and the value added generated in Spain contained in exports to other countries that ultimately end up in US demand.
4. Implementation of tariffs on Input Output Tables. The impact of tariffs translates into a price increase that affects quantities according to pass-through (i.e., the extent to which the seller passes on the tariffs to the buyer) and price elasticity (i.e., the extent to which demand decreases with a one percent increase in price). This article assumes 100% pass-through and an elasticity of 0.8 for recalculating export flows after tariffs are applied. Sensitivity analysis based on this assumption can be easily performed, as the model is linear
5. Scenario comparison. The analysis concludes by comparing the initial scenarios with the resulting scenario after applying the tariffs.

The main result of the paper is shown in the next table. Exposure of the Spanish economy to the US economy and the impact of a 15% increase in US tariffs (along with the assumption on passthrough and elasticity) for year 2023

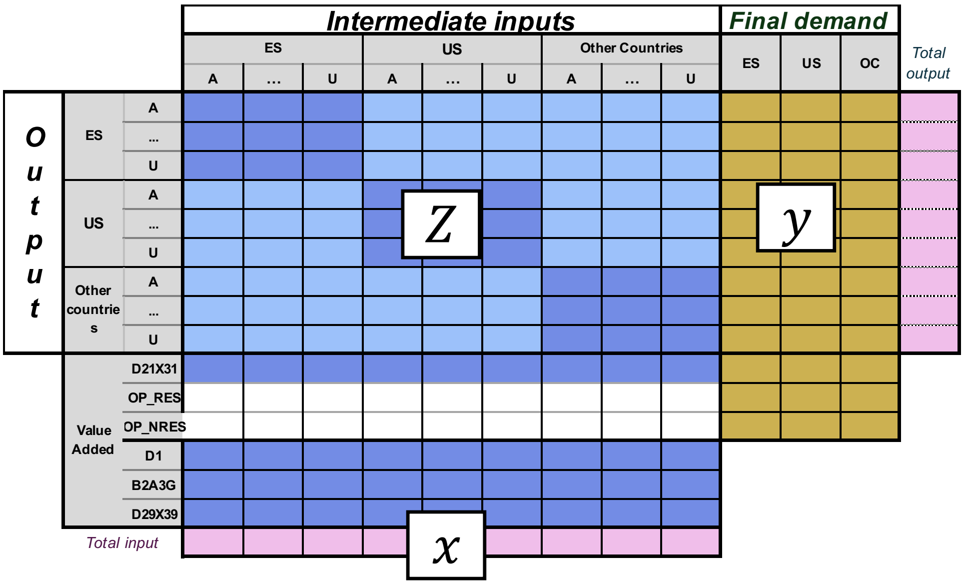
	Exposure	Impact	Impact/Expo
Value added (million euros)	34,133	2,549	7.5%
Share of GDP	2.3%	0.17%	
Employment (k of persons)	531	38	7.2%
Share of employment. Persons	2.5%	0.18%	

Data: Figaro database

FIGARO (Full International and Global Accounts for Research in Input-Output analysis) is the official multiregional input-output (MRIO) database produced by Eurostat in collaboration with the European Commission's Joint Research Centre (JRC). Unlike many academic MRIO projects, FIGARO is a statistical product, meaning it is built directly from official national accounts, supply-use tables (SUTs), and balanced bilateral trade statistics, ensuring a high degree of consistency with European statistical standards (ESA 2010). The database provides a detailed "snapshot" of the global economy by tracking the flow of goods and services between industries and countries. It covers from year 2010 to year T-2 with releases each July, so at the time of publishing this paper (May 2026), the last year available is 2023. Each release review all the series to be aligned with the last official figures of the National Accounts of the countries, except for the imports and exports that obviously must be adjusted to eliminate the imbalances between the figures published by countries. A core strength of FIGARO is its "balanced view" of international trade. It resolves the common statistical discrepancy where Country A's reported exports to Country B do not match Country B's reported imports from Country A.

The following figure shows the IoT structure (we have rearranged the rows and columns to show Spain first, then the US, and then the rest of the world to facilitate subsequent calculations). The tables contain 50 countries[1] and 64 industries for each country. The table can be divided into 3 matrices. The Z matrix for intermediate use, with dimensions 3200 x 3200 (where 3200 = 50 countries x 64 industries). The Y matrix for final demand, with dimensions 3200 x 3 (one vector for the total final demand of Spain, the US, and the rest of the world, respectively), and the X vector for total production or, equivalently, total input.

