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Agricultural Subsidies in the Economy of Ecuador – An Assessment of Impact Through CGE Modelling

Student: Gabriela GARCÍA MERCHÁN

Supervisor: Patrick TOMBERGER, PhD

DECLARATION

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31 January 2023, Geneva, Switzerland.

Gabriela García Merchán

ABSTRACT

Many countries use agricultural subsidies to support their farmers, with the aim of fostering the rural economy, supplementing farm income, increasing productivity, and many other aims. However, different types of subsidies have diverse effects, and certain types can have a detrimental impact on the economy, on international trade, as well as on the environment.

Numerous researchers and international organizations have made recommendations on how to reform agricultural support in order to curtail or eliminate these adverse effects. Often, different types of minimally distorting "green box" subsidies are suggested as an alternative to highly distorting, environmentally adverse "amber box" subsidies.

Using the power of Computable General Equilibrium (CGE), we construct a model of the economy of Ecuador, which we use to simulate the alternate application of two different types of subsidies. We then analyze and compare the effects that each of them has on agricultural production activities, on the production factors, on agricultural output, on the income of farmers' households, on foreign trade, and on GDP, taking into consideration the specific characteristics of Ecuador's agricultural economy and subsidy structure, as well as the limitations of the model.

In Scenario 1, three types of subsidies (output, input and land factor subsidies) are provided at a level corresponding to a weighted average of all OECD countries. This experiment produced mixed effects in terms of prices and output, depending on the specific sector. It also produced negative effects on the trade balance, but gave positive results for GDP and farm income. The subsidy with the strongest effect was the land factor subsidy.

In Scenario 2, the target was the level of farm income produced by the subsidies in Scenario 1, but only through green box subsidies, specifically decoupled land payments. Direct payments were not the most economically efficient, causing important decreases in allocative efficiency and national GDP. On the other hand, price and output effects were also more generally positive, with increase of exports and improvement of the trade balance.

Targeting of subsidies to small and medium producers is recommended.

TABLE OF CONTENTS

1. INTRODUCTION

Agriculture is an essential productive activity. There are over 3,4 billion people in the world who live in a rural environment (World Bank, 2023b), and whose livelihoods revolve around agriculture. Ecuador is not an exception, with a rural population estimated at more than 6,3 million people, over a third of the entire country (World Bank, 2023a), and an economy still strongly centered in agriculture.

Agriculture and agricultural trade have never been an easy business: on top of the inherent difficulties and risks of growing food, agricultural producers and exporters in developing countries have always, to varying degrees, been affected by lack of legal security in land ownership, lack of financing, insufficient technical assistance, inadequate infrastructure, price volatility, tariff protectionism, non-tariff barriers, etc.

But the challenges for agriculture in today's world are perhaps the greatest that mankind has ever faced, particularly when it comes to climate change: all over the planet, weather patterns are rapidly shifting, fields are being wiped out by extreme weather events, staple crops are no longer dependable, and nutritious foods are becoming unavailable or unaffordable.

In 2020, up to 811 million people in the world faced chronic hunger and nearly one in three people in the world (2,37 billion) did not have year-round access to adequate food. In 2019, around three billion people, across every region of the world, could not afford a healthy diet (FAO, UNDP and UNEP, 2021).

Although different regions of the world will experience climate change differently, its effects are projected to grow worse for everyone: crop diseases and pest infestations are expected to increase, aquifers are expected to run dry, and in general more frequent and severe weather events will cause food insecurity (McCormack, 2021). The COVID-19 pandemic and the Russian war in Ukraine have further disrupted global production and distribution of food.

Developing countries, in particular low-income countries and small economies, are already the ones most affected by the interplay of these global crises. Poor consumers are particularly vulnerable, even in middle-income and net-food-exporting countries like Ecuador[1].

[1] Ecuador has also been among the countries suffering from the world shortage of wheat. The country imports more than 98% of its internal wheat requirements (Holguín Burgos & Aguayo Alvarado, 2017), which in 2021 came to 1,5 million tons, worth USD 499 million, mostly from Canada (USD 381 million), followed by the US,

In the face of all these mounting difficulties, it is imperative for governments to choose the best policy instruments to support and foster the agricultural sector. After all, agriculture is not only central for ensuring food security, but with the right policies it has the potential to promote economic development and poverty reduction, for example by progressing to higher value-added agriculture, bringing non-agricultural activities and employment to the rural environment, tapping into the value of environmental services provided by agricultural producers, and providing education and opportunities for some of those who work in agriculture to move to industries and services (World Bank, 2007).

