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Potential effects of US tariffs on the Marche economy: a dynamic multisectoral analysis

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Abstract

The re-emergence of protectionism that was advanced by the new Presidency of the United States is expected to have an extensive impact on the global economic landscape. The economic relations between the Marche region and the US are characterised by trade flows that are linked to specific industries, that can lead to a marked difference between, the amount, of exported and imported goods. This paper constructs a Social Accounting Matrix for Marche and develops a Dynamic Computable General Equilibrium model to assess the direct, indirect and induced effects of the US import tariffs on the Marche regional system in both aggregated and disaggregated terms. Regional real GDP will, by estimation, reduce by 0.11% in 2025 and by 0.20% between 2026 and 2029. Household and corporation disposable income will undergo a significant contraction. The metallurgical and pharmaceutical industries alone will be responsible for almost 50% of the overall decrease, in real value added within the region over 2025.

JEL Classification: F13, D57, D58, R13

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1. Introduction

The re-emergence of a protectionist economic policy under the leadership of Donald Trump in the United States of America will have a considerable impact on global economic dynamics, directly and indirectly modifying the relations between the United States and many other countries. From an American standpoint, the implementation of tariffs and quotas, including import restrictions, could be intended to reduce the trade deficit. However, these measures could also serve as a catalyst for the reshoring phenomenon (Irwin, 2020). The introduction of customs duties is differentiated by geographical area and product type, thus taking on the characteristics of a targeted economic policy instrument.

In this regard, the adoption of a multisectoral general equilibrium approach has been proven effective in assessing the economic impacts of import tariffs in the countries and/or regions affected because it captures the complexity of intersectoral and institutional relationships within the economy (De Melo, 1988; Kilkenny & Robinson, 1990). Tariffs do not affect only the directly-targeted imports but also generate economy-wide repercussions through changes in production costs, final prices, disposable incomes and the entire process of resource allocation. Unlike partial equilibrium models, which isolate individual markets, multisectoral general equilibrium models do allow to account for substitution effects across industries, to differentiate between domestic and imported goods, in addition to allow for changes in primary factor demand. Overall, multisectoral general equilibrium models have the capacity to retrieve the aggregate and disaggregated production and distributional effects that result from the imposition of import tariffs on identified products (Hanson & Reinert, 1997; Caceres et al., 2019).

Projecting the focus on a regional scale, the Marche region could experience harsh consequences on domestic production, both directly and indirectly, resulting from such protectionist trade policies.

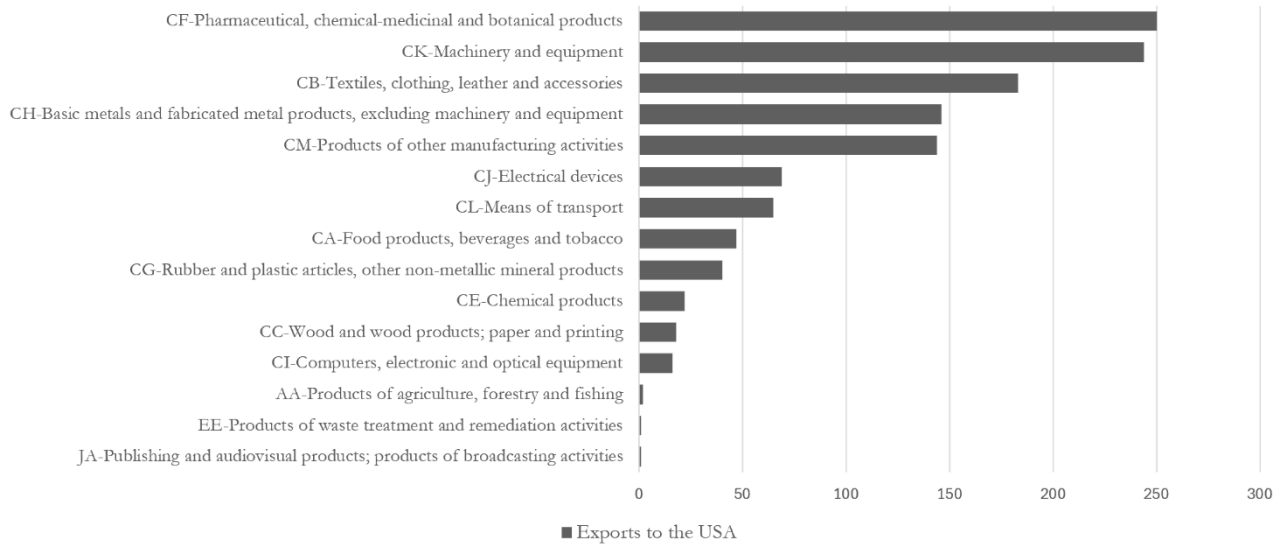
Therefore, an in-depth analysis of the impact of US tariffs on the Marche's economic system is highly relevant in order to gain a preliminary understanding of the mechanisms that will be triggered and to make more informed policy decisions at the regional level. The objective of the analysis is to highlight the extent to which trade dynamics are interrelated at the regional, national and international levels, in order to provide elements for reflection in the planning of trade and support policies in terms of differentiation of target markets, industrial and agricultural policies.

Within the context of international trade, the economic relations between the Marche region and the US are characterised by trade flows that are linked to specific industries, with a marked difference between the amount of exported and imported goods. Exports to the US markets account for approximately 3% of the 2024 regional real GDP, while imports are limited to 0.4%. Table 1 illustrates the categories of goods and services exported from Marche to the United States and to the Rest of the World, along with their relative weight in millions of euros.

Table 1. The value of exports from Marche to the US and the Rest of the World in 2024 (millions of euros).

	USA	Rest of the World
AA-Products of agriculture, forestry and fishing	2	128
BB-Products of mining and quarrying	0	19
CA-Food products, beverages and tobacco	47	459
CB-Textiles, clothing, leather and accessories	183	2,325
CC-Wood and wood products; paper and printing	18	448
CD-Coke and refined petroleum products	0	136
CE-Chemical products	22	552
CF-Pharmaceutical, chemical-medicinal and botanical products	250	1,942
CG-Rubber and plastic articles, other non-metallic mineral products	40	766
CH-Basic metals and fabricated metal products, excluding machinery and equipment	146	1,711
CI-Computers, electronic and optical equipment	16	361
CJ-Electrical devices	69	1,381
CK-Machinery and equipment	244	1,963
CL-Means of transport	65	699
CM-Products of other manufacturing activities	144	949
EE-Products of waste treatment and remediation activities	1	44
JA-Publishing and audiovisual products; products of broadcasting activities	1	32
RR-Products of artistic, entertainment and recreational activities	0	1
Total	1,249	13,918

Figure 1. The value of exports from Marche to the US in 2024 (millions of euros).



Source: *Coeweb – Istat. Authors' elaboration.*

The exports of Marche to the United States account for almost 9% of total exports and, as shown in Figure 1, these exports are concentrated in products related to the secondary sector. In particular, as reported in Table 2, the United States is the main destination for exports of manufacturing, pharmaceutical, machinery and food products.

Table 2. Products exported to the USA - Percentage share of total exports by type of product.

	%
CM-Products of other manufacturing activities	15.2
CF-Pharmaceutical, chemical-medicinal and botanical products	12.9
CK-Machinery and equipment	12.4
CA-Food products, beverages and tobacco	10.2

Source: *Coeweb – Istat. Authors' elaboration.*

The economic repercussions of the tariffs on the economy of the Marche region, in a still highly uncertain context, can be quantified by applying the trade instrument to the above-listed product categories. Therefore, the simulation scenario for import tariffs in the Marche region is a generalised 20% increase in tariffs applied to the exports of Marche to the United States, as announced by the White House for the period starting from July 2025. The imposition of such tariffs would result in an increase in the price of goods paid by US importers, which could lead to a contraction of foreign demand for products obtained in the Marche region.

In light of the described evidence-based landscape and political context, the multisectoral approach can be regarded as the most suitable approach to assess the direct, indirect and induced effects of the tariff instrument as a sectoral trade policy (Caliendo & Parro, 2015; Chow et al., 2022). Such a framework allows for a comprehensive analysis of the interdependencies between production processes and trade partners over time and the investigation of both the immediate and longer-term implications of protectionist measures. Accounting for the specific structure of the Marche regional economy and its trade composition with the United States, this study constructs the Social Accounting Matrix (SAM) for the

region of Marche and develops a Dynamic Computable General Equilibrium (DyCGE) model that allows a nuanced understanding of industrial and underlying welfare vulnerabilities alongside the potential path of the regional economic system in the face of the announced trade restrictions.
The structure of the paper follows with Section 2 which describes the methodology used, which is represented by the DyCGE model calibrated on the SAM for Marche. Subsequently, Section 3 presents the aggregated and disaggregated results of the implementation of US import tariffs in the Marche region. The paper will conclude with Section 4 which discusses a number of important aspects that were identified to be relevant from results obtained.

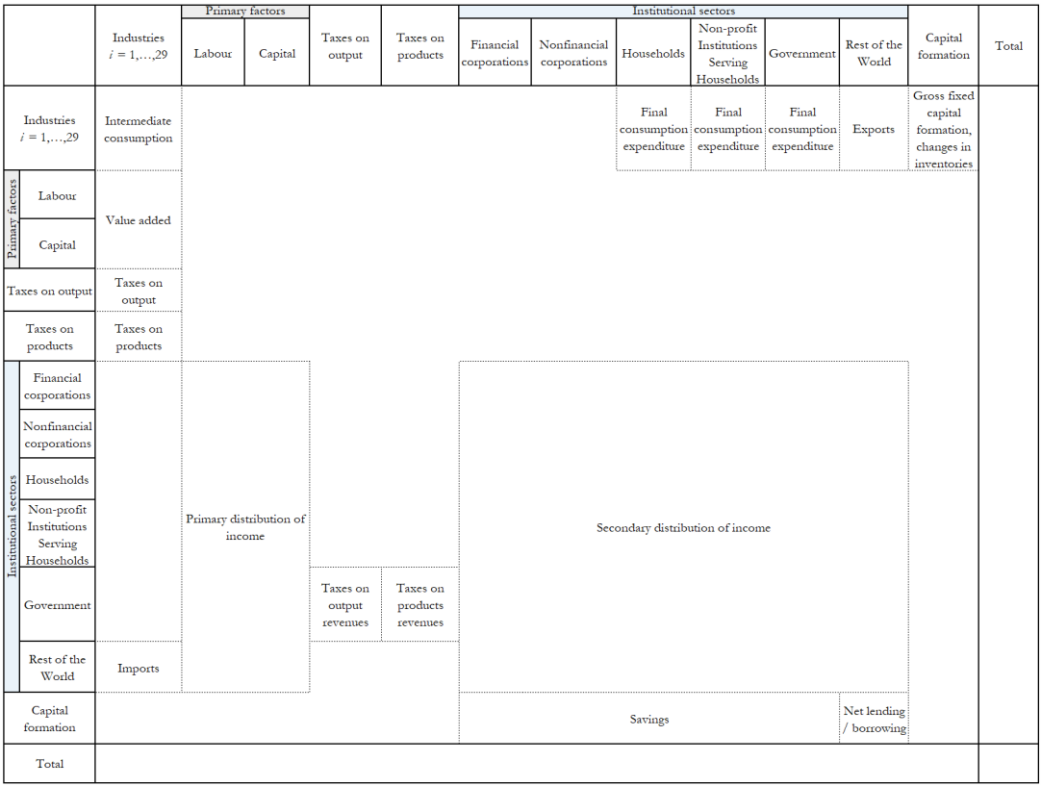
2. Methodology

The methodology that combines the regional SAM and the DyCGE model has the capacity to map the region's socioeconomic structure by providing a detailed representation of the entire circular flow of income based on a consistent accounting framework (Socci, 2004; United Nations, 2010). The SAM-based DyCGE model for Marche therefore formalises the relationships among the operators in the economic system by defining their core behavioural functions, namely production, consumption, and accumulation over time (Taylor, 1990; Deriu et al., 2024). These fundamental economic functions are the ties between production activities, primary factors and institutional sectors. Each operator in the economic system is characterised by a specific objective function, which involves profit maximisation for production activities, constrained by available resources and production capacity, and utility maximisation for institutional sectors, given their disposable income.

2.1. The Social Accounting Matrix for the Marche region

"SAMs are comprehensive databases that offer a detailed and coherent snapshot of the structure and interdependencies within the area considered. The SAM for the Marche region is constructed for the year 2023, based on the regional Input-Output (IO) table and following the methodology outlined in Socci et al. (2025). The institutional sector accounts from the Italian National Institute of Statistics (Istat) are used for the primary and secondary distribution of income. The year 2023 was selected as the base year of the SAM because it is the most recent year for which Istat provides updated regional data.
As a square matrix that systematically record economic transactions, the SAM is based on the information from national accounts and institutional sector accounts concerning production, value added generation, the tax system, the primary allocation of income, the secondary distribution of income and its use between consumption and savings (Stone et al., 1942). Figure 2 depicts the scheme of the SAM for Marche.

Figure 2. The scheme of the SAM for the Marche region.



Source: *authors' elaboration.*

The production structure of the region is described by a symmetric industry-by-industry IO table. It comprises 29 industries, alongside two factors of production (labour and capital), taxes on output and taxes on products. The SAM includes four private institutional sectors – nonfinancial corporations, financial corporations, households and Non-profit Institutions serving households (NPISHs) – as well as the government and the Rest of the World (RoW). The primary income distribution reflects the allocation of value added to the institutional sectors in the form of compensation of employees, gross operating surplus and mixed income, while the secondary distribution accounts for tax payments and transfers among the institutional sectors. Income taxes are included in the secondary distribution of income. The capital formation account registers gross fixed capital formation and the changes in inventories.

2.2 The regional Dynamic Computable General Equilibrium model

Regional DyCGE models based on SAMs offer a rigorous and empirically grounded framework for policy analysis that is particularly well-suited to contexts characterised by different spatial and economic interactions. By explicitly incorporating the structure and interdependencies of regional economies, these models enable researchers and policymakers to simulate how economic shocks or policy measures reverberate across space and time (Ciaschini et al., 2012; Ghaith et al., 2021; Severini et al., 2018; Deriu et al., 2022). The dynamics allows for the modelling of medium-term processes that provide insights into the trajectory of economic transformations. In other words, the temporal dimension is valuable in examining the structural and perduring implications of shocks and policies, such as climate adaptation, infrastructure investment, but also trade liberalization or restriction (Vicente Cateia et al., 2025). In this respect, DyCGE models have been used to assess the regional effects of tariff reductions (Kim & Kim, 2002), quantify the distributional effects of preferential trade agreements (Calì et al., 2019), and explore the impacts of joining international trade blocs (Cororaton & Orden, 2015).

By construction, static CGE models neglect the time path of the response to an exogenous shock or policy measure. The reaction of the socioeconomic area considered to the shock or policy change may differ in time and magnitude depending on the technological and behavioural characteristics of the economy. In this view, the parameters and shares of the DyCGE model are specified such that the model reproduces the benchmark data that are reported in the SAM instead of relying on time-series estimations (Ahmed et al., 2024). Once the peculiar parameters and shares are specified, the DyCGE model is solved to replicate the benchmark equilibrium and its trajectory over time, which is compared to the potential trajectory of the economy in the event of an exogenous shock or policy occurring on the demand, supply side or distribution side (Socci et al., 2023). The simultaneous system of linear and nonlinear equations of the model recursively finds the vectors of endogenous prices and quantities that clear the markets of factors and commodities. The technical details of the DyCGE model calibrated on the regional SAM for Marche are presented in Appendix B.

3. Results and discussion

The methodology adopted is tailored to the structure of the Marche region in order to assess the economic impact of US import tariffs on the regional system. In this context, the regional SAM-based DyCGE model is particularly effective in capturing the sectoral transmission mechanisms of reduced final demand from the Rest of the World over time, following the implementation of tariffs. The model provides a comprehensive framework for evaluating the economic and social impacts of specific trade policy instruments, accounting for direct, indirect, and induced effects triggered over time. Multisectoral analyses, in particular, enable the identification of each industry's contribution to income generation and its distribution across primary factors. They also facilitate the tracking of income allocation to institutional sectors and the subsequent use of disposable income for final demand and accumulation in each period.
The potential impact of the US tariffs on the production system of the Marche region is assessed through a simulation exercise that applies a proportional reduction to the value of regional exports targeted by the tariffs. The magnitude of the reduction corresponds to the tariff rates announced for each product category. The simulation period extends from July 2025 – when the tariffs are expected to come into effect – through the end of 2029, allowing for an analysis of both the short- and medium-term effects.
The simulation is based on the regional export structure as of 2024, which is assumed to better reflect the composition and scale of trade flows at the time of tariff implementation. To ensure consistency with the 2023 regional SAM, export flows have been rescaled to match the 2024 export structure. This adjustment captures the evolution of regional trade flows between 2023 and 2024, thereby taking into account the most recent trade dynamics relevant to the policy shock[1]. The results of the US tariff scenario on the Marche macroaggregates are reported in Table 3 and are expressed in percentage changes compared to the benchmark.

[1] As such, the contraction in macroaggregates resulting from the implementation of tariffs is based on a lower baseline level with respect to 2023, reflecting their reduced weight in the 2024 structure. This ensures that the impact is not overstated by the higher 2023 export flows.

Table 3. Economic impact of the 20% US tariffs on the main macroeconomic aggregates of the Marche region (percentage changes compared to the benchmark).

	2025	2026	2027	2028	2029
Real variables					
GDP	-0.11	-0.20	-0.20	-0.20	-0.20
Household consumption	-0.05	-0.09	-0.09	-0.09	-0.09
NPISH consumption	-0.01	-0.03	-0.03	-0.03	-0.03
Investments	-0.07	-0.12	-0.08	-0.07	-0.07
Exports	-0.54	-1.05	-1.05	-1.05	-1.05
Imports	-0.34	-0.65	-0.64	-0.64	-0.64
Nominal incomes					
Government revenue	-0.29	-0.55	-0.54	-0.54	-0.54
Household disposable income	-0.19	-0.36	-0.35	-0.34	-0.34
Corporation disposable income	-0.11	-0.21	-0.20	-0.20	-0.20
GDP deflator	-0.18	-0.34	-0.33	-0.33	-0.33

***Source**: DyCGE model estimates.*

The transmission mechanism of the effects of the import tariff originates in the production sphere. The decline in foreign demand that is expected following the introduction of tariffs is associated with a reduction in the value added of all production activities, both directly and indirectly affected by the tariffs, given the regional production interdependencies. The lower value added generated, as measured by compensation of employees, gross operating surplus and mixed income, therefore brings about a fall in the primary income attributed to households and corporations. The contraction of regional primary income is reflected in declining tax revenues for the government, which are diminished by 0.29% in 2025 with respect to the benchmark, by 0.55% in 2026, and by 0.54% in the following years.

The deceleration of the production system, and therefore of income creation and distribution, results in decreased disposable incomes of households and corporations. In light of the contraction in the primary allocation of income, household disposable income will decline by 0.19% in 2025 and by 0.36% in 2026, while corporation disposable income is projected to decrease by 0.11% in 2025 and by 0.21% in 2026 compared to the benchmark. The contractionary effect on disposable incomes, in turn, affects the formation of final demand for consumption expenditure and for investment, whose corresponding real GDP components decline over the time frame considered. The imposition of the US tariffs exerts an induced impact on the local economy of the Marche region, which further intensifies the adverse effects on the production system. The drop in final demand tends to spill over to the industries that are not directly affected by the tariffs, due to underlying production interdependencies. This implicitly amplifies the negative impact of the US protectionist trade policy.

Regional real GDP would decline by 0.11% in 2025, with a subsequent reduction of 0.20% in the following years. A substantial contribution to this decline is attributable to the decrease in exports, household consumption and investments. As previously stated, the decline in final demand reverberates on the production sphere, thereby influencing labour income and capital remuneration, with implications for the disposable income of households and corporations. The decline in the disposable income of the

private institutional sectors exerts an influence on savings and, ultimately, on investments, which decrease by 0.07% in 2025 as an indirect effect of tariffs, and by 0.12% in 2026. Table 4 expresses the results of the imposed tariffs on the Marche region in millions of euros compared to the benchmark. The decline of 0.11% of the real GDP of Marche in 2025 is equivalent to a contraction of 52.1 million euros, which approaches 100 million euros in the period between 2026 and 2029. In 2025, the reduction in exports is valued at 108.4 million euros, which increases in subsequent years to reach 212.2 million euros in comparison to the benchmark.

Table 4. Economic impact of the 20% US tariffs on the main macroeconomic aggregates of the Marche region (changes in millions of euros compared to the benchmark).

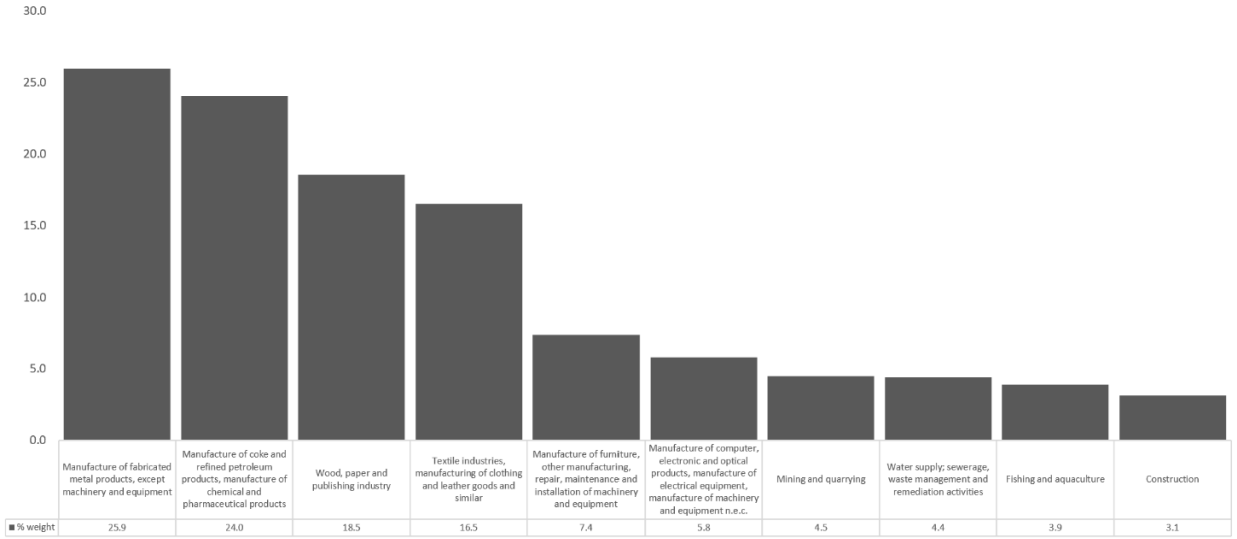
	2025	2026	2027	2028	2029
Real variables					
GDP	-52.1	-99.7	-98.1	-97.5	-97.3
Household consumption	-14.2	-27.2	-26.7	-26.5	-26.4
NPISH consumption	0.0	-0.1	-0.1	-0.1	-0.1
Investments	-9.1	-14.5	-10.2	-8.7	-8.2
Exports	-108.4	-210.6	-211.7	-212.1	-212.2
Imports	-79.7	-152.6	-150.5	-149.8	-149.6
Nominal incomes					
Government revenue	-56.4	-107.3	-105.1	-104.3	-104.0
Taxes on products	-19.5	-37.0	-36.5	-36.3	-36.3
Taxes on output	-2.9	-5.6	-5.4	-5.4	-5.4
Transfers	-34.0	-64.8	-63.1	-62.5	-62.3
Household disposable income	-62.8	-119.6	-116.4	-115.4	-115.0
Corporation disposable income	-9.9	-18.9	-18.4	-18.2	-18.1

Source: *DyCGE model estimates.*

A key advantage of the multisectoral approach is its capacity to examine the disaggregated direct and indirect effects of US tariff imposition on sectoral value added in the Marche region. By capturing the interdependencies among industries, this approach allows for a detailed exploration of the propagation of shocks, such as trade restrictions, through the entire circular flow of income. It enables the identification of specific production activities most impacted by fluctuations in foreign demand and quantifies the corresponding variations in sectoral value added within the regional economy. Figure 3 shows the ranking of the ten industries that contribute most to the overall decline in real value added compared to the benchmark in the months of 2025 when the tariffs are scheduled to be introduced. The ranking includes several key sectors of the Marche economy. In particular, the "Manufacture of fabricated metal products, except machinery and equipment", the "Manufacture of coke and refined petroleum products, manufacture of chemical and pharmaceutical products", the "Wood, paper and publishing industry", and "Textile industries, manufacturing of clothing and leather goods and similar" industries are expected to experience significant contractions in 2025, due to both the fall in demand and the slowdown in supply chains, which will translate into lower production capacity. The decline in the real value added from the production of "Manufacture of fabricated metal products, except machinery and equipment" is responsible for 25.9% of the overall real value added reduction in 2025. In the same year,

the "Manufacture of coke and refined petroleum products, manufacture of chemical and pharmaceutical products" industry accounts for 24% of the overall real value added reduction, whereas the "Wood, paper and publishing industry", the "Textile industries, manufacturing of clothing and leather goods and similar" and the "Manufacture of furniture, other manufacturing, repair, maintenance and installation of machinery and equipment" industries represent 18.5%, 16.5% and 7.4% of the total decline, respectively.

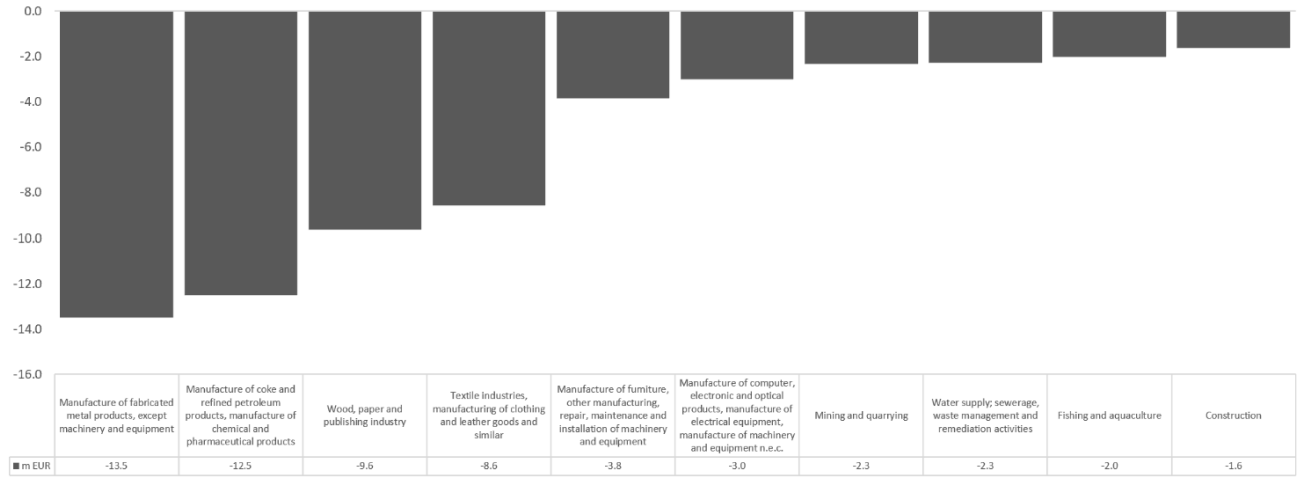
Figure 3. Contribution to real value added reduction by industry – ranking of the 10 worst performances (percentage contribution to the total change in real value added).



Source: *authors' elaboration based on the DyCGE model estimates.*

The Marche region is widely regarded as one of the most industrialised areas in Italy, in virtue of its manufacturing-oriented economy, which is populated by small, locally rooted firms. The region has undergone a substantial transformation in its productive structure over time, transitioning from an agricultural base to a prominent manufacturing presence, particularly in the domains of footwear, textiles and clothing, and furniture. This evolution has prompted the emergence of globally recognised companies, which are exposed to the US tariffs that are scheduled to be implemented from July 2025 onwards. Figure 4 presents the ranking of the ten industries that contribute most to the contractions in real value added, expressed in millions of euros.

Figure 4. Contribution to real value added reduction by industry – ranking of the 10 worst performances (millions of euros).



Source: *authors' elaboration based on the DyCGE model estimates.*

In 2025, the reduction in real value added from "Manufacture of fabricated metal products, except machinery and equipment" is valued at 13.5 million euros. Meanwhile, the decline in real value added from the "Manufacture of coke and refined petroleum products, manufacture of chemical and pharmaceutical products" industry is estimated at 12.5 million euros. The "Wood, paper and publishing industry", "Textile industries, manufacturing of clothing and leather goods and similar" and "Manufacture of furniture, other manufacturing, repair, maintenance and installation of machinery and equipment" industries are responsible for a contraction of 22 million euros in real value added.
The disaggregated effects on real value added indicate that tariffs, as a trade policy, have a pronounced impact on regional manufacturing industries, whose market shares and dynamics are particularly sensitive to business cycles and foreign markets. The definition of targeted support measures will be crucial to mitigate the negative effects of the US protectionist trade policy in the region and promote a balanced recovery across Marche manufacturing industries.

4. Conclusions

The contraction in foreign demand that is anticipated from the imposition of US tariffs, effective from July 2025, which could be settled through negotiations by both US importers and exporters in the Marche region, will involve the entire circular flow of income of the region. The Marche region will acutely experience the slowdown of production processes. The discouragement of production will reflect in the economic system, on the basis of the structural interdependencies that do exist among the various industries. As a result, the Marche industries, as a whole, will generate lower value added and, through the combination of direct, indirect and induced effects, lower GDP.
The introduction of US tariffs is predicted to have three distinct effects. Firstly, there will be a direct effect on production activities whose products are targeted by the trade policy. Secondly, there will be an indirect effect on industries stemming from production interdependencies. Thirdly, there will be an induced effect on both corporations and households. When production is contracted, the use of the labour factor is automatically reduced. However, it is important to note that households also hold a proportion of shares in corporations. Hence, the decline in profit generation further contributes to the decrease in household income. Households will experience a decline in disposable income, which will subsequently result in a contraction in household consumption expenditure within the Marche region.
This paper considers the direct relationship between the Marche region and its exports to the United States. In order to assess the aggregated and disaggregated effects of the forthcoming American trade policy, the Social Accounting Matrix for the Marche region is constructed and a Dynamic Computable General Equilibrium model is developed and calibrated on the regional SAM. This methodology is highly suited to the quantification of the comprehensive impacts of the tariff instrument in the medium run, and to the provision of recommendations to the Marche policymaker in terms of appropriate recovery and support measures to sustain the most affected industries.
The estimates of the SAM-based DyCGE model suggest that regional real GDP will be reduced by 0.11% in 2025 and by 0.20% between 2026 and 2029. A substantial contribution to this decline is imputable to the decrease in exports (-0.54% in 2025 and -1.05% in subsequent years compared to the benchmark), household consumption (-0.05% in 2025 and -0.09% in the following years compared to the benchmark) and investments (-0.07% in 2025 and -0.12% in 2026 compared to the benchmark). Household disposable income is anticipated to decline by 0.19% in 2025 and by 0.36% in 2026, while corporation disposable income is projected to decrease by 0.11% in 2025 and by 0.21% in 2026 compared to the benchmark.
The metallurgical, pharmaceutical, wood, textile, and furniture industries are expected to experience

significant contractions in 2025, due to both the fall in final demand and the slowdown in supply chains, which will translate into diminished production capacity. These industries will account for a reduction in real value added of nearly 48 million of euros in 2025. The metallurgical and pharmaceutical industries alone, will be responsible for almost 50% of the overall decrease in real value added, as a result of the US import tariffs in 2025.

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Appendix A

Table A1. English translation of the Italian classification of products exported by the Marche region.

Italian classification	English translation
AA-Prodotti dell'agricoltura, della silvicoltura e della pesca	AA-Products of agriculture, forestry and fishing
BB-Prodotti dell'estrazione di minerali da cave e miniere	BB-Products of mining and quarrying
CA-Prodotti alimentari, bevande e tabacco	CA-Food products, beverage and tobacco
CB-Prodotti tessili, abbigliamento, pelli e accessori	CB-Textiles, clothing, leather and accessories
CC-Legno e prodotti in legno; carta e stampa	CC-Wood and wood products; paper and printing
CD-Coke e prodotti petroliferi raffinati	CD-Coke and refined petroleum products
CE-Sostanze e prodotti chimici	CE-Chemical products
CF-Articoli farmaceutici, chimico-medicinali e botanici	CF-Pharmaceutical, chemical-medicinal and botanical products
CG-Articoli in gomma e materie plastiche, altri prodotti della lavorazione di minerali non metalliferi	CG-Rubber and plastic articles, other non-metallic mineral products
CH-Metalli di base e prodotti in metallo, esclusi macchine e impianti	CH-Basic metals and fabricated metal products, excluding machinery and equipment
CI-Computer, apparecchi elettronici e ottici	CI-Computers, electronic and optical equipment
CJ-Apparecchi elettrici	CJ-Electrical devices
CK-Macchinari e apparecchi n.c.a.	CK-Machinery and equipment n.e.c
CL-Mezzi di trasporto	CL-Means of transport
CM-Prodotti delle altre attività manifatturiere	CM-Products of other manufacturing activities
EE-Prodotti delle attività di trattamento dei rifiuti e risanamento	EE-Products of waste treatment and remediation activities
JA-Prodotti dell'editoria e audiovisivi; prodotti delle attività radiotelevisive	JA-Publishing and audiovisual products; products of broadcasting activities
RR-Prodotti delle attività artistiche, di intrattenimento e divertimento	RR-Products of artistic, entertainment and recreational activities

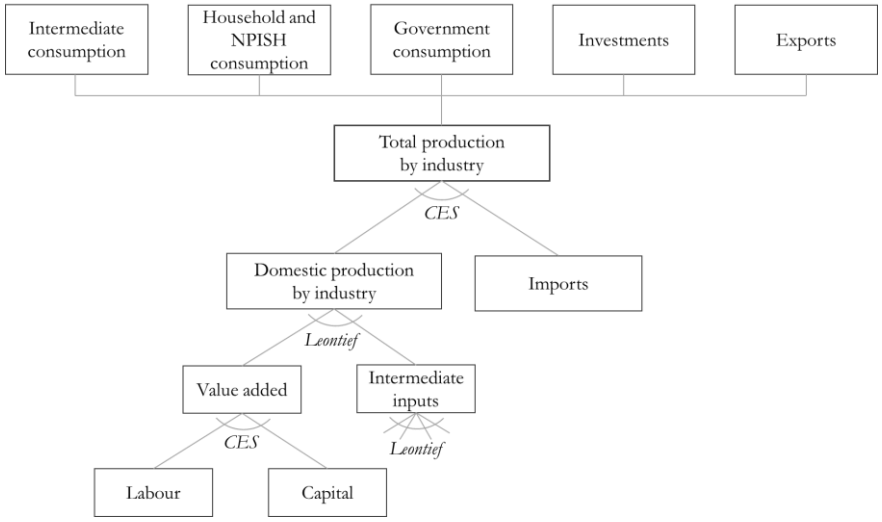
Table A2. The classification of industries in the SAM for the Marche region.

Nr	Industries	Nr	Industries
1	Crop and animal production, hunting and related service activities, forestry	16	Wholesale and retail trade, repair of motor vehicles, motorcycles
2	Fishing and aquaculture	17	Transportation and storage
3	Mining and quarrying	18	Accommodation and food service activities
4	Food, beverage and tobacco industries	19	Telecommunications, computer programming, consulting, computing infrastructure and other information service activities
5	Textile industries, manufacturing of clothing and leather goods and similar	20	Financial and insurance activities
6	Wood, paper and publishing industry	21	Real estate activities
7	Manufacture of coke and refined petroleum products, manufacture of chemical and pharmaceutical products	22	Professional, scientific and technical activities
8	Manufacture of rubber and plastic products and manufacture of other non-metallic mineral products	23	Administrative and support service activities
9	Manufacture of fabricated metal products, except machinery and equipment	24	Public administration and defence; compulsory social security
10	Manufacture of computer, electronic and optical products, manufacture of electrical equipment, manufacture of machinery and equipment n.e.c.	25	Education
11	Manufacture of transport equipment	26	Human health and social work activities
12	Manufacture of furniture, other manufacturing, repair, maintenance and installation of machinery and equipment	27	Arts, sports and recreation
13	Electricity, gas, steam and air conditioning supply	28	Other service activities
14	Water supply; sewerage, waste management and remediation activities	29	Activities of households as employers and undifferentiated goods - and service-producing activities of households for own use
15	Construction		

Appendix B – The technical details of the regional DyCGE model

The DyCGE model for Marche is based on the structure of the production function and the structure of demand represented in Figure B1.

Figure B1. The structure of the production function and demand in the DCGE model.



Source: *authors' elaboration.*

Figure B1 shows the nested stages of production starting from total output and relative prices by industry alongside the allocation of total output by industry to the demand components in each period, $t = 1, \dots, 5$. In line with the theory of imperfect substitutability between domestic and imported output by industry, total output of industry i is the combination of domestic production and imports from the Rest of the World (Armington, 1969). The dual cost function for the final price of output by industry at time t, $P_{i,t}$, can be derived as follows:

$$P_{i,t}(1 - tq_{out,i} - tq_{prod,i}) = \left[\beta_i^D Pdom_{i,t}^{1-\sigma_D} + (1 - \beta_i^D) Pm_{i,t}^{1-\sigma_D}\right]^{\frac{1}{1-\sigma_D}} \quad (1)$$

The subscript $i = 1, \dots, 29$ identifies industries, $tq_{out,i}$ denotes the implicit tax rate on output and $tq_{prod,i}$ indicates the implicit tax rate on products by industry. The parameter β_i^D is the share of domestic output in total production by industry and $Pdom_{i,t}$ is the price of domestic output by industry at time t. The complement to one, $(1 - \beta_i^D)$, indicates the share of imports in total production, while $Pm_{i,t}$ is the price of imports at time t. The elasticity of substitution between domestic output and imports, σ_D, is equal to 0.3.

The price of domestic output by industry at time t, $Pdom_{i,t}$, is determined by the aggregation of the costs associated with primary factors and intermediate inputs:

$$Pdom_{i,t} = \beta_i^B Pint_{i,t} + (1 - \beta_i^B) Pva_{i,t} \quad (2)$$

The variable $Pint_{i,t}$ is the price of intermediate inputs at time t, multiplied by β_i^B, which identifies the share of intermediate inputs in domestic output. The variable $Pva_{i,t}$ is the price of value added at time t, determined by the combination of labour and capital, whilst $(1 - \beta_i^B)$ is the share of value added in domestic production. Intermediate inputs and value added are considered to be perfect complements in production processes, following the Leontief technology assumption.

The price of intermediate inputs at time t, $Pint_{i,t}$, is calculated by aggregating the average prices of each good and service in each period, with account taken of their relative shares in total costs for intermediate inputs:

$$Pint_{i,t} = \sum_j \beta_{ij}^{IN} P_{j,t} \tag{3}$$

The variable $P_{j,t}$ is the average price of goods and services in each period and β_{ij} is the cost share in total costs for intermediate inputs. The Leontief technology assumption imposes perfect complementarity between intermediate inputs.

Value added is derived from the combination of labour and capital in each industry, as follows:

$$Pva_{i,t} = \left[\beta_i^F PL_t^{1-\sigma_{VA}} + (1-\beta_i^F) PK_t^{1-\sigma_{VA}}\right]^{\frac{1}{1-\sigma_{VA}}} \tag{4}$$

The variable PL_t is the price of labour and PK_t is the price of capital in each period. The parameters β_i^F and $(1-\beta_i^F)$ are the shares of labour and capital employed in production processes, respectively, in total costs for primary factors. The elasticity of substitution between labour and capital, indicated as σ_{VA}, is assumed to be constant and equal to 0.52.

Total supply in the economic system must be equal to total demand for intermediate consumption, final consumption by households, NPISHs and the government, investment and exports. Given the square intersectoral matrix, the market clearing condition for goods and services at time t can be formalized by setting $i = j$:

$$\begin{aligned}\left(\sum_i P_{i,t} \cdot INT_{i,j,t}\right) + \left(\sum_j Pm_{j,t} \cdot M_{j,t}\right) + \sum_j t\_out_j + \sum_j t\_prod_j \\ = P_{i,t} \cdot \left(\sum_j INT_{i,j,t} + \sum_i C_{i,t} + \sum_i G_{i,t} + \sum_i I_{i,t} + \sum_i X_{i,t}\right)\end{aligned} \tag{5}$$

The variable $INT_{i,j,t}$ is the quantity supplied/demanded of intermediate inputs, $M_{j,t}$ is the quantity demanded of imports, t_out_j is the tax flow on output paid by industry and t_prod_j is the tax flow on products paid by industry. The variable $C_{i,t}$ is the quantity demanded for consumption by households and NPISHs, $G_{i,t}$ is the quantity demanded for consumption by the government, $I_{i,t}$ is the quantity demanded for investment purposes, while $X_{i,t}$ is the quantity of exports. Therefore, under the assumption of perfect competitiveness in the markets of goods and services, prices are subject to fluctuations to achieve the equilibrium between the left and right sides of equation (5).

Regarding the market clearing conditions for primary factors, the assumption of perfect competitiveness only holds in the market of capital. In each period, the endogenous price of capital varies to balance total demand for capital, as expressed by the industries, with the total supply of capital, corresponding to institutional sector endowments, which are supposed to be exogenously determined:

$$\sum_{ins} (PK_t \cdot K_t^{ins}) = \sum_i (PK_t \cdot K_{i,t}) \tag{6}$$

The variable K_t^{ins} denotes capital endowment by institutional sector, ins, at time t. The variable $K_{i,t}$ is capital demand by industry at time t.

The market clearing conditions for the labour markets at time t takes the following form:

$$(1-u_t) \sum_{ins} (PL_t \cdot L_t^{ins}) = \sum_i (PL_t \cdot L_{i,t}) \tag{7}$$

The variable L_t^{ins} labour endowment by institutional sector, ins, at time t, whilst $L_{i,t}$ is labour demand by industry at time t. The variable u_t represents the unemployment rate that allows the labour market to be cleared in each period. The variation of the unemployment rate is obtained following Okun's law:

$$\Delta u_t = -b\left(\frac{Y_t}{Y_{t-1}} - 1\right) \quad (8)$$

The variable Y_t is nominal GDP at time t and the parameter b denotes the sensitivity of the unemployment rate to changes in nominal GDP in the Marche region, which is fixed at 0.347 (Bonaventura et al., 2020).

Regarding the demand side of the model, the demand for intermediate consumption in each period, $INT_{i,t}$, is determined endogenously by the industries. The demand for final consumption by households, $C_{i,t}$, depends on the disposable income. Households are assumed to use the disposable income for consumption expenditure and savings in fixed proportions in each period:

$$Yd_t^{HH} = \sum_i C_{i,t}^{HH} + S_t^{HH} \quad (9)$$

Households' disposable income at time t is obtained by subtracting transfers received and adding transfers paid from the secondary income. In particular, households' primary income at time t can be defined as:

$$Yp_t^{HH} = \gamma^{HH} \sum_i (PL_t \cdot L_{i,t}) + \delta^{HH} \sum_i (PK_t \cdot K_{i,t}) \quad (10)$$

The parameter γ^{HH} is the share of labour income that is attributed to households in the form of compensation of employees, whereas δ^{HH} is the share of capital remuneration that is allocated to households as gross operating surplus and mixed income. These shares are computed on the basis of the SAM flows.

The secondary income of households at time t, Ys_t, is calculated by adding to the primary income transfers received from the other institutional sectors:

$$Ys_t^{HH} = Yp_t^{HH} + \sum_{ins\_in} Tr_{ins\_in,t}^{HH} \quad 1)$$

The summation $\sum_{ins\_in} Tr_{ins\_in,t}^{HH}$ indicates the incoming transfers to households and the set ins includes the institutional sectors of the Marche region – households, NPISHs, financial and nonfinancial corporations, the government and the RoW.

By subtracting from the secondary income taxes paid on income and transfers from households to the other institutional sectors of the economy, the disposable income of households is thus determined:

$$Yd_t^{HH} = Ys_t^{HH} - \left(tq_{inc,HH} \cdot Yp_t^{HH}\right) - \sum_{ins\_out} Tr_{ins\_out,t}^{HH} \quad 2)$$

The parameter $tq_{inc,HH}$ is the implicit income tax rate of households, the tax base of which is primary income in each period, Yp_t^{HH}. The summation $\sum_{ins\_out} Tr_{ins\_out,t}^{HH}$ consists of outgoing transfers from households to the other institutional sectors at time t.

The disposable income of financial and nonfinancial corporations in each period, Yd_t^{corp}, corresponds to the level of savings, given that corporations do not engage in consumption expenditure:

$$Yd_t^{corp} = S_t^{corp} \quad 3)$$

The disposable income of financial and nonfinancial corporations is equivalent to the following:

$$Yd_t^{corp} = \delta^{corp} \sum_i (PK_t \cdot K_{i,t}) + \sum_{ins\_in} Tr_{ins\_in,t}^{corp} - \left[tq_{inc,corp} \cdot \delta^{corp} \sum_i (PK_t \cdot K_{i,t}) \right] - \sum_{ins\_out} Tr_{ins\_out,t}^{corp} \quad 4)$$

Contrarily to the private institutional sectors, the government cannot be defined as a utility-maximising operator, since it adopts the envisaged fiscal policies independently from the disposable income constraint. The difference between the government revenues and the government expenditure gives rise to the public deficit (negative S_t^{gov}) or surplus (positive S_t^{gov}) in each period:

$$S_t^{gov} = Yd_t^{gov} - \sum_i G_{i,t} - \sum_{ins\_out} Tr_{ins\_out,t}^{gov} \quad 5)$$

Equation (15) represents the closure condition with respect to the government in the model. The variable Yd_t^{gov} denotes refers to the government disposable income, $\sum_i G_{i,t}$ represents public consumption and $\sum_{ins\_out} Tr_{ins\_out,t}^{gov}$ adds up all transfers from the government to the other institutional sectors at time t. In the model, the government expenditure is assumed to be exogenous in real terms and endogenous in nominal terms. Savings are thus calculated as the difference between government disposable income and expenditure. The government disposable income at time t derives from the difference between the share of capital remuneration attributed to the government plus tax revenues – namely, direct taxes on household and corporation incomes and indirect taxes on industries – plus transfers received from the other institutional sectors and transfers paid by the government:

$$Yd_t^{gov} = \delta^{gov} \sum_i (PK_t \cdot K_{i,t}) + \sum_{inc,HH} \left(tq_{inc,HH} \cdot Yp_t^{HH} \right) + \sum_{inc,corp} \left(tq_{inc,corp} \cdot Yp_t^{corp} \right) + \sum_i \left(tq_{out,i} \cdot P_{i,t} Q_{i,t} \right) + \sum_i \left(tq_{prod,i} \cdot P_{i,t} Q_{i,t} \right) + \sum_{ins\_in} Tr_{ins\_in,t}^{gov} - \sum_{ins\_out} Tr_{ins\_out,t}^{gov} \quad 6)$$

In equation (16), $Yp_t^{corp} = tq_{inc,corp} \cdot \left[\delta^{corp} \sum_i (PK_t \cdot K_{i,t}) \right]$. The variable $Q_{i,t}$ is total production by industry.

The closure condition with respect to the Rest of the World establishes that the level of net lending/borrowing of the Marche region, designated by the balancing item S_t^{row}, arises from the difference between total inflows (factor income to the RoW, the nominal value of Marche imports and other transfers from the Marche institutional sectors to the Rest of the World) and total outflows of the RoW (Marche exports and transfers from the Rest of the World to the Marche institutional sectors) in each period:

$$S_t^{row} = \gamma^{row} \sum_i (PL_t \cdot L_{i,t}) + \delta^{row} \sum_i (PK_t \cdot K_{i,t}) + \sum_i (Pm_{i,t} \cdot M_{i,t}) + \sum_{ins\_in} Tr_{ins\_in,t}^{row} - \sum_i X_{i,t} - \sum_{ins\_out} Tr_{ins\_out,t}^{row} \quad 7)$$

Exports, $\sum_i X_{i,t}$, are a function of the endogenous domestic prices, the exogenous foreign prices, the exogenous income of the Rest of the World, and the exogenous nominal exchange rate.

The recursive dynamics of the model are led by the law of capital accumulation, which is driven by the flexible version of the accelerator principle (Jorgenson, 1967). In particular, this flexible version of the accelerator principle allows for a partial adjustment of investment to the desired level of capital stock in each period. Investment at time t depends on the accelerator v, which is the ratio between investment and GDP in the Marche region, as derived from the national accounts in the base year of the SAM (2023), as formalised in the equation below:

$$I_t = v[\lambda(RY_t - RY_{t-1}) + \delta RY_{t-1}] \quad 8)$$

The accelerator v is equal to 0.77. The investment accelerator is estimated by setting an autoregressive model using the time series of real investment and GDP between 1995-2021 for the Marche region, as published by Istat.[2] The variable RY_t indicates real GDP in each period. The parameter λ, which ranges between 0 and 1, is equal to 0.44 and indicates the proportion of the supply of capital goods that instantaneously adjusts to capital good demand. The parameter δ is the depreciation rate of capital, with a value of 0.13.

The accelerator principle can coexist with the macroclosure rule that imposes the equality between investments and savings in each period as follows:

$$\sum_i I_{i,t} = \sum_{ins} S_t^{ins} \quad 9)$$

[2] Available at: https://esploradati.istat.it/databrowser/#/en/dw/categories/IT1,DATAWAREHOUSE,1.0/UP_ACC_TERRIT.