[1] 27 EU countries, 22 other countries (2 EFTA Countries: Norway, Switzerland, 5 EU Candidates: Albania, Montenegro, North Macedonia, Serbia, Türkiye and 15 Main Trading Partners Argentina, Australia, Brazil, Canada, China, India, Indonesia, Japan, Mexico, Russia, Saudi Arabia, South Africa, South Korea, United Kingdom, United States), and the region “rest of the world” totalling all the world economy



The Leontief model and the TiVA indicators

The Leontief model is a well-known model that allows us to calculate the production needed to achieve a given demand.

- The coefficient matrix A, is defined as $A = Z\langle x\rangle^{-1}$, where Z is the intermediate inputs matrix (3,200 x 3,200) and $\langle x\rangle^{-1}$ is the inverse of the diagonalized vector of total inputs x (1 x 3,200)

- The inverse of Leontief B, is defined as $B = (I - A)^{-1}$

- The Leontief model $By = x$, that allows to calculate the total input x necessary to meet any given demand y

In the context of the MRIO, the exports of country A for intermediate use in country B, denoted by $e^{A\,B}$, can be considered as a demand for country A. But in that case, to calculate the production needed in country A to satisfy that demand, it is not correct to use the inverse Leontief, and the local inverse Leontief, which we will denote by the letter L, must be used.

To identify unambiguously the countries, we will use superscripts to identify flows from specific countries. Two superscripts will be used when specifying the origin and destination in matrices, and a single superscript for vectors. Consequently, L^A will denote the local Leontief inverse of country A and x^A the production of country A. Then

$$L^{A} e^{A\,B} = x^{A}$$

Where,

$$L^{A} = (I - A^{A\,A})^{-1}$$

$A^{A\,A}$ is a submatrix of $A = Z\langle x \rangle^{-1}$

The brackets $\langle \cdot \rangle$ signify the transformation of a vector into its diagonalized form.

The superscript used are

Index	Meaning
$.^{ES}$	Spain
$.^{US}$	United States of America
$.^{oc}$	Other countries. All countries, including the rest of the world, except Spain and United States of America
$.^{all}$	All countries, including the rest of the world, Spain and United States

These superscrips can be used either to identify the elements of a vector or the elements of a matrix. For example, $B^{US\,all}$ represents the submatrix of the inverse Leontief composed by the intersection of the rows of US and all the columns.

The next table shows a list of the variables used in the calculations

Variable	Dimension	Meaning
x^{ES}	1 x 64	Spanish total production by industry
va^{ES}	1 x 64	Spanish Value added by industry
v^{ES}	1 x 64	Value added coefficient for Spain $va^{ES} \cdot \langle x^{ES} \rangle^{-1}$
$pers^{ES}$	1 x 64	Total Spanish employees (k-persons) by industry
p^{ES}	1 x 64	Person coefficient, $pers^{ES} \cdot \langle x^{ES} \rangle^{-1}$
L^{ES}	64 x 64	Local Leontief inverse for Spain
$A^{ES\,US}$	64 x 64	Submatrix of A. Spanish rows and columns
$A^{ES\,oc}$	64 x 3,072	Submatrix of A. Spanish rows, oc columns
$B^{US\,all}$	64 x 3,200	Submatrix of Global Leontief inverse. US rows, all columns
$B^{oc\ all}$	3,072 x 3,200	Submatrix of Global Leontief inverse. oc rows, all columns
$y^{all\,all}$	3,200 x 1	Total final demand
$y^{all\,US}$	3.200 x 1	US final demand in all countries
$y^{ES\,US}$	64 x 1	Spanish exports to US final demand

Then the following equations and identities holds

$$B^{all\,all} y^{all\,all} = x^{all}$$

$$B^{ES\ all} y^{all\ all} = x^{ES}$$

Once we calculate the production x for a given demand y, we can calculate any other aggregate that depends on production, as Value Added or Employment. To do that we need two additional vectors calculated as the shares of value added and employment respectively of total production, industry by industry

$$v = va \cdot \langle x \rangle^{-1}$$

$$p = pers \cdot \langle x \rangle^{-1}$$

Finally, with these vectors of coefficients we calculate the value added and the employment