For many decades, subsidies have been an important tool for governments to support agriculture, in both developed and developing countries. Nonetheless, most forms of subsidization, however effective they may be to stimulate agricultural production, also generate negative effects, not only for the economy but also for world trade and for the environment, by encouraging unsustainable uses of natural resources, as researchers have been pointing out with increasing emphasis in the last few years. One remarkable study in this sense is the joint report that was published in 2021 by FAO, UNDP and UNEP, titled "*A multi-billion-dollar opportunity: Repurposing agricultural support to transform food systems*" (FAO, UNDP and UNEP, 2021), which will be referenced further in this work.

With regard to world trade, agricultural subsidies have contributed to creating an uneven playing field, as developing countries cannot afford to pay subsidies to their farmers in the same proportion as their developed counterparts, and thus lose export competitiveness compared to richer countries (Torayeh, 2011).

Simply removing agricultural support is not a realistic answer, as it may carry important adverse effects. Trade distortions would be minimized, and emission of greenhouse gases (GHG) would be reduced by millions of tons, but crop and livestock production, as well as agricultural employment, would also decrease, particularly in emerging economies. Consumers would be impacted with higher food prices, and the income of rural families that live off of agriculture would be reduced, thus sinking families in developing countries into extreme poverty (FAO, UNDP and UNEP, 2021).

Argentina and Ukraine (Ministerio de Agricultura y Ganadería del Ecuador, 2021a), making Ecuador the 9th largest wheat importer in the world (World Integrated Trade Solution, 2023).

Supporting agricultural producers will remain high on the list of goals for governments, both developing and developed, but as FAO, UNDP and UNEP highlight in their joint report, subsidies should be *redesigned* and *repurposed* in a way that not only minimizes their economic inefficiency and trade distortion potential, but also reduces and mitigates the environmental impacts of farming. And all without sacrificing the poor farmers of the world.

The United Nations (UN) specialized agencies mentioned above, as well as many other researchers, such as Mosquera (2018) and McCormack (2021), suggest reorienting support, through gradual, balanced curbing and reduction of those subsidies that have proved harmful, while repurposing that support to prioritize sustainable practices and minimally distorting support, such as investment in public goods and services, infrastructure, and innovation.

When it comes to agriculture, Ecuador resembles many other developing countries: it needs to foster its agricultural sector, not only to ensure food security but also because its economy still depends heavily on agricultural exports; and it also needs to support its farmers, who are for the most part poor and disadvantaged. It is therefore paramount for the country to know what type of support constitutes the best policy alternatives, given the characteristics of the national economy, with a view to ending rural poverty and hunger, and reducing inequality while promoting sustainable agriculture and food sovereignty.

In this context, I would like to find out which target level of income Ecuador should aim to provide to farmers, and what would be the beneficial or harmful effects to different agricultural sectors and to the economy of Ecuador in general, depending on what type of subsidy is used to provide this level of income.

For this task, we will use Computable General Equilibrium (CGE) analysis, in order to simulate the implementation of two different types of agricultural support policies, and evaluate the advantages and drawbacks of each.

1.1. Scope of the study

In Part I, we will review a few fundamental characteristics of agricultural subsidies, and we will examine some of the challenges that they create. We will also become acquainted with Ecuador's economy, in order to set the stage for the simulations that will be conducted in the second part. In Part II, we will provide a basic introduction to CGE modelling, and we will create a model of the economy of Ecuador, that we will use to conduct two experiments with the structure of agricultural subsidies.

For our first experiment, we will simulate that Ecuador gives agricultural support to a level similar to OECD countries, through the three most common types of subsidies: output subsidies, factor subsidies, and intermediate input subsidies. Then for our second experiment, we will replace these subsidies with direct payments to land.

We will then examine the results of our simulations, and assess the impact of these two different policy options on our model economy of Ecuador: we will look at how they affect production in agriculture and other sectors, the income of farmer households, the factor market, trade, and GDP, in order to answer the question "Which type of subsidy allows us to increase farm income, while giving the best overall outcome in our model economy of Ecuador?"

