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Macroeconomic impacts of customs tariffs on Armington's composite and transfer exports/domestic goods in Algeria: A CGEM approach

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***Abstract*---**This paper focuses on the macroeconomic consequences of customs tariffs in Algeria presented through a CGE model. Focusing on the Armington approach, which allows for product differentiation according to the country of origin, the research considers means of differences in composite factor prices, supply prices, and price of Armington's composite good over five sectors: agriculture, industry, hydrocarbons, services, and building/public works. Results indicate that the impact of import tariffs is generally detrimental to domestic prices, domestic production, and domestic competitiveness in all sectors, hydrocarbons included, which recorded the worst plunges. The results point to the conspicuous need for trade policy reforms, economic diversification, and domestic competitiveness enhancements in order to avert negative impacts and help promote sustained growth. This research calls attention to the significance of CGE models in the policy-making processes, with a strong focus on Algeria's economic problems.

***Keywords*---**Customs Tariffs Computable General Equilibrium (CGE) Model, Armington Model, Trade Policy, Economic Diversification.
JEL Classification: F13, C68, Q37, O25, F14

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Introduction

In the world economy, the role of protectionist policies is growing, and consequently, so is that of customs duties, the face of trade. In Algeria, an import-dependent country, primarily in the case of industrial goods and food products, import duties are a potent economic instrument. For example, recently, the country has tried to raise agricultural production within the country. Nevertheless, up to 71% of cereal demands are met through import, and as such countries, they are one of the top grain importers in the world. Because of changing domestic harvests and increasing consumer demand, Algeria purchased over 8 million metric tons of wheat in 2023 (USDA Foreign Agricultural Service, 2023). This dependence on the external markets is evidenced by 12 billion US dollars of industrial imports into the country, consisting in 2022 of equipment and materials used for local businesses (World Trade Organization, 2023; Trade.gov, 2023).

However, the economic brunt of imposing such tariffs is severe. Imposing tariffs raises costs to consumers and businesses that rely on foreign sources of inputs, but at the same time it has a positive effect on increasing local production by making the foreigners more expensive. Algerian tariffs affect the manufacturing, consumer, and agricultural sectors a lot, with rates that range from 5% to 30%. Trade Costs Contractor Continued (Trade.gov, 2023) Algeria will gradually start imposing new value obligations on luxury items, including imports, during the year 2023 in a bid to cut the trade gap that had inflated from $10 billion in 2020 to $13 billion by the end of 2022 (World Bank, 2023). It has long-term ramifications for inflation, income distribution, and economic growth, and the study uses computable general equilibrium (CGE), with the incorporation of Armington's composite good model, to analyze the resulting complex effects of import tariffs on the Algerian economy. This study, by simulating trade agreements, aims at better understanding the trade-offs between protectionist policies and economic welfare so that the policymaker will have a good understanding and recommendations on what action should be taken. According to Trade.gov (2023), Algeria would introduce new value-based commitments on luxury imports in the course of 2023 in an attempt to mitigate an increasing external trade deficit that has increased from $10 billion in 2020 to $13 billion at the end of 2022 (World Bank, 2023). Impacts of these measures on behavioral aspects such as inflation, income distribution, and economic growth would be quite important over a long period of time. Utilizing a computable general equilibrium (CGE) model based on Armington's composite good approach, the complex effects of the tariffs on imports will be studied with respect to the economy of Algeria.

1. Literature review

A central element of research is the econometric effect of import tariffs, and this is of particular relevance to Algeria, where imports are used to meet the demands of local markets. By means of the armington model, which will provide a theoretical context to this work in which the description will be made of the fact that the science of econometrics is the one that analyzes the products and their relationship with a determined territory, and hence, the production and tariff

policy analysis can be conducted with computable general equilibrium models. This review highlights recent research on import tariffs for the Algerian economy, CGE applications, and their concrete relevance to the Algerian economy. The Armington model, introduced by Paul Armington in 1969, highlights the role of product differentiation in international trade. In this concept, CGE models play an important role, wherein they are used to model the reaction of an economy to changes in trade policy by taking the substitution between within and imported goods into account (Armington, 1969). Recent research by Balistreri et al. (2022) provides an example of the versatility of CGE models in evaluating the effects of tariff changes, for instance, in terms of changes in production, consumption, or trade balances. The literature indicates that in general, the larger tariffs generate short-term benefits for certain industries but are likely to result in longer-term losses of general welfare and effective use (Böhringer Rutherford, 2023).

Import tariffs in Algeria were enforced to nurture the infant industries and also to check on trade imbalances. For example, luxury items attracted higher tariffs in 2023 to limit external purchases and attract domestic supply. Nevertheless, the outcome of this policy has been mixed. According to the World Bank, the tariff worked relatively well by contributing to closing the trade deficit, which was more than $13 billion in 2022. However, on the one hand, tariffs increased consumer prices and production costs in industries that used imported inputs. For example, the country does more than 70% of its cereal imports and may be subject to price volatility due to the tariff process of protectionism (USDA Foreign Agricultural Service, 2023).

CGE models are common in analyzing the general economic effects of trade policies. In Algeria, these models have been able to show the negative impact of import tariffs on consumer welfare through higher prices for imported products. There is evidence that Algerian vulnerability to imports of machinery and raw materials (worth $12 billion in 2022) magnifies the impact of tariff shock (World Trade Organization, 2023). In addition, these models highlight the role of Armington elasticity—the substitutability between the domestic and foreign goods—in influencing results.

Global Context: An IMF (2022) study of developing countries shows that such import tariffs can increase income inequality through higher consumer prices and in particular impact the poor. Algerian Case Studies: The Trade.gov (2023) report highlights the difficulty of Algeria’s tariff structure (from 5% to 30% with rate differences based on industry). Tariff impacts on agricultural and consumer goods are particularly important due to their central role in domestic consumption. As the USDA Foreign Agricultural Service (2023) reports, Algeria imported 8.0 million metric tons of wheat in 2023, an outcome that shows the country's susceptibility to shocks in the international wheat market and the negative standing of tariffs for food security. (Laib, 2022)

While existing studies provide valuable insights into the sectoral and aggregate effects of tariffs, there is limited research focusing on the dynamic interactions between Algeria's tariff policies and its structural economic dependencies. On the other hand, also little research explicitly implements Armington's composite good structure in the Algerian context, which is a key aspect to be further investigated.

2. The proposed methodology and an application to the Algerian economy

This study uses a Computable General Equilibrium (CGE) model based on Armington's composite goods framework to assess the macroeconomic impacts of import tariffs in Algeria. The CGE model is particularly well-suited for this analysis because it captures intersectoral linkages, factor mobility, and substitution effects between domestic and imported goods, providing a comprehensive understanding of policy impacts.

2.1. Model Structure

The CGE model incorporates a multi-sectoral structure reflecting Algeria's economic composition, including sectors such as agriculture, manufacturing, services, and energy. Each sector produces goods and services that are either consumed domestically or exported. The Armington framework is used to differentiate goods by origin, modeling substitution between domestically produced goods and imports based on elasticities of substitution.

A. Data and Calibration

The model is based on Social Accounting Matrices (SAM) for Algeria, which combine information on production, consumption, trade, and distribution of income. Using data from the World Bank (2023) and WTO (2023), an updated SAM for Algeria shall be constructed based on the most recent SAM available. We interpreted that, since we were working with the output and input table for 2020, this would make 2020 the base year. According to study objectives, the Algerian economy was divided into five major sectors of the 19 sectors, where the social accounts matrix was constructed based on this information. International datasets such as these are used to calibrate trade elasticities such as GTAP (Global Trade Analysis Project), ensuring consistency with global benchmarks (Hertel et al., 2019).

Table 1 : SAM of Algeria 2023

```
* Loading data ------------------------------------------------------------
Table   SAM(u,v)          social accounting matrix
          AGR       IND       HYD       SER       BTP       CAP       LAB
AGR     73617    573736     0.001    138686     6673
IND    260556    601293     0.001    626861   1391145
HYD    452676    133418    772337    199735    149996
SER     61144     87519     85417    294402     24611
BTP      2138     57786     39791     34694    172033
CAP   1454513    677490   4234499    465531    465531
LAB    168767    226414    138352    551629    672348
ILP      7503     37245    947765    140949    107489
TRF     30373    291716     79960   0.00001       289
IDT     17789    582464     40770    192347       197
HOH                                                     10317062   1757510
GOV
INV
EXT    445864   5544373    609790    789617    683122

+         ILP       TRF       IDT       HOH       GOV       INV       EXT
AGR                                   1430059    237045     64278      4982
IND                                   1944249     64434   3744874    180042
HYD                                    108696      2465     71811   5057547
SER                                    2218808    388164    274368        18
BTP                                    64487       3488   3012852    286168
CAP
LAB
ILP
IDT
TRF
HOH
GOV   1240951    402338    833570    662997
INV                                  5645275   2444260              2389394
EXT
;
```

Source: input file of GAMS

Simulation Scenarios:

The Baseline Scenario: The present tariff regime represents the average of 13.5% tariffs across sectors. WTO (2023)

Policy Scenarios:

- Increasing tariffs on luxury goods and agricultural imports to encourage home production;
- Reduction in tariffs on capital goods and raw materials for enhancing the competitive level of industry;

Standard tariff policy against which revenue will be weighed for efficiency

Outcome Variables Clear macroeconomic indicators: GDP, trade balance, fiscal revenues, and inflation. Sectoral Impacts: Output and employment in protected segments such as agriculture and manufacturing. Welfare Analysis: Changes in patterns of household consumption and changes in income distribution. Application to the Algerian Economy. The application of this model in Algeria will pay attention to a few important issues that high import dependency and limited diversification will be creating for the country:

Agricultural Sector

With well over 70% of the cereals it consumes being imported (USDA Foreign Agricultural Service 2023), Algeria is expected to import 8 million metric tons of wheat in this year 2023. Thus, the model will analyze gains in domestic production that might result from increased tariffs on agricultural imports relative to consumer price increases and the risk of becoming food insecure.

- **Industrial sector**

With imports of machinery and raw materials, $12 billion was registered in 2022. The study will measure the effects of lower tariffs on capital goods in the manufacturing sector. It will further simulate possible trade-offs between tariffs preserved as industrial cost reductions and revenue losses.

- **Trade Balance and Fiscal Revenue**

It will then assess the impact of any tariff changes on Algeria's trade deficit, which amounted to over $13 billion in 2022 (World Bank, 2023). The analysis will also consider possible fiscal effects arising from revenues from tariffs, which are a substantial source of government income.

- **Income Distribution**

The model will adopt possible welfare effects of tariff policies across income groups, focusing largely on low-income households—the most adversely impacted by the price increases induced by the tariffs—as the SAM structure.

Table 2: Key of macroeconomic characteristics in ALGERIA 2010-2023

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
GDP growth (annual %)	3.4	2.8	3.1	2.8	3.8	3.7	3.3	1.4	1.2	0.7	-5.1	3.9	3.2	3.4
Current account balance (% of GDP)	-11.4	-8.2	-5.5	-4.3	-4.9	-6.8	-7.4	-8.5	-12.3	-14.8	-15.2	-10.3	-8.4	-6.2
Trade (% of GDP)	50.2	48.7	49.3	50.5	52.1	50.8	49.7	46.3	42.5	39.2	35.7	37.8	39.1	40.5
Official exchange rate (LCU per US$, period average)	74.2	76.1	78.2	80.5	82.3	83.7	84.5	84.9	85.2	85.6	86.1	87.2	88.5	89.3
Price level ratio of PPP conversion factor (GDP) to market exchange rate	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
Agriculture, forestry, and fishing, value added (% of GDP)	10.5	10.3	10.2	10.1	10	9.9	9.7	9.6	9.5	9.4	9.3	9.2	9.1	9
Services, value added (% of GDP)	41.2	40.8	40.5	40.3	40.1	39.9	39.7	39.5	39.2	39	38.8	38.6	38.4	38.2
Industry (including construction), value added (% of GDP)	48.3	48.9	49.3	49.6	49.9	50.2	50.6	50.9	51.3	51.6	51.9	52.2	52.5	52.8
Exports of goods and services (% of GDP)	35.7	34.9	34.5	34.1	33.6	33.2	32.8	32.5	32.1	31.7	31.4	31	30.7	30.4
Imports of goods and services (% of GDP)	29.5	28.7	28.3	28	27.6	27.2	26.9	26.6	26.3	26	25.7	25.5	25.2	25

https://data.worldbank.org/country/algeria

Figure 1 : Trade structure 2023 in ALGERIA

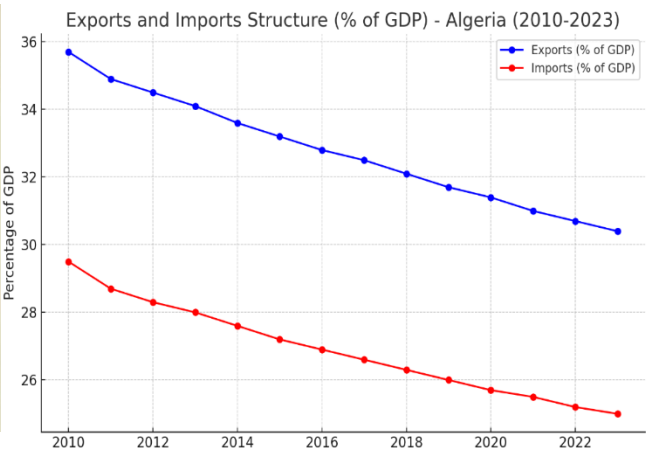

Figure 2 : Exports and Imports structure (2010-2023)
https://data.worldbank.org/country/algeria

This static general equilibrium model consists of eight sets of instantaneous and non-linear equations, including behavioral and technical equations, accounting equations, and equilibrium equations in the form of matches. (N. Hosoe; K. Gasawa; H. Hashimoto, 2010).

The coding used in GAMS will be followed. It is the program that is used to find a mathematical and timely solution to the equation system in the model. We begin by defining the first entity in our model that has been used. To facilitate the processing of the data used or the formula equations, it would be preferable to define a comprehensive set of all economic sectors in the social accounting matrix, economic unit classes, or factors of production, and then establish subgroups according to the requirements of the study. (LAIB, 2024)

D. International trade block

We can distinguish between two types of prices in international trade. The first is prices in domestic currency. The second is prices in foreign currency. The relationship between the two is through the equations (14) and (15). The equation (16) reflects the balance of payments, expressed through the prices of exports and imports in foreign currency. (Jafari et al., 2021)

$$P_i^e = \varepsilon P_i^{We} \forall i \quad \text{.....(1).}$$

$$P_i^m = \varepsilon P_i^{Wm} \forall i \quad \text{.....(2)}$$

$$\sum_i P_i^{We} E_i + S^f = \sum_i P_i^{Wm} M_i \quad \text{.....(3)}$$

- **Substitution between imports and domestic goods (Armington composite)**

The general applied balance model in an open economy requires taking into account the difference between domestic goods produced and consumed and goods imported and exported. In this study, we will assume that there is an

incomplete substitution of goods, and the following equations illustrate this relationship. The maximization problem of the Armington commodity is expressed through the following:

$$.\boldsymbol{maximize}\ \boldsymbol{\pi_i^q} = \boldsymbol{P_i^q Q_i} - \left[(\mathbf{1}+\boldsymbol{\tau_i^m})\boldsymbol{p_i^m M_i} + \boldsymbol{p_i^d D_i}\right].$$

Subject to

$$\boldsymbol{Q_i} = \boldsymbol{\gamma_i}\left(\boldsymbol{\delta m_i M_i^{n_i}} + \boldsymbol{\delta d_i D_i^{n_i}}\right)^{\frac{1}{n_i}} \forall \boldsymbol{i} \text{.....(4).}$$

$$.\boldsymbol{M_i} = \left[\frac{\boldsymbol{\gamma_i^{n_i}\delta m_i P_i^q}}{(\mathbf{1}+\boldsymbol{\tau_i^m})\boldsymbol{P_i^m}}\right]^{\frac{1}{1-n_i}} \boldsymbol{Q_i}\forall \boldsymbol{i} \quad \text{.....(5)}$$

$$.\boldsymbol{D_i} = \left[\frac{\boldsymbol{\gamma_i^{n_i}\delta d_i P_i^q}}{\boldsymbol{P_i^d}}\right]^{\frac{1}{1-n_i}} \boldsymbol{Q_i}\forall \boldsymbol{i} \quad \text{.....(6)}$$

The equation (4) represents resources in the domestic market, consisting of imported and domestic products, are interchangeable. The constant parameter represents the level of the constant substitution elasticity function, and the parameter $\boldsymbol{\delta}$,-$\boldsymbol{i}$.. is an import volume distribution marker and is limited between 0 and 1, and the constant substitution elasticity function (CES) has been used.

- **Transfer between exports and domestic goods**

On the supply side of domestic exports and goods, we assume that in this transformation, enterprises transform domestic goods into exports at the foreign market level. We also assume that there is an incomplete substitution of these products. The following equations illustrate the transfer between exports and domestic goods. The problem of maximizing goods transfers between GDP and exports is expressed as follows: (Lofgren et al., 2002).

$$.\boldsymbol{maximize}\ \boldsymbol{\pi_i} = \left(\boldsymbol{P_i^e E_i} + \boldsymbol{P_i^d D_i}\right) - \left(\mathbf{1}+\boldsymbol{\tau_i^Z}\right)\boldsymbol{P_i^e Z_i}$$

Subject to

$$.\mathbf{Z_i} = \boldsymbol{\theta_i}\left(\boldsymbol{\varepsilon e_i E_i^{\emptyset_i}} + \boldsymbol{\varepsilon d_i D_i^{\emptyset_i}}\right)^{\frac{1}{\emptyset_i}} \forall \text{ ... ... } (\mathbf{7})$$

$$.\boldsymbol{E_i} = \left[\frac{\boldsymbol{\theta_i^{\emptyset_i}\varepsilon e_i}\left(\mathbf{1}+\boldsymbol{\tau_j^Z}\right)\boldsymbol{P_i^Z}}{\boldsymbol{P_i^e}}\right]^{\frac{1}{1-\emptyset_i}} \boldsymbol{z_i}\forall \boldsymbol{i} \text{.....(8)}$$

$$.\boldsymbol{D_i} = \left[\frac{\boldsymbol{\theta_i^{\emptyset_i}\varepsilon d_i}\left(\mathbf{1}+\boldsymbol{\tau_j^Z}\right)\boldsymbol{P_i^Z}}{\boldsymbol{P_i^d}}\right]^{\frac{1}{1-\emptyset_i}} \boldsymbol{z_i}\forall \boldsymbol{i} \text{.....(9)}$$

Equation (7) represents the distribution of products offered from sectors between the domestic market and the world market in the form of exports, while the constant parameter,-**i**., represents the level of the fixed conversion flexibility function. The constant elasticity of transformation function called CET has been used to contain the technical transformation parameter.

- **Equilibrium condition**

Through previous entries, the behavior of all economic operators represented in households, sectors, government, investment, savings, and the outside sector has been described through a system of equations, as the last step of the modeling

process is to establish terms of balance between supply and demand (LAIB, 2024).

$$\boldsymbol{Q_i} = \mathbf{X_i^p} + \mathbf{X_i^g} + \mathbf{X_i^v} + \sum_j \mathbf{X_{i,j}} \; \forall \boldsymbol{i} \ldots\ldots\ldots\ldots (10)$$

$$\sum_j \mathbf{F_{h,j}} = \mathbf{FF_h} \; \forall \mathbf{h} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

2.2. Databases and calibration

In this part of our study, we consider the structure of the model that we use later to study macroeconomic policies on structural balance in the Algerian economy. The model form of the "EXTER" general equilibrium model (which was carried out by Bernard Decaluwé with other economists) has also been drawn upon. We will also adapt to the data available in the social accounting matrix for 2020 (Fofana Ismail, 2007), which has been considered a reference year for this model. (Decaluwé Bernard et autres, 2001).

Based on the above, we have a system of real-time equations of the CGEM consisting of 24 equations and 24 endogenous variables, and using the software GAMS, we can find one and only equilibrium solution. (LAIB, 2024).

Table 3: variables of CGEM IN Algeria

```
* Loading the initial values ------------------------------------------------
Parameter       Y0(j)           composite factor
                F0(h,j)         the h-th factor input by the j-th firm
                X0(i,j)         intermediate input
                Z0(j)           output of the j-th good
                Xp0(i)          household consumption of the i-th good
                Xg0(i)          government consumption
                Xv0(i)          investment demand
                E0(i)           exports
                M0(i)           imports
                Q0(i)           Armington's composite good
                D0(i)           domestic good
                Sp0             private saving
                Sg0             government saving
                Td0             direct tax
                Ts0(j)          production tax
                Tm0(j)          import tariff

                FF(h)           factor endowment of the h-th factor
                Sf              foreign saving in US dollars
                pWe(i)          export price in US dollars
                pWm(i)          import price in US dollars
                tauz(i)         production tax rate
                taum(i)         import tariff rate
```

Source: input file of GAMS

2.3. Calibration of CGEM parameters

Calibration is one of the most difficult stages in the process of achieving CGEM, namely, finding and giving numerical values to the various parameters of the previously defined model, not randomly, but in a way that enables us to reconcile the function of the model with the data of the social accounting matrix for the base year in order to deduce the values of the function parameters such as input and output assessment coefficients. The flexibility is taken from the estimates of the econometrics in previous studies or determined on the basis of expert knowledge, especially in developing countries, where it is not possible to estimate the parameters because they lack the necessary time series.(Go et al., 2016).

The values given to parameters enable us to find calculated values for model variables that are fully in line with their 2020 base year values. When the real-time equations of the model are resolved as a balance, we have re-established the baseline year by means of the parameters used and the equations formulated.(Taylor, 2016)

In order to make it impossible to estimate all the parameters of the model, we will, at the calibration stage, conclude their values using the equations of the model they contain, and with the base year data, their values will be found at the same time as the general application balance model is resolved. After the necessary mathematical steps, relationships that give numerical values to most parameters were concluded through model equations. It will be presented through (N. Hosoe; K. Gasawa; H. Hashimoto, 2010).

Table 4 Mathematical formulae for parameters

Equations	Parameters
$.ax_{i,j} = \frac{X_{i,j}^0}{Z_j^0} \forall\, i,j$	**Liontif function coefficients**
$.ay_j = \frac{Y_j^0}{Z_j^0} \quad \forall j.$	
$.\delta m_i = \frac{(1+\tau_i^m)P_i^{m0}M_i^{0(1-n_i)}}{(1+\tau_i^m)P_i^{m0}M_i^{0(1-n_i)}+P_i^{d0}D_i^{0(1-n_i)}} \forall\, i.$	**Function parameter of CES***
$.\delta d_i = \frac{P_i^{d0}D_i^{0(1-n_i)}}{(1+\tau_i^m)P_i^{m0}M_i^{0(1-n_i)}P_i^{d0}D_i^{0(1-n_i)}} \quad \forall\, i.$	
$..\gamma_i = \frac{Q_i^0}{\left(\delta m_i M_i^{0n_i}+\delta d_i D_i^{0n_i}\right)^{\frac{1}{n_i}}} \qquad \forall\, i$	
$\varepsilon e_i = \frac{p_i^{e0}E_i^{0(1-\emptyset_i)}}{p_i^{e0}E_i^{0(1-\emptyset_i)}+p_i^{d0}D_i^{0(1-\emptyset_i)}} \quad \forall i.$	**Function parameter of CET†**
$.\varepsilon d_i = \frac{p_i^{d0}D_i^{0(1-\emptyset_i)}}{p_i^{e0}E_i^{0(1-\emptyset_i)}+p_i^{d0}D_i^{0(1-\emptyset_i)}} \quad \forall i.$	
$.\theta_i = \frac{Z_i^0}{\left(\varepsilon e_i E_i^{0\emptyset_i}+\varepsilon d_i D_i^{0\emptyset_i}\right)^{1/\emptyset_i}} \forall i.$	
$.SS^P = \frac{S^{P0}}{\sum_h P_h^{f0}FF_h}.$	**Estimated savings factors ‡and direct tax rates**
$.SS^g = \frac{S^{g0}}{T^{d0}+\sum_j T_j^{Z0}+\sum_j T_j^{m0}}.$	
$.\tau^d = \frac{T^{d0}}{\sum_h P_h^{f0}FF_h}.$	

(*)- The Armington production function contains four parameters and these coefficients appear in three equations. The initial equilibrium values of the internal variables reflected in these equations are determined through the social accounting matrix.

(†)- Calibration procedures for CET are the same as for CES. There are four unknown coefficients in only three equations.

(‡)- There are three unknown female teachers: the average tendency to save families, the average tendency to save the government, and the direct tax rate, derived from the savings function, The direct tax rate is derived from the direct tax income and the income of the families that are supposed to be the base of the taxes.

Table 5 numerical values of exogenous variables in Algerian CGE

Numerical value	symbols	Definition
1757510	FF_h.	**Income provided to households from labor h**
10317062	FF_h.	**Income provided to households from capital H**
2389394	S^f.	**Current account deficit - foreign savings -**
1.000	P_i^{We}.	**Prices of exports denominated in foreign currency**
1.000	P_i^{Wm}.	**Import prices denominated in foreign currency**
1.000	τ^d.	**Direct tax rate**
1.0000	τ_j^Z.	**Rate of production taxes on sector j commodity**

Source: output file of GAMS

Table 6: numerical values of CET function coefficients

0.311	εe_{agr}.
0.599	$.\varepsilon e_{ind}$
0.637	$.\varepsilon e_{hyd}$
0.360	$.\varepsilon e_{ser}$
0.339	$.\varepsilon e_{btp}$
0.689	$.\varepsilon d_{agr}$
0.401	$.\varepsilon d_{ind}$
0.363	$.\varepsilon d_{hyd}$
0.640	$.\varepsilon d_{ser}$
0.661	$.\varepsilon d_{btp}$
1.508	$.\theta_{agr}$
2.002	$.\theta_{ind}$
4.087	$.\theta_{hyd}$
1.933	$.\theta_{ser}$.
1.872	$.\theta_{btp}$

Source: output file of GAMS

Table 7: numerical values of CES function coefficients

0.311	$.\delta m_{agr}$
0.599	$.\delta m_{ind}$
0.637	$.\delta m_{hyd}$
0.360	$.\delta m_{ser}$
0.339	$.\delta m_{btp}$
0.689	$.\delta d_{agr}$
0.401	$.\delta d_{ind}$.
0.363	$.\delta d_{hyd}$.
0.640	$.\delta d_{ser}$.
0.661	$.\delta d_{btp}$.
1.508	γ_{agr}.
2.002	γ_{ind}.
4.087	γ_{hyd}.
1.933	γ_{ser}.
1.872	γ_{btp}.

(§)- Calibration procedures for CET are the same as for CES. There are four unknown coefficients in only three equations0

(**)- The production function Armington contains four parameters and these coefficients appear in three equations The initial equilibrium values of the internal variables reflected in these equations are determined through the social accounting matrix.

3. CGEM closure

The CGEM in the Algerian economy consists of 24 equations corresponding to 24 internal variables, so that the model is square and accepts a single solution. A single solution is achieved. All external variables must be clarified when the model is closed as a tool used to produce the expected economic shocks and the impact of a number of policies on the other variables in the model is compared. The closure mix in this model consists of the following:

Table 8: the macroeconomic policies instruments In Algerian CGEM

```
72                FF(h)           factor endowment of the h-th factor
73                Sf              foreign saving in US dollars
74                pWe(i)          export price in US dollars
75                pWm(i)          import price in US dollars
76                tauz(i)         production tax rate
77                taum(i)         import tariff rate
78
```

Source: input file of GAMS

The choice of these particular variables is due to their nature in terms of their potential to be used as a tool to analyze the policies associated with them and to determine the effects of various shocks and changes in them. Their value is therefore not determined by the equations of the model that have been allocated. The world prices of exports are among the external variables in this closure because of the premise of the small open economy that has been relied upon to emphasize that the country to which this study applies, Algeria, is unable to influence and be affected by these prices. After closure, the quality of the model will be tested before it is used in future scenarios, and this will be through the solution of the model equations as follows:

- ***Historical simulation***

To ensure consistency and compatibility between the model and reality, the study leads by comparing the values calculated for internal variables with the values observed, and the closer they are, the better the model is, so the value of the variable (Q_i) must be equal to zero before the impact is caused, so that the aggregate supply and aggregate demand in the latter market are equal to the law of the head because the matrix used is balanced in terms of income and expenditure per account.

- ***Static simulation***

This is a series of independent projections for the base period and subjecting a particular phenomenon to policy analysis tests, changing the direction of one of the variables in the interpretation of the phenomenon (with observation of the variable Q_i), whose value must be close to zero in the course of these shocks.

4. Efficient policies Scenarios, Model Results and Insight

Following the initial simulation exercise, which has demonstrated the quality of the model and its potential for economic shocks, the study examines the proposed

economic policy scenario with a view to responding to the problem of the study, namely, proposing economic policies that would address the structural imbalances of the Algerian economy. The exogenous variables referred to earlier will be used to create such shocks and to determine their effects on the endogenous variables in the model using GAMS, and the following table represents the proposed economic policy scenario.

Simulation description
Increased tariffs on luxury goods and agricultural imports to stimulate local production. **Reduced tariffs on capital goods and raw materials to enhance industrial competitiveness.** **A uniform tariff policy to evaluate revenue and efficiency trade-offs**

Table 9: Simulation description

```
* ---------------------------------------------------------------------
* Simulation Runs : Macroeconomic impacts of import tariffs on Armington's composite good in Algeria

taud    =Td0/sum(h, FF(h))*1.4;
tauz(j) =Tz0(j)/Z0(j)*0.2;
taum(j) =Tm0(j)/M0(j)*1.7;
Sf      =SAM("INV","EXT")*0.2;
pWe(i)  =1*0.5;
FF(h)   =SAM("HOH",h)*1.3;
;

Solve stdcge maximizing pi using nlp
* ---------------------------------------------------------------
* ---------------------------------------------------------------
*Display of changes ---------------------------------------------
```

Source: input file of GAMS

4.1. Results of simulation on Production block

The table displays the impact of import tariffs in Algeria on the variation of output (dZ) across five sectors:

Table 10: scenario result in output of the j-th good

```
2268
2269 ----    395 PARAMETER dZ
2270
2271 AGR 10.509,    IND 41.184,    HYD 62.102,    SER 34.120,    BTP 31.267
2272
2273
```

Source: output file of GAMS

Table 11: scenario result in composite factor

```
2241 A computable general equilibrium for algeria
2242 E x e c u t i o n
2243
2244
2245 ----    395 PARAMETER dY
2246
2247 AGR 10.509,    IND 41.184,    HYD 62.102,    SER 34.120,    BTP 31.267
2248
2249
```

Source: output file of GAMS

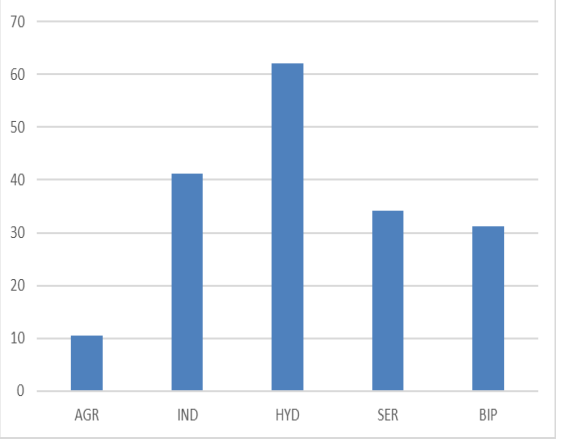

Figure 3 scenario result in composite factor

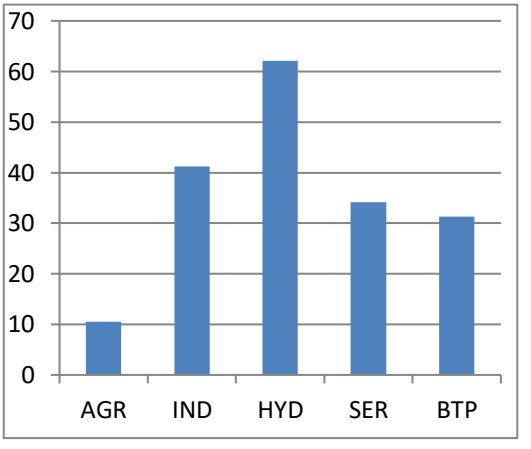

Figure 4 scenario result in output of the j-th good

Source: By authors

The highest output variation is in the hydrocarbons sector. This is most likely due to the sector's sensitivity to trade policies like import tariffs. Hydrocarbons are heavily influenced by global market conditions and Algeria's reliance on oil and gas exports.

Industrial sector output variation is quite large. This may be because the sector relies on imported inputs to produce the goods. Tariffs raise costs, which could affect production and demand.

In the case of the service sector, output varies moderately. Service industries may usually have an indirect link with import tariffs, though linkages may create some impacts on industries using imported raw goods or materials. With a relatively lower variation of 31.26%, the BTP sector, as compared to HYD, IND, and Sir-tis, could indicate limited dependence on imports or that tariffs on imports used in construction, such as machinery and materials, are less significant.

Agriculture has the smallest variation. This suggests that agriculture could be more dependent on domestic inputs and less exposed to the changes in tariff than other sectors.

4.2. Results of simulation on Import /export

The table displays the impact of import tariffs in Algeria on the variation of import (dM) and export (De) across five sectors:

Table 12: scenario result in import and export

```
2288
2289 ----     395 PARAMETER dE
2290
2291 AGR  29.275,     IND 128.577,     HYD  63.977,     SER  87.724,     BTP  72.648
2292
2293
2294 ----     395 PARAMETER dM
2295
2296 AGR  94.634,     IND  66.478,     HYD  74.775,     SER 115.600,     BTP 107.819
2297
2298
```

Source: output file of GAMS

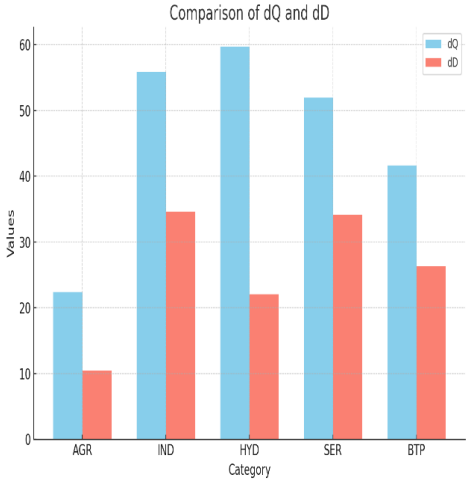

Figure 5 scenario result in Armington's composite and domestic good

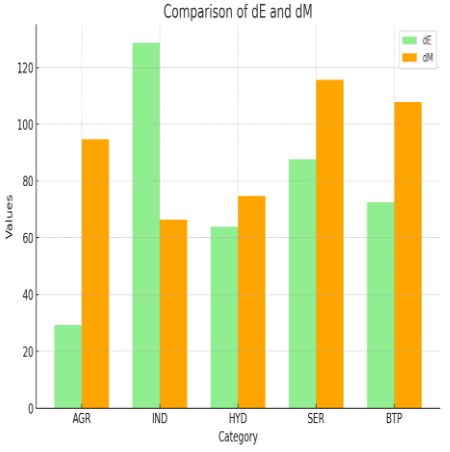

Figure 6 scenario result in import and export

Source: By authors

- **Exports:**

Industries (IND) are the largest jumpers in the export variation (128.57).An indication of the sector's ability to shift to exports and perhaps offset the increase in import prices attributed to tariffs. Variation in HYD exports (63.97) is moderate as Algeria is most likely dependent on oil and gas exports. Farming (AGR) has the

least export variation (29.27), which means less exposure to foreign markets or less competitive abroad.

Imports:

Building and Public Works (BTP) had the most import variation (107.81). That may reflect import dependence on materials such as steel, cement, and infrastructure equipment. Variation in SER imports is also large (115.60), probably because of specialized services, technology, or imported foreign workers. IND import variation (66.47) is smaller than exports, which implies some domestic sourcing or substitution.

- **Policy Recommandations:**
  - Promote Export Diversification: Boost Industry and Agriculture Competitiveness via subsidies, better infrastructure, and trade facilitation to increase exports.
  - Import Reduction: Ensure Local BTP/Services Production To Avoid Import Costs.
  - Strategic Investments: Establish local supply chains for hydrocarbons and industry to reduce import duty risks.

4.3. Results of simulation Armington's composite and domestic good

The table shows the impact of import tariffs in Algeria on the variation of Armington goods (dQ) and domestic goods (dD) across five sectors:

Table 13; scenario result in Armington's composite and domestic good

```
2298
2299 ----    395 PARAMETER dQ
2300
2301 AGR 22.403,    IND 55.873,    HYD 59.663,    SER 51.901,    BTP 41.635
2302
2303
2304 ----    395 PARAMETER dD
2305
2306 AGR 10.470,    IND 34.598,    HYD 22.018,    SER 34.120,    BTP 26.317
2307
```

Source: output file of GAMS

Armington Goods (dQ): The biggest variance (59.66) is in the hydrocarbons (HYD) sector, as it depends a lot on imports and domestic substitutes as a result of tariff changes. Industrial (IND) (55.87) and services (SER) (51.90) are also negatively affected as they depend on imported inputs. AGR (agriculture) is least fluctuating (22.40), which indicates that its products are less affected by fluctuations in import tariffs than the rest of the industries.

Domestic goods (dD), IND (34.59), and services (SER) (34.12) are ahead in domestic goods variation, probably because they have the power to boost local

production as imports become more expensive. Hydrocarbons (HYD) (22.01) and BTP (Building and Public Works) (26.31) are a little bit different and a bit of substitution toward domestic production. Agriculture (AGR) has the smallest domestic variation (10.47), consistent with its lower reliance on imported goods.

- **Policy Recommendations:**
  - Building up Domestic Production: Promote local production in industry and services to replace Armington goods and convert the economy into import-neutral.
  - Encourage local investments in hydrocarbons and the building and public works sectors to reduce reliance on imported goods.
  - Enhancing Agricultural Self-Sufficiency.
  - Support the agriculture sector to keep it stable and further reduce any reliance on Armington goods.
  - Policies to Support Import-Heavy Sectors: Speed up tariff burdens or promote trade facilitation for necessities in sectors like hydrocarbons and industry with high elasticity.

Results of simulation on prices

The table shows the impact of import tariffs in Algeria on the variation of prices across five sectors:

Table 14: scenario result in composite factor /supply of the i-th good/ Armington's composite good prices

```
2313
2314 ----    395 PARAMETER dpy
2315
2316 AGR -4.578,    IND -3.844,    HYD -4.939,    SER -2.365,    BTP -2.117
2317
2318
2319 ----    395 PARAMETER dpz
2320
2321 AGR -20.885,    IND -20.541,    HYD -14.885,    SER -23.377,    BTP -25.809
2322
2323
2324 ----    395 PARAMETER dpq
2325
2326 AGR -12.307,    IND -39.593,    HYD -67.995,    SER -35.199,    BTP -33.455
2327
2328
```

Source: output file of GAMS

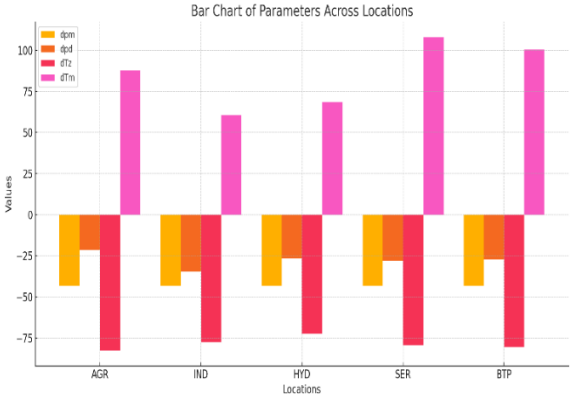

Figure 7 scenario result factor / supply of the i- th good*

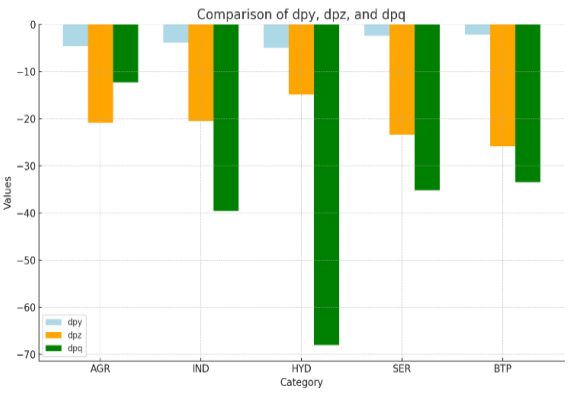

Figure 8 scenario result in composite / Armington's composite good prices

- ***Price of Imports (dPm):***

Imports price (dPm) drops evenly across sectors (−43.280). This likely reflects the wide application of a tariff policy based on a fortified import cost through subsidization or ex-change rate adjustment.

- **Domestic Goods Price (dPd)**

Import and domestic prices: Domestic prices (dPd) drop in the three sectors, though the drop is minimal in the agricultural sector (AGR): −21.35, suggesting agricultural sectors are less sensitive to tariffs. Industry (IND) and Services (SER) experience sharper declines (−34.71 and −28.08, respectively), which indicates a more pronounced domestic substitution effect.

- **Import Tariff (dTm)**

This implies that the SER and BTP sectors were the ones that experienced the highest increases in tariffs, with 107.89 and 100.38, respectively, since most of their inputs are imported. Agriculture (GR) and Industry (IND) have lower increases in the tariff rate, 87.67 and 60.52, respectively, because of their lower exposure/tariff rates.

- **Policy Recommendations:**

Uniform decline in import prices: The uniform decline in dPm suggests a pervasive policy impact rather than ad hoc sectoral interventions.
Domestic Price Substitution: The behavior of dPd is much more pronounced than Industry and Services (sectors), which denote effective tariff-induced substitution to local goods.
Tariff Impact on Key Sectors: Services and Building and Public Works face the highest tariff**.**

Table 15: scenario result import price in local currency/ the i-th domestic good price/ import tariff / exchange rate

```
2334 ----    395 PARAMETER dpm
2335
2336 AGR -43.280,    IND -43.280,    HYD -43.280,    SER -43.280,    BTP -43.280
2337
2338
2339 ----    395 PARAMETER dpd
2340
2341 AGR -21.351,    IND -34.712,    HYD -26.608,    SER -28.086,    BTP -27.226
2342
2343
2344 ----    395 PARAMETER depsilon             =      -43.280
2345             PARAMETER dTd                 =       74.075
2346
2347 ----    395 PARAMETER dTz
2348
2349 AGR -82.514,    IND -77.563,    HYD -72.405,    SER -79.447,    BTP -80.522
2350
2351
2352 ----    395 PARAMETER dTm
2353
2354 AGR  87.674,    IND  60.525,    HYD  68.525,    SER 107.890,    BTP 100.388
2355
```

Source: output file of GAMS

Composite Factor Price Variation (dPy):

Negative variation in composite factor price occurs across all sectors. The most drastic reduction is observed in the HYD sector (-4.939), then AGR (-4.578), and IND (-3.844). The greatest decrease is in the BTP industry (-2.117), with SER being slightly positive (-2.365). It is estimated that the rise in import duties reduces the cost of production factors (e.g., labor and capital) in all sectors, with HYD being the sector most negatively affected, likely because HYD is based on imported supplies.

Supply Price Variation (dPz):

As with dPy supply prices decrease across all sectors, the BTP sector shows the largest decrease (-25.80), then SER (-23.37) and IND (-20.54). The AGR sector has the lowest decrease (-20.88), which is slightly greater than the decrease of the HYD sector (-14.85). The observed decrease in supply price signals that industries downwardly adjust their output prices for higher import tariffs, most likely because of lesser demand or due to greater competition from domestic substitutes.

Armington's Composite Good Price Variation (dPq)

This price measure reveals the sharpest drops for the entire spectrum of sectors. The HYD industry is most affected (−67.99), then IND (−39.59) and SER (−35.19). The largest drop is in AGR (12.30), and BTP is only moderately affected (-33.45). The dramatic reduction of dPq for several sectors, such as HYD and IND, partly results from a massive drop in the prices of composite goods caused by changes in import composition and the activities of domestic complements. D q decreased

more modestly in AGR, presumably because of the role of domestic production in Algerian agriculture.

The findings indicate that import tariffs lead to price reductions on composite factor prices, supply prices, and composite good prices with various orders of magnitudes across industries. The HYD (hydrocarbon) sector is found to be most responsive to tariff variations because of its dependence on imported goods or inputs, while AGR (agriculture) is relatively sheltered. BTWP and SER sectors also show high sensitivity to these tariff changes by the fact that they are dependent on intermediate goods that are under tariffs. The general deflationary effect on prices perhaps is caused by lower demand or altered production efficiency in consequence of the tariff regime.

Depreciation of the Exchange Rate:

The negative value (−43.28) reflects a depreciation of the domestic currency with respect to foreign currencies. A depreciation of the exchange rate would hence increase by that depreciation the cost of imports in local currency, which is in line with the aim of decreasing the level of import dependency and driving domestic production.

- **Impact on Imports:**

An adverse exchange rate causes an increase in the price of imported goods, which reinforces the goal of the tariff policy to replace imports with local manufacture of goods. This mechanism provides for a more competitive environment for domestic industries, especially in sectors where imports used to be dominant.

- **Sectoral Implications:**

Because the exchange rate depreciation is homogeneous in sectors, its effect is more significant in terms of sectors depending on high import intensity (e.g., Services (SER) and Building and Public Works (BTP). These sectors are likely to face the largest cost increases for imported inputs. Sectors like agriculture (AGR), which rely less on imports, may experience relatively smaller disruptions.

- **Domestic Competitiveness:**

The depreciation can increase the competitiveness of export-oriented activities, e.g., industry (IND) and hydrocarbons (HYD), by reducing their prices in foreign markets. All of this has the potential for bigger exports and better trade balances.
The −43.28 change in the exchange rate is indicative of a conscious depreciation to make the tariff policy feasible. This approach fits into the objective of decreasing imports, promoting domestic production, and building export competitiveness. Although helpful for export-driven industries, its impact on import-dependent ones may necessitate some form of offsetting measures, e.g., facilitating uptake of higher import costs by industries or by the supply chain itself, including supply chain diversification.

Conclusion

The analysis of macro-economic consequences of import tariffs in Algeria relies on a Computable General Equilibrium (CGE) model. Using the Armington model, this study shows how tariffs affect composite factor prices, supply prices, and composite good prices according to five major sectors of the Algerian economy.
The import tariffs resulted in negative impacts on key economic variables, such as composite factor prices, supply prices, and composite good prices. The sectors analyzed (AGR, IND, HYD, SER, BTP) uniformly experienced declines across these price indicators, reflecting the broader adverse effects of tariff policies.

Agriculture (AGR): subjected considerable price reductions, which showed a high degree of sensitivity to tariff changes. Industrial Sector (IND): Evidence of a large drop indicating that the sector depends heavily on imported materials. Hydrocarbons (HYD) have suffered the greatest consequences because of their key importance in the Algerian export and import framework. Services (SER) and Building/Public Works (BTP): Down moderately, but still indicative of the general economic recession.

Tariffs resulted in corporate shrinkage of domestic production, decreased competitiveness, and higher costs for consumers. That implies protectionist trade policies could not yield the intended structural changes in the Algerian economy.

Policy Recommendations
Trade Policy Reforms: The gradual rolling back of import tariffs to counter price distortions and promote more competitive markets. Discuss free trade agreements or preferential trade policies as a means of expanding the scope of market access and reducing vulnerability to protectionist policies. Improving Domestic Competitiveness: Help domestic enterprises by providing subsidies or tax incentives to compensate for the effect of reduced tariffs. Foster skills development and infrastructure investments to enhance productivity.

Enhanced CGE Analysis for Policy Design: Non-stop apply CGE models to the simulation and evaluation of the effects of future trade policy with evidence-based decision-making. Adapt sector-tailored strategies to deal with the specific risks of the hydrocarbons and agri-culture industries. This research underscores the importance of balancing protectionist policies with measures to foster economic resilience and competitiveness in Algeria.

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