- Value added: $vx = vBy$
- Employment: $px = pBy$

Note that above indicators are scalars. If we want a breakdown by industry where the value added or the employment are generated, we can diagonalize the production vector:

- Value added: $v\langle x \rangle = v\langle By \rangle$
- Employment: $p\langle x \rangle = p\langle By \rangle$

If we want a breakdown by demand industry that cause the generation of the value added or the employment, we can diagonalize the demand vector

- Value added: $vB\langle y \rangle$
- Employment: $pB\langle y \rangle$

If we want to calculate the value added in Spain of a flow, e^{ES} then we must first calculate the production in each industry and then the value added associated to that production

$$v^{ES} L^{ES} e^{ES}$$

Note that this is a number. If we want to separate the value added generated in each industry, we can calculate the vector

$$\langle v^{ES} \rangle L^{ES} e^{ES}$$

And if we want to calculate the value added in each industry in the demand of each industry, we can calculate the matrix

$$\langle v^{ES} \rangle L^{ES} \langle e^{ES} \rangle$$

Where the element i, j of this matrix is the value added generated in the industry i in the industry j. That is the columns are the industries where the value added is generates and the rows are the industries that generate this value added.

The same reasoning can be done but changing the vector v^{ES} of value-added coefficients by the vector p^{ES} of employee coefficients

The Exposure Indicator

The Exposure Indicator (often formally termed Trading Partner Exposure or the Single Exposure Indicator) is a key metric within the Trade in Value Added (TiVA) framework. It is designed to measure the total economic reliance of a domestic economy on other specific trading partner, accounting for the complexities of global value chains (GVCs).

The exposure indicator represents the total Domestic Value Added generated within an economy that is "exposed" to the demand of a selected partner.

To calculate the exposure of the Spanish economy to the US economy, we will consider three flows[2] (each flow is a vector 64 x 1)

	Flow	**Formula**
1	Spanish exports destined for final use in the U.S. *Products that are finished in Spain and shipped to the U.S. for final demand.*	$y^{ES\ US}$
2	Spanish exports destined for intermediate use in the U.S. that ultimately reach final use in the U.S. or reach final use in countries other than the U.S. *Intermediate products that are sent from Spain to the U.S. for further processing and then are finally consumed anywhere in the world*.	$A^{ES\ US} B^{US\ all} y$ or $Z^{ES\ US} u_{(64x1)}$
3	Spanish exports to other countries for intermediate use that ultimately reach final use in the U.S. *Intermediate products that are shipped from Spain to other countries for further processing and ends up in the US final demand.*	$A^{ES\ oc} B^{oc\_all} y^{all\_US}$

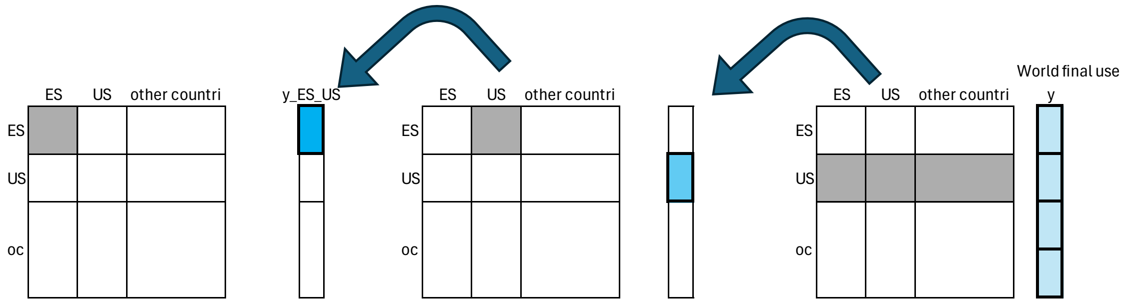
[2] The flows considered in the "FIGARO-based macroeconomic indicators of globalization, 2024 edition" are the same, but divided into four:

1. Spanish exports destined for final use in the U.S.
2. Spanish exports destined for intermediate use in the U.S. ending up in US final use
3. Spanish exports destined for intermediate use in the U.S. ending up in a thirds country's final use
4. Spanish exports to other countries for intermediate use ending up in US final use

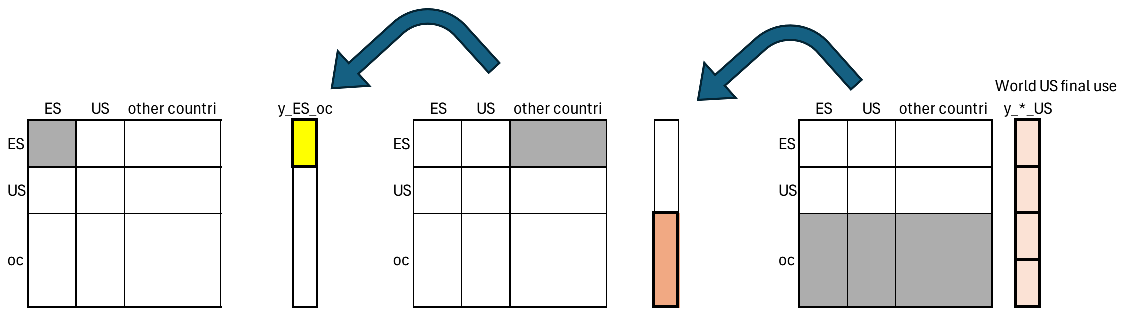
From these flows, it is possible to calculate the Spanish economy's production needed to satisfy them and, subsequently, the corresponding domestic value added and employment.

For flow number 1, no formula is needed. The flow can be obtained directly from the IoT.

The formula used for flow number 2 is represented graphically in the following diagram. From right to left: first, the product of $B^{US\,all}y$ is calculated, and the resulting vector is multiplied by the matrix $A^{ES\,US}$ to obtain the vector of Spanish exports destined for intermediate use.



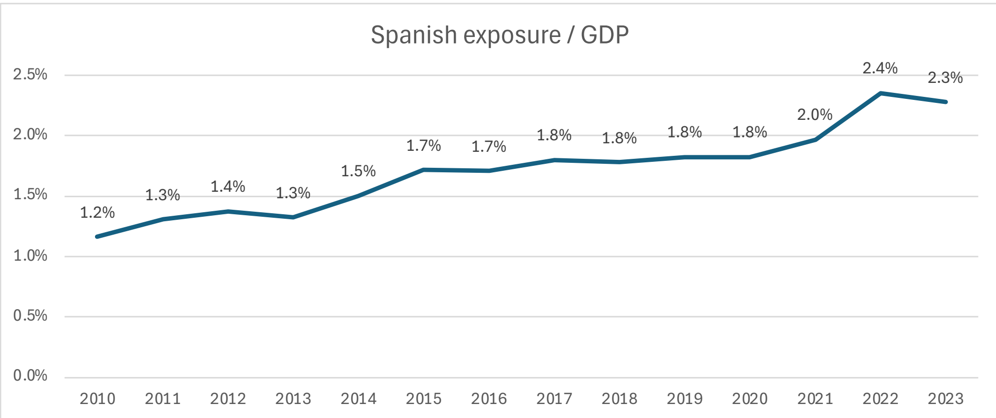
Analogously, the formula used to calculate the flow number 3 is represented graphically in the following diagram

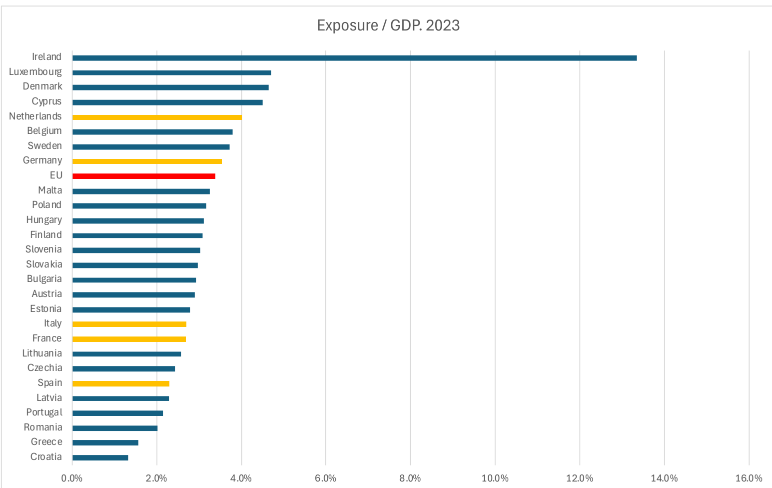


Once the flows have been calculated, the next step is to determine the production, and subsequently the value added and employment associated with that production. The results are shown in the following table (in millions of euros and thousands of employees).

Type of flow	Exposure 2023			
	Flow	Production	Value Added	Employment k Persons
1.- Exports to US final use	11,327	20,295	8,004	118
2.- Exports to US intermediate use	19,177	32,579	13,639	218
3.- Exports to other countries that end up in US final use	17,874	30,899	12,491	195
TOTAL	48,378	83,773	34,133	531
TOTAL / GDP or Employment	3.2%	5.6%	2.3%	2.5%

In addition to Spain's exposure indicator for 2023, we have calculated the evolution of the indicator in recent years, as well as the exposure of all EU27 countries to the US economy.





In red, the weighted average exposure of the EU27 and in yellow, the economies with a GDP over 1 trillion.

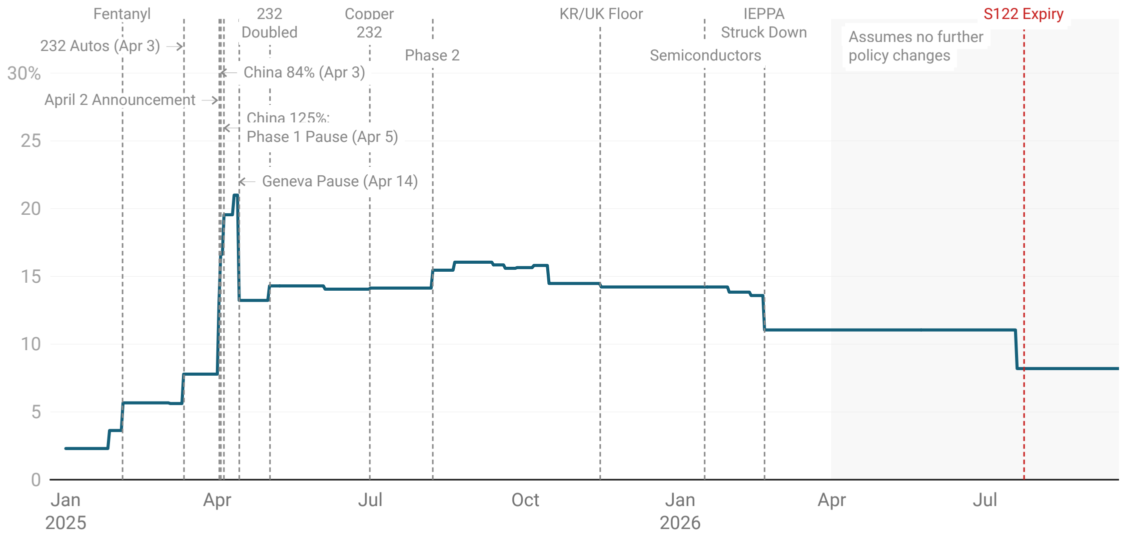
Implementing tariffs in IOT

According to The Rate Tracker, published by Yale's Budget Lab, the tariffs that the United States applies to imported products show great volatility and there is no reason to think that this volatility will disappear in the future.

Daily Rates from Raw HTS Data

Figure 1. Daily Effective Tariff Rate

Import-weighted average across all products and countries



Rates weighted by 2024 annual Census import values at HS10 x country level.

Chart: The Budget Lab • Source: Yale Budget Lab Tariff Rate Tracker; 2024 Census import values • Created with Datawrapper

https://budgetlab.yale.edu/node/1424/pdf

To simulate the impact of tariffs, we defined a scenario under the following assumptions:

The passthrough describes how the costs of a tariff are distributed between exporters and importers. While importers pay the tariff, its "economic burden" can be shifted to exporters if they reduce their export prices. Let's illustrate the passthrough with an example: suppose exporters charge €100 for a product and the tariff is 20%. If the price abroad remains at €100, the tariff paid is €20, raising the import price to €120. In this case, the tariff burden falls entirely on the importer, and the passthrough is 1. If the exporter charges €96.67 for a product (instead of €100), then the importer pays €116, and the shifting principle is 0.8. In the simulation, we assumed a shifting principle of 1.

The other assumption is the combination of two parameters: the tariffs imposed on goods and the price elasticity. We have used a reference scenario comprising the combination of a 20% tariff with an elasticity of -0.75 or, equivalently, a 15% tariff and an elasticity of -1. Perhaps a lower tariff would be more realistic. However, we chose 20% with elasticity -1 because it serves as an upper bound. Furthermore, given that the model is linear, the impact of a 10% rate (which would be a lower bound) would be 50% of the impact of a 20% rate.

All three flows are subject to the same tariffs. The first and second flows correspond to goods shipped directly from Spain to the United States. The third flow consists of goods arriving in the United States from various countries, and although tariffs depend on the country of provenance, for simplicity, we have used the same tariffs that apply to Spain. It is assumed that tariffs apply only to goods and not to services. To differentiate between goods and services, flows from NACE A to F are considered goods (and therefore subject to tariffs), while the remaining flows are services (which are not subject to tariffs).

Once tariffs (and their passthrough) are applied, buyers observe the new price they must pay and adjust their purchases according to elasticity.

Elasticity is defined as the percentage of change in quantity by percentage point increase of price. It is assumed an elasticity of -0.8

Elasticity = $\frac{\text{Percentage change in quantity}}{\text{Percentage change in price}} = \frac{(q_2-q_1)/q_1}{(p_2-p_1)/p_1} = \frac{\%\Delta q}{\%\Delta p} = \mathcal{E}_p$

The percentage change in quantity is equal to the elasticity times the percentage change in price

$$\%\Delta q = \mathcal{E}_p \%\Delta p$$

The percentage change in price can be calculated as

$$\%\Delta p = \frac{p_2 - p_1}{p_1} = \frac{(1+\tau)p_1 - p_1}{p_1} = \frac{p_1 + \tau p_1 - p_1}{p_1} = \tau$$

Therefore, the percentage change in quantity is equal to the elasticity multiplied by the tariffs (note $\mathcal{E}_p < 0$)

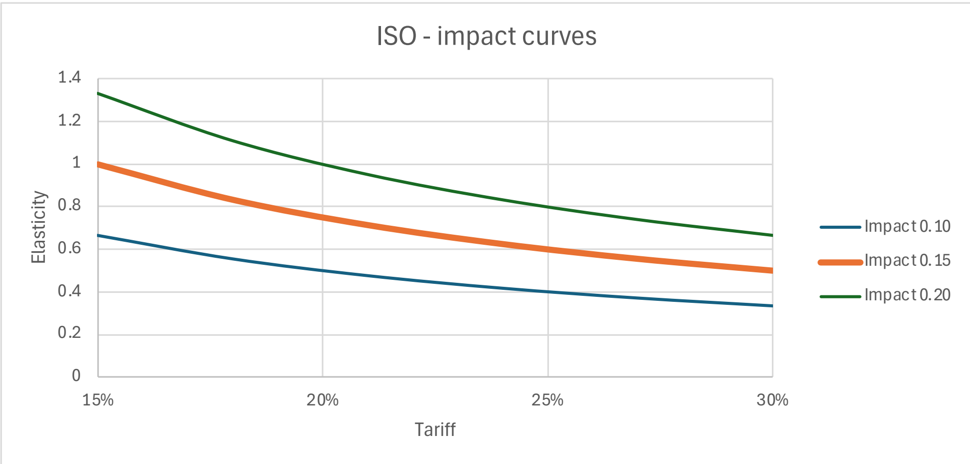
$$\%\boldsymbol{\Delta q} = \boldsymbol{\mathcal{E}_p \tau}$$

For the simulations, we assumed $\%\Delta q = \mathcal{E}_p \tau = -15\%$, which can represent various elasticity and tariff scenarios that result in the same volume change. For example, an elasticity of -1 combined with a 15% tariff defines the same scenario as an elasticity of -0.75 combined with a 20% tariff.

The next table contains different scenarios as a function of tariffs and elasticities.

		Tariffs			
		15%	20%	25%	30%
Price elasticity	1.2	0.18	0.24	0.30	0.36
	1.1	0.17	0.22	0.28	0.33
	1	0.15	0.20	0.25	0.30
	0.9	0.14	0.18	0.23	0.27
	0.8	0.12	0.16	0.20	0.24
	0.7	0.11	0.14	0.18	0.21
	0.6	0.09	0.12	0.15	0.18

For simulations we have chosen the combinations $\%\Delta q = \mathcal{E}_p \tau \ = 0.15$

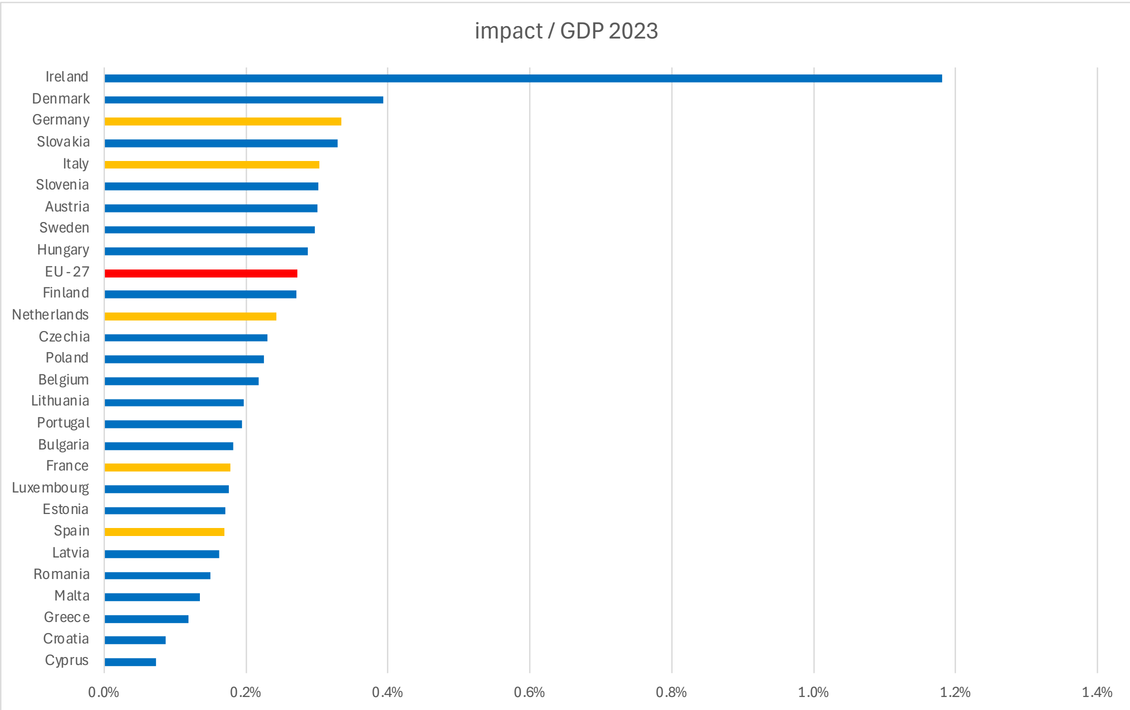


Results

The results can be summarized in the following table

Type of flow	Exposure 2023				Impact			
	Flow	Production	Value Added	Employment k Persons	Flow	Production	Value Added	Employment k Persons
1.- Exports to US final use	11,327	20,295	8,004	118	1,057	1,966	673	10
2.- Exports to US intermediate use	19,177	32,579	13,639	218	1,355	2,341	741	10
3.- Exports to other countries that end up in US final use	17,874	30,899	12,491	195	1,636	2,855	1,135	18
TOTAL	48,378	83,773	34,133	531	4,049	7,162	2,549	38
TOTAL / GDP or Employment	3.2%	5.6%	2.3%	2.5%	0.27%	0.48%	0.17%	0.18%
Impact / Actual					8.37%	8.55%	7.47%	7.16%

Where we can see than the impact of tariffs, under the assumptions we have made is 0.17% and 0.18% in value added and employment respectively



Impact is not a simple function of exposure; it is moderated by the mix of value added. For a constant level of exposure, the actual impact decreases as the economic mix shifts from physical goods toward services. Essentially, the more 'service-biased' a country's trade flows are, the more the total impact is insulated against a given level of exposure.