For this purpose, the CGE model I will use is the one created by the Global Trade Analysis Project (GTAP), specifically the GTAP-AGR modification developed by Roman M. Keeney and Thomas Hertel (Keeney & Hertel, 2005), in order to simulate and analyze the different scenarios described above.

As I will explain in detail, a CGE model is suitable for this type of analysis of different types of subsidies as instruments of governmental support for agriculture, as it takes fully into account the complexity of economic relations, by keeping track of the linkages between all economic agents withing an economy, and between all economies in the model.

1.2. Literature review

Abundant research has been conducted on the positive and negative effects of different subsidies on the economy of different countries, and numerous studies have been conducted on agricultural subsidies using CGE modeling.

Many studies focus on EU countries. Burfisher et al. (2002) use a multi-country CGE model to analyze the effects of agricultural policy reform in three OECD members, namely the United States (US), the European Union (EU), and Japan, in order to find out how domestic support reform in one country affects its trade partners (Burfisher et al., 2002). The study includes all types of subsidies provided in the three countries.

On the other hand, Křístková and Habrychová (2011) concentrate only on direct payments to agriculture, and their impact on only one national economy (Czech Republic). This study uses CGE modeling to simulate both an increase and a complete withdrawal of direct payments, finding that in general these subsidies have a positive effect on the economy (Křístková & Habrychová, 2011). The paper also looks especially at the impact of direct payments on farmer income, as I will be doing in the present work.

Other researchers give their attention to developing countries. Boccanfuso and Savard (2007) develop a country-specific CGE model for Mali, in order to examine how the elimination of cotton subsidies in developed countries would cause poverty in this African country to decrease considerably, even if other agricultural subsidies stay in place (Boccanfuso & Savard, 2007).

Dixon et al. (2016) create a CGE model of India, and simulate removing current agricultural subsidies in that country, and replacing them by other types of support, which results in positive effects on real farm income, and small impacts on welfare and GDP (Dixon et al., 2016).

Nonetheless, I find no such analysis centering on the particular case of agricultural subsidies in Ecuador. While recent studies have looked at *fuel* subsidies in Ecuador (Jara et al., 2018), and one has also applied a CGE model (Montenegro & Ramirez-Alvarez, 2022), I have been able to find no such research regarding agricultural subsidies.

The FAO, UNDP and UNEP joint report about agricultural support reform (FAO, UNDP and UNEP, 2021), which we will come back to in this work, also uses CGE methodology to study the effects of restructuring agricultural support, but it’s a fundamentally different experiment in many ways:

In the first place, it was not focused on any country in particular, which has the disadvantage of arriving at conclusions that may be too general, and therefore imprecise when applied to Ecuador, or any other specific country.

Secondly, the policy shock they chose to simulate is the complete withdrawal of all current protections to agriculture; the reallocation of those funds to the recommended policies was not modeled. Hence, their assessment of the beneficial impacts and opportunities that would come from repurposing current support was only based on individual country experiences, which is merely anecdotal.

Finally, the experiment is modeled in a different framework, which is reflected in the way they define and categorize support. Their description of what is considered agricultural support for the purposes of their study, includes all policies that in one way or another protect domestic agriculture. This comprises border import measures, such as tariffs and tariff-rate quotas, along with export bans, export subsidies, and market price regulations, and also proper subsidies, which are termed "*fiscal* subsidies". Practically only services are left outside what they count as "support".

Their results are nonetheless very interesting, since they include the effects of removing agricultural domestic support, market access restrictions *and* export subsidies, along with quantitative restrictions to trade, therefore showing something very close to what a truly free market might look like.

In contrast, the scope of the present study is more specifically focused on subsidies; from the point of view of this work, tariffs, quantitative restrictions and subsidies are all very different measures. Therefore, the experiments carried out for this work will not include any import or export restrictions.

But before we approach our model and our simulations, let us review some basic notions about the subsidies used in agriculture, which will be referred to extensively throughout this work.

PART I

2. AGRICULTURAL SUBSIDIES: KEY CONCEPTS

Taxes impose a burden on the private sector; subsidies impose a burden on the government, and indirectly on the taxpayers.

Subsidies can increase or lower the prices of goods, acting as a "wedge" between buyers and sellers, or they can transfer resources directly into households, affecting their level of income, and therefore their levels of consumption, savings, and taxes (Burfisher, 2016).

When governments provide subsidies, they create an impact on the economy. When they are given to farmers, subsidies can affect employment and income-generating opportunities, and they can influence decisions regarding the choice of crop to invest in, as well as production practices, input use, and markets (Burfisher, 2016). Subsidies can also affect the optimal utilization of resources in producing agricultural goods (Torayeh, 2011), since they tend to discourage farmers from making production decisions based on efficiency considerations (FAO, UNDP and UNEP, 2021).

To support their farmers, governments have at their disposal an array of instruments and incentives, direct and indirect, which can be applied in different combinations and result in a particular level of transfer of resources to producers and households. In fact, WTO Members' domestic support notifications show us that numerous governments, within their capabilities, provide farmers with various subsidies that complement one another.

Table 1 shows different types of subsidies that can have an impact on agricultural production:

Subsidy	Example
Export subsidies	When agricultural producers receive government aid contingent on whether their crops are being exported
Production subsidies	When farmers receive support based on the production of certain crops, or of a target output of a product
Purchase / input subsidies	When agricultural producers receive a rebate for purchasing certain domestic or imported intermediate inputs
Factor use subsidies	When landowners receive support based on the size of their land, provided it is being used for farming
Income subsidies	When families at certain lower levels of annual income, receive a bonus from the government to help them to cover their expenses

Table 1. Types of subsidies (Burfisher, 2016).

Different types of subsidies can have different effects. Generally speaking, factor use subsidies, input subsidies and production subsidies can be very similar, in terms of their effects: decreasing the cost of production, which results in a lower market price for consumers, a higher after-tax price for farmers, and an increase in the quantity of supply and demand (Burfisher, 2016).

Income subsidies, on the other hand, do not alter relative market prices because they are not linked directly to specific goods, so they are generally less distorting with regard to production and consumption decisions, and therefore more economically efficient (Burfisher, 2016).

Let us look in more detail at some of the effects that agricultural subsidies can have, both on world trade in agricultural products, and on the environment.

2.1. Agricultural subsidies in international trade

In order to understand the different types of subsidies that governments provide and their impact with regard to international agricultural trade, the framework provided by the WTO is a useful tool, specifically the subsidy rules in its Agreement on Agriculture (AoA) (World Trade Organization, 2016).

The AoA differentiates agricultural government support instruments according to their effects on production and trade.

WTO Members commonly use an informal system of classification based on different colored "boxes", amber, blue and green, depending on whether subsidies are *coupled* or *decoupled*, and how much they distort trade and production. A subsidy is considered coupled when it is related to the production or the price levels; it is decoupled, or delinked, when it is not even necessary for farmers to produce anything in order to obtain the subsidy. Only the subsidies that fit the criteria of the "green box" are considered to be decoupled, and therefore to be minimally distortive (World Trade Organization, 2016).

"Amber box" policies are those that directly subsidize production and therefore influence production decisions. According to the AoA, they are submitted to limitations and reduction commitments, and were supposed to be eventually eliminated.

Under WTO rules, all developed Member countries, as well as some developing Members[2], have the right to provide trade-distorting subsidies, up to a certain bound level. This margin of allowed distorting domestic support is known as the Aggregate Measure of Support (AMS).

Developing countries, for the most part, can only provide subsidies in general up to the level called *de minimis*, that is, up to a maximum of 10% of the value of production (8.5% for China, as part of its accession commitments). The AMS and *de minimis* support constitute the amber box.

<u>"Blue box" policies</u> are also linked to production but are allowed because they are granted pursuant to supply constraints, which minimizes their trade distorting effect.

Blue box subsidies are basically distorting; that is, they would normally go in the amber box and should be accounted for within the limits of the AMS or *de minimis* rights. However, the AoA allows the placement of certain subsidies in the blue box when said the rules compel the farmer who receives them to limit their production.

Blue box subsidies are not in themselves subject to limitations. Nonetheless, they are part of what is known as the Overall Trade-distorting Domestic Support (Base OTDS)[3], which is subject to reduction in WTO agricultural negotiations.

<u>"Green box" policies</u> are those assumed to be minimally trade-distorting. The green box category includes certain types of subsidies that are generally understood to generate minimal market distortion, because they are decoupled from the results of agricultural production.

There are mainly two types:

a) General agricultural services which benefit farmers collectively, such as agricultural infrastructures, research, disaster prevention, phytosanitary assistance, etc., and

b) Direct payments and decoupled income support to farmers, who receive payments without any obligation to produce anything[4]. They must be delinked from any requirement regarding types or quantities of output produced by the farmer[5].

[2] Argentina, Brazil, Colombia, Costa Rica, Israel, Jordan, South Korea, North Macedonia, Mexico, Morocco, Moldavia, Papua New Guinea, Saudi Arabia, South Africa, Thailand, Tunisia, Venezuela and Vietnam.

[3] The Base OTDS also includes the final bound total AMS commitment, and *de minimis* specific and non-product specific subsidies.

Green box subsidies are also unconstrained by any limitations, as long as the support programs fit the criteria contained in Annex 2 of the AoA.

The last category of subsidies in the WTO is the "development box", which allows developing countries to provide subsidies for agricultural inputs, for investment and for the replacement of illicit crops (destined to the manufacture of narcotics), and only for low-income or resource-poor producers. Development box policies are not subject to limitations, and are an example of the WTO's special and differential treatment for developing countries.

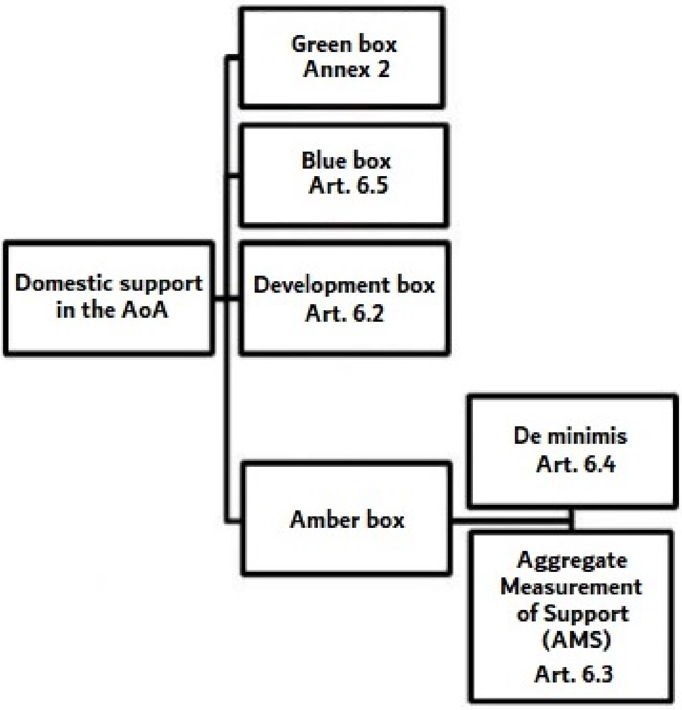

Figure 1. Agricultural support in the AoA (World Trade Organization, 2016).

[4] Direct payments like these existed in the US from 1996 to 2014, when they were brought to an end by the 2014 Farm Bill (U. S. Government Accountability Office, 2012). In the EU, they have been in place since 2005, as one of the financial support mechanisms available under the Common Agricultural Policy (CAP), and they are slated for increase starting in 2023 (European Commission. Directorate-General for Agriculture and Rural Development, 2022).

[5] In the EU, direct payments are also linked to compliance with environmental regulations, as well as plant health and animal health and welfare regulations (Commission Delegated Regulation (EU) No 640/2014, 2021).

On the subject of direct payments, it is important to highlight that there are differing points of view in literature, specifically with regard to whether they constitute a factor subsidy, or rather a direct monetary transfer to farmers (Křístková & Habrychová, 2011).

Burfisher (2016) considers that direct payments based on land area, even when de-linked from production and therefore compatible with the green box, are still a kind of factor use subsidy, and even if they are decoupled from production decisions, in general they do have the effect of encouraging the use of the subsidized factor beyond its most efficient level of employment (Burfisher, 2016).

The FAO, UNDP and UNEP report also considers direct payments to land to be a type of factor subsidy, and therefore they are included as a fiscal subsidy in their classification, along with output and input subsidies (FAO, UNDP and UNEP, 2021).

On the other hand, the WTO places support provided through direct payments to producers and decoupled income support, squarely within the green box, establishing that they are minimally trade- and production-distorting, provided that they are not in any way related to any specific type or volume of production, or to any requirement to produce (World Trade Organization, 2016).

Many researchers have highlighted the important role that direct payments have had in alleviating rural poverty, and numerous studies confirm the link between direct payments and the socioeconomic sustainability of rural regions (Morkunas & Labukas, 2020). Direct payments also contribute to environmental sustainability, as they encourage farmers to prefer organic farming, and have a positive impact on adaptiveness and resilience, helping farms to stay in business in the event of unfavorable conditions. (Morkunas & Labukas, 2020)

Compared to input or output subsidies, direct payments do in fact have less potential to distort prices and production, while offering an additional safety net for rural households, providing income stability, protecting against agricultural price fluctuations, and ensuring the economic viability of farms (Volkov et al., 2019). Direct payments also compensate farmers for the environmental public goods and services they provide, which are otherwise not remunerated by the market (European Parliament, 2022). They are an important tool to help maintain the income of farmers at a level comparable to other economic sectors (Morkunas &

Labukas, 2020) as even in developed countries the income of agricultural workers tends to be below the average for other sectors of the economy[6].

During the Uruguay Round, the AoA was negotiated with a view to establishing limits for trade-distorting agricultural domestic support; however, the limitations were modest in comparison with the expectations of many developing countries, as developed countries were able to continue subsidizing close to 80% of the volume of products that received support before the creation of the WTO (Maiguashca, 2021).

Nowadays certain countries continue to provide farmers with massive amounts of subsidies that have a distorting effect on trade and depress world prices, especially when highly concentrated on specific crops, while most developing countries cannot afford to support their farmers to the same extent, and thus lose export competitiveness (Torayeh, 2011).

According to the 2021 Agricultural Policy Monitoring and Evaluation report of the Organization for Economic Co-operation and Development (OECD), agricultural support in the 54 countries covered came to USD 720 billion on average per year, in the period 2018–2020 (OECD, 2021).

The support afforded to agriculture in Ecuador, as we will see in more detail, is substantially inferior to the level provided by OECD countries to their corresponding agricultural sectors. This is a reality to which Ecuador and other developing countries have needed to adjust, as it is not possible to compete, in terms of fiscal transfers, with such high levels of support.

Since the creation of the WTO, some countries and blocks have undertaken some measure of reform of their agricultural subsidies. Major agricultural producers, like the US and the EU, in the successive iterations of the Farm Bill and the CAP, respectively, have changed the structure of their agricultural support, in order to move resources from amber box subsidies towards green box instruments, which can be provided with no limitations. In the US, green box subsidies increased from 46 billion to 120 billion from 1995 to 2010, while in the EU they went from 9,2 billion to 68 billion euro in the same period, effectively replacing most of amber and blue subsidies previously provided in these countries (Betge, 2016).

[6] In 2020, US farmworkers earned only USD 14,62 per hour on average, just under 60% of what comparable workers outside of agriculture earned (Costa, 2021). In 2016, EU farmworkers earned on average 40,6% of the wages in the wider economy (European Commission. Directorate-General for Agriculture and Rural Development, 2022).

Other developed countries, as well as many developing ones, still rely heavily on amber box support for their agriculture, sometimes in combination with blue box support. In particular, the last decade has seen the rise of China and India as significant providers of amber box support for their enormous volumes of production, to the point where nowadays the EU, the US, India and China together account for approximately 3/4 of all trade-distorting support, according to WTO rules (Glauber et al., 2020).

In this context, statistical data cited by Torayeh (2011) reveals that between 1995 and 2005 the gains from reducing trade-distorting agricultural subsidies in the EU and the US were much less than anticipated, as the share of developing countries in world agricultural exports increased only marginally by 2,6%.

At the heart of the AoA there is a mandate for WTO Members to continue reforming the rules regarding agricultural domestic support, towards further limiting the distorting effects of excessive subsidization on the world market. Nonetheless, the WTO agricultural negotiations have encountered limited success. Their last important result was achieved during the Nairobi Ministerial Conference of 2015, namely the commitment by all WTO Members to eliminate export subsidies, but it failed to produce the expected effects. Elimination of export subsidies brought only slight benefit for developing countries, mainly due to the fact that it is not export subsidies, but output and input subsidies, that are the main source of distortion (Torayeh, 2011). Another factor in the limited success of the elimination of export subsidies is the narrow scope of the Nairobi Ministerial Decision, targeting mainly direct export subsidies and leaving out indirect export subsidies such as food aid, which also often undermine producers in recipient countries. As Torayeh (2011) points out, the definition of export subsidies in the GATT 1994 is restrictive.

2.2. Agricultural subsidies and the environment

Agriculture takes up 40% of the Earth's land surface and uses 70% of the freshwater available (Mosquera, 2018). And, according to the joint report published in 2021 by FAO, UNDP and UNEP, most of the subsidies given to farmers nowadays negatively influence access to, and control of, land and water sources, and encourage an unsustainable use of those natural resources (FAO, UNDP and UNEP, 2021).

The joint report shows that agricultural support provided through fiscal subsidies worldwide comes to about USD 245 billion[7] (FAO, UNDP and UNEP, 2021) and, according to the report, most of it is used in a way that is degrading the environment, adding to the emission of GHG and thereby by reinforcing the current climate crisis.

This is especially true of the support for animal agriculture. It has been known for many years that the amount of GHG emissions that animal agriculture produces is comparable to all the world's modes of transportation combined. The first UN report to shed light on this issue was FAO's report "Livestock's long shadow", from 2006 (Food and Agriculture Organization of the United Nations (FAO), 2006), which showed that intensive animal farming is responsible for approximately 7.1 Gt CO_2eq per year; that is close to 14,5% of world emissions of GHG such as CO_2, as well as methane and nitrous oxide. Crop production also produces GHG, mainly through fertilization with manure and ammonia, but in a smaller scale[8].

Dairy and meat, the most emission-intensive industries, receive the most support in developed countries and, as meat and dairy consumption are expected to rise globally by 76% and 64% respectively in the next 30 years (FAO, UNDP and UNEP, 2021), dealing with such a large contributor of GHG emissions is imperative to curbing climate change.

It is important to underline that, aside from the emission of GHG, there are many other negative environmental consequences of unsustainable agricultural practices and the subsidies that support them, such as excess energy consumption, deforestation and desertification through soil erosion, as well as water and air pollution (McCormack, 2021). Subsidies can also create incentives for land use change, and in that way can have repercussions on the conservation of natural landscapes and resources, and can drive the loss of species, soils, forests and aquatic ecosystems (WWF, 2022).

An example of how subsidies create hidden costs to society and to the environment, is the production of corn in the US. The US Department of Agriculture (USDA) spends over USD 20 billion a year on farming subsidies, which go mostly to protect wheat, soybean, cotton,

[7] Almost 60 percent of the total fiscal subsidies, or USD 142 billion, are subsidies based on factors of production, more than half of which (USD 73 billion) are coupled subsidies, meaning they are given conditional to production of certain crops. Another USD 69 billion are farming subsidies decoupled from the production of any given commodity. Currently this type of subsidy accounts for 30 percent of all fiscal subsidies worldwide (FAO, UNDP and UNEP, 2021).

[8] Recent studies estimate that the whole supply chain of nitrogen-based synthetic fertilizers, from sourcing to final use, was responsible for around 10.6% of agricultural emissions, which is only 2.1% of global GHG emissions (Menegat et al., 2022).

and corn. Corn uses more fertilizer and water than other crops; nowadays the area used to grow corn in the US is the size of California. Corn has a very high yield compared to other crops, but 40% of production ends up used in biofuels, and 36% in animal feed. Only the remaining 14% ends up processed into foods, but mostly unhealthy, such as high-fructose corn syrup and vegetable hydrogenated fats (Mosquera, 2018).

This is a clearly inefficient and energy-intensive use of a food crop, an especially important issue nowadays with the growing global population and the food shortages projected for the future. Subsidies for corn and wheat make certain foods cheaper for families, but as we can see these are mostly unhealthy foods, while the production of more varied and nutritious foods, such as vegetables and fruit, receives no incentive.

In this way, subsidies that encourage environmental degradation are contributing to future food insecurity and hunger for millions through a vicious cycle, where the only way to keep producing enough food with dwindling and depleted natural resources, is with ever more intensive methods of agricultural production.

Furthermore, while climate change affects all humanity, it is the more vulnerable agricultural producers in developing countries that suffer the effects more intensely, such as extreme heat and drought, floods, and proliferation of pests, in the form of devastating plagues of insects and fungal or microbial diseases.

It is imperative that we look at all the factors and all areas of human activity that intervene to exacerbate climate change, and this includes the agricultural practices that contribute to it. At the same time, the disastrous experiment of Sri Lanka with organic agriculture shows us that it is also vital that policies aimed at fighting climate change do not jeopardize the agricultural productivