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Scale, Technique and Composition Effects of CO2 Emissions under Trade Liberalization of EGS: A CGE Evaluation for Argentina

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***Abstract*—**Current literature about trade liberalization of environmental goods and services (EGS) raises doubts about the extent of the triple win-win situation for trade, development and the environment. However, much of this literature does not consider the possibility that this agreement carries technological transmissions, either through trade or foreign direct investment. This paper presents a computable general equilibrium model calibrated for Argentina, where there are alternative technologies (one dirty and one clean according to carbon emissions) to produce the same goods. In this context, the trade liberalization of EGS allows to increase GDP, trade, reduce unemployment and improve the households welfare. However, the capital mobility appears as the key assumption to jointly reach the environmental target, when the positive scale effect generated by the increase in trade is offset by the change in the composition of production (composition and technical effects by the use of the clean alternative technology) and of consumption (composition effect by substitution of relatively lesspolluting imported goods).

***Keywords*—**CGE modeling, CO2 emissions, composition effect, scale effect, technique effect, trade liberalization of EGS.

I. Introduction

THE current literature on the trade liberalization of environmental goods and services (EGS), both in the multilateral and plurilateral framework [1], [2] raises certain doubts about the possibility of achieving the triple-win situation for trade, development and the environment, [3] particularly in developing countries where the state of technology is not in order to mitigate climate change [4], [5]. In this context, it is necessary to take into account the impact of a greater trade in EGS through the transmission of technologies and the possibility of implementing relatively cleaner means of production, as a result of the incentive of the foreign direct investment [6].

For this reason, the purpose of this work is to improve the quantification of the environmental effects, decomposed in scale, technique and composition, of the trade liberalization of EGS. The contribution of this paper is the development of a computable general equilibrium model that incorporates two alternative production technologies (one clean and one dirty from the point of view of carbon emissions) in the energy and industrial sectors. This model also considers an important substitution in consumption (intermediate, final and capital goods) between domestic and imported goods, the latter being relatively less polluting (e.g., energy-saving lamps, inputs for the generation of solar or wind energy, etc.). This modeling will capture the effects of technology transfer through trade and the incentive of foreign direct investment towards developing countries, such as Argentina, that can reduce carbon emissions due to the trade liberalization oriented to environmentally friendly goods. The analysis of the change in carbon emissions will be broken down into scale, technical and composition, thanks to the modeling of latent technologies in production and different elasticities of substitution in consumption.

Middle-income countries such as Argentina display a strong potential to sustainable development taking advantage of this international trade and environmental context (e.g., the Environmental Goods Agreement -EGA-, the Paris Agreement -PA-) oriented towards the EGS as a possible measure to reduce carbon emissions [6], [7]. For this reason we will evaluate two scenarios that illustrate the current state of the plurilateral negotiations for a EGA. At the moment, Argentina does not actively participate in the negotiations, however, it has done before within the framework of the Doha Round, so it may be interested to join the group of 17 countries[1] which are negotiating an the EGA. The simulated scenarios consider the evaluation of Argentina's non-participation as well as its tariff elimination on EGS. Consequently, the economic and environmental (decomposition) results will also provide policy-oriented suggestions to this country, that could be extended to others of similar characteristics.

The work is organized as follows. In Section II we present the computable general equilibrium model used to simulate the impact of the EGA for Argentina. Section III presents the results and Section IV discusses preliminary conclusions and future improvements in this research.

II. A CGE Model with Latent Technologies: The Methodological Approach

In order to evaluate trade policy incentives to reduce CO2 emissions, we have improved the [8]'s a multi-sector

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[1]Australia, China, Costa Rica, the European Union, Hong Kong, Iceland, Israel, Japan, Korea, New Zealand, Norway, Singapore, Switzerland, Chinese Taipei, Turkey and the United States.

mono-country CGE model by introducing latent technologies in strategic sectors (energy and manufactures). This modeling allows decomposing the scale, composition and technical effects imbedded in the indicator of total national carbon emissions.

We thus illustrate the impact of trade policies to seek environmental purposes by running the implementation of the EGA for Argentina. The model is initially calibrated using a Social Accounting Matrices (SAM) of this country for 2006.[2]

According to the sectoral disaggregation of the SAM, we work with six sectors: Agriculture and Fishing (S1), Energy and Mining (S2), Industry (S3), Electricity and Water (S4), Transport (S5) and Other Services (S6). Since the industrial sector is relatively less pollutant than agriculture and energy (Table I), and since most EGS lists under discussion mainly concern manufactures, we assume the S3 and S6 as EGS.

Next subsections present the main assumptions of the CGE models and describe the EGA scenarios to be simulated.

A. Basic Assumptions and New Improvements of the CGE Model

The demand side is modeled assuming two representative households (poor and rich), a government and the rest of the world.

Households consume domestic and imported goods and services, invest and buy/sell bonds in a constant proportion of their income (Cobb-Douglas assumption). Their incomes are composed by labor and capital remunerations and transfers received from the government. Each type of household maximizes its utility function subject to its budget constraint to choose the optimal composition of its consumption basket of final goods and services. The two-levels nested utility function assumes a higher degree of substitution between EGS imported products and 'dirty' domestic goods (i.e., a Cobb-Douglas assumption for the first level and a CES with an elasticity of substitution of 5 for the second level of the final demand tree).

The government also consumes, invests and makes transfers to households in a constant proportion (Cobb-Douglas), financing those expenses mainly with its tax collection, and debt in a lower proportion. In this sense the modeling of the government behavior is neutral because each dollar received by the government is always spent in the same way.

The rest of the world buys domestic exports and sells imports in addition to making transaction in the financial market and collecting dividends from investment. In the benchmark situation, the value of exports equalizes the value of imports (trade balances).

The equivalent variation is the welfare measure chosen to evaluate the change in the level of the agents' utility when prices of goods, services and factors' change.

On the supply side, each sector combines intermediate consumption and value added in a fixed proportion (Leontief). The intermediate consumption also assumes two-levels nested function where imported EGS are substitutes to domestic 'dirty' inputs such as in the final consumption of households (CES with an elasticity of substitution of 5). Value added is a Cobb-Douglas production function of labor and domestic capital under the 'dirty' technology, while the 'clean' one requires a combination of labor and foreign capital (FDI).

The modeling of the labor market assumes a positive unemployment rate due to constant wages in real terms, i.e. wages are indexed to the price of the consumption basket of the poor household.

Two types of capital are available in the model, fixed and mobile. Fixed capital is installed in each sector as a specific resource and the mobile capital is allocated across sector according to the rate of return in each of them. Concerning capital mobility across sector we initially assume that a low proportion of capital is mobile, 12.5%, and then, this assumption will be modified increasing the percentage of the mobile capital to the half of all capital.

Closures of the model assume: a saving-driven investment, endogenous exchange rate given the equilibrium of the current account, endogenous unemployment rate given a constant real wage, and for the rest of goods, services and factors markets clear under perfect competition conditions. We additionally assume that Argentina is small with respect of the international market, which is particularly true in the case of EGS international markets. The *numeraire* is the remuneration of the foreign production factor. In this way the system fills the basic properties of Walrasian model.

The CGE model is numerically solved using the interface GAMS/MPSGE where the problem is programmed as a Mixed Complementarity Approach (MCP).

In order to measure the environmental impact of the simulated scenarios, we follow, such as in [8], the taxonomy developed by [9]. These authors identify three channels to explain the change in carbon emissions:

- the *scale effect* when the scale of the activity can increase or reduce when some policy (in this case a trade policy) is implemented;
- the *composition effect* when the sectors' value-added structure changes due to the implemented policy; and
- the *intensity effect* when the coefficients of emissions per unit of output change, when adopting an alternative technology.

The three channels could be isolated running the model under different assumptions: with and without substitutions in demand (final and intermediate) between clean and dirty products, and with and without allowing an alternative cleaner technology in production.

We thus compute two indexes about carbon emissions: the total CO2 emission index and the Kuznets CO2 emissions index. The latter captures the variation of CO2 emissions related to the GDP growth. In order to isolate the scale from the composition and technique effects in the change of CO2 emissions we have run each simulation three times:

1) with the normal degree of substitution described above and latent technologies (allowing the switching from dirty to clean technologies),
2) with latent technologies but without substitution neither

[2]We are developing a more recent SAM to update the calibration of the model.

TABLE I
ARGENTINA'S CO2EQ EMISSIONS [9]

Energy (S2)	148755
Fossil Fuels (S2, S4)	40620
Manufactures (S3)	20313
Transport (S5)	39485
Others (S1, S6, HH)	36210
Fugitive Emissions (S2)	12128
Industry (S3)	16514
Agriculture + LULUCF (S1)	113953
Waste (S1, S2, S3, HH)	19714
Total	298935

Notes: HH refers to CO2 emissions related to the private consumption of households. The CO2 emissions related to (S...) concern intermediate consumption and value added generated in sector, and the intermediate consumption of domestic and imported energy.

on the demand nor on the supply side (i.e., all Leontief functions), and finally,

3) without latent technologies nor substitution.

The CO2 emission indexes computed in 2) and 3) are corrected by the scale of the GDP from 1). Then the difference between the values of this index in 1) and 2) allows isolating the composition effect, and between 2) and 3) computes the technique effect. Finally, the scale effect is represented by the index growth under 3). This ex-post computation of the three effects is possible since all functions in the model are homothetic.

B. Scenarios

We simulate two possible scenarios of the plurilateral trade liberalization on EGS.

The first one considers the increase in world prices of EGS as a consequence of the tariff reduction on these products in the 17 countries which are negotiating the EGA and which concentrate more than 70% of the EGS trade in the world. Since the tariffs on EGS are currently low in the concerning countries, we assume a shock of 5% in the EGS international price.

The second scenario assumes that all countries, including Argentina, are part of the plurilateral EGA. Consequently, we add the tariffs elimination on EGS in this Latin American country to the previous increase in the world price of EGS. Tariffs are relatively high on manufactures compared to other sectors in Argentina (Table II). These patterns of protection provide us an idea of the potential changes in relative prices.

According to the sectors details in the SAMs of this country and based on the contribution of each sector in the global carbon emissions, we assume that EGS are exclusively industrial goods and other services, such as those including in the APEC list. However, we admit that our sectors aggregation does not allow for a fine detail in order to isolate completely 'clean' products from those which pollute, thus the industrial sector is not excluded as carbon emitter as a whole (Table I).

Finally, it is important to note that those shocks affects relative prices between domestic and foreign goods, affecting the household consumption decisions, the purchasing of capital goods for investment and the intermediate consumption of firms, as well production and export decisions of domestic sectors.

TABLE II
AD-VALOREM TARIFFS (SIMPLE AVERAGE) IN ARGENTINA BY PRODUCT AND USE [10]

	Inputs	Final goods	Investment goods
S1	3.60%	25.14%	9.94%
S2	0.15%	-	-
S3	-	28.00%	14.94%
S4	-	-	-
S5	-	-	-
S6	-	23.20%	-

TABLE III
ECONOMIC AND CO2 EMISSIONS (3 EFFECTS DECOMPOSITION) RESULTS FOR ARGENTINA UNDER THE EGA SCENARIOS

	EGS17	EGS20
GDP at market prices	3.60	5.71
Real Exports	13.99	18.84
Real Imports	7.45	10.90
Households' welfare (average)	2.76	4.82
Unemployment (average)	9.81	9.01
CO2 Emission index	101.82	103.84
Scale Effect	6.58	8.58
Composition Effect	-2.31	-2.51
Technical Effect	-2.45	-2.24
CO2 Emission Kutznetz index	98.29	98.24

Note: In the Baseline the unemployment rates is 10.2 in Argentina according to the calibration data taken for the country. 'EGA 17' denotes the scenario of EGS trade liberalization in the 17 countries of the current plurilateral negotiations and the 'EGA 20' considers also Argentina tariff cut on EGS.

III. PRELIMINARY RESULTS OF THE EGA SCENARIOS

We analyze the results of the two EGA scenarios, with (EGA 20) and without (EGA 17) the active participation of Argentina on tariff cuts in EGS. Even though we present some selected and aggregated indicators, more detailed information at the sector level (level of activity, intermediate consumption, etc.), at the factor level or for poor/rich households, is available and can be provided upon request.

The increase in the international world prices of EGS as a consequence of the tariff cuts in the 17 countries concerned by the plurilateral EGS negotiation (EGA 17) increases the real trade and the GDP in Argentina. These results reduces the unemployment rate (initially at 10.2%) and increase households welfare particularly due to the improvement in either capital profits and wages (Table III, column (a)).

Unfortunately, carbon emissions increase in this country; however, the results in terms of the scale on a side, and technique and composition effects on the other go in opposite directions. The composition and technique effects in Argentina shows an reduction in terms of total carbon emissions, which are not enough to compensate the positive scale effect. But they show that the change in relative prices induces substitution in demand from high to low carbon intensive goods as well as the switch from a dirty to a clean technology

TABLE IV
SENSITIVITY TO NOMINAL RIGIDITIES IN WAGES AND GREATER CAPITAL MOBILITY ACROSS SECTORS

	Constant Nominal Wages		Higher Capital Mobility	
	EGS17	EG20	EGS17	EG20
	(a)	(b)	(c)	(d)
GDP at market prices	18.15	18.95	2.02	3.76
Real Exports	38.48	41.30	9.34	13.01
Real Imports	25.81	27.83	6.26	9.18
Households' welfare (average)	15.28	16.34	1.96	3.81
Unemployment (average)	4.85	4.38	10.11	9.38
CO2 Emission index	112.93	114.19	97.98	99.69
Scale Effect	17.38	18.15	5.00	6.65
Composition Effect	-3.98	-4.39	-5.36	-5.51
Technical Effect	-0.48	0.43	-1.66	-1.45
CO2 Emission Kutznetz index	95.58	96.00	96.04	96.08

Note: Results with constant nominal wages considers the same degree of intersectoral capital mobility as results in Table III, and the results assuming a greater capital mobility across sectors considers that real wages remain constant as in Table III.

in production. These results are coherent with the change in the Kuznets index of emissions that shows Argentina become less carbon-intensive as a whole.

If Argentina also decides to eliminate tariff on EGS imports (EGA 20), the gains in terms of GDP, trade and households' welfare become greater. This improvement in the level of national activity also reduce even more the unemployment rate when assuming indexed wages (Table III, column (b)). Nevertheless, the indicator of total emissions deteriorates, particularly explained by a greater scale effect. The scale effect is even greater is not once again compensated by the composition and technique effects. Even though, the increase in total emissions is greater, Argentina becomes a less carbon-intensive economy.

Now, we evaluate the sensitivity of the results when capital mobility is greater across sectors in Argentina (Table III, columns (c) and (d)).

A more flexible capital allocation across sector in Argentina improves slightly reduce the impact on macroeconomic indicators because of the indexation of wages more than the consumption price index, but improve environmental results. While GDP, trade and households' welfare increase less when capital mobility increase, the unemployment rate remains at the same levels at before. The total carbon emissions reduce (the scale effect is more than compensated by the composition and the technique effects) and the carbon intensity, measured by the Kuznets index, also falls. This appears as the best situation for the whole Argentinean economy when an EGA is signed. However, the real situation of Argentina does not show that half of capital is mobile across sectors, but less of that.

In short we can say that, even when the implementation of the EGA (either EGA 17 or EGA 20) increases total carbon emissions while reducing unemployment in Argentina assuming low capital mobility across sectors, these trade liberalization scenarios of EGS allow reducing its carbon intensity. Nevertheless, when capital mobility across sectors becomes greater, the EGA becomes compatible scenarios of GDP growth, welfare improvement for households and lower carbon emissions.

Sometimes, policies are designed for some countries and under some particular functioning assumptions of the factors markets which are not necessarily reproduced in every economy of the world [10], [11]. Here, we have evaluated two possible degrees of capital mobility in Argentina when facing the EGA plurilateral negotiations, and found that: the greater the capital mobility across sectors, the lower carbon emissions when allowing the shifting to a cleaner technology of production.

IV. CONCLUSION

Given the discouraging results of the literature about the environmental impacts of an EGA, we have allowed for the implementation of alternative cleaner technologies in production and a greater substitution in consumption between dirty and EGS, in order to have a better representation of this agreement on carbon emissions, particularly for developing countries.

We have developed a CGE model with latent technologies and we have illustrate the EGA scenarios for Argentina, which is a middle-income country with a great potential to increase EGS trade and a sustainable growth.

Results shows that the active participation of Argentina in the EGA allows for a greater GDP, trade and welfare and a lower unemployment rate. However, total carbon emissions increase but showing important negative composition and technique effects. The latter intensify and more than compensate the positive scale effect when a greater capital mobility across sectors is allowed. This evidence is also supported by [12].

Finally, we have found that an improved modeling of technological transmission through trade (and even through FDI) could provide a better representation of potential environmental impacts of the EGA, particularly for developing countries concerned in the negotiations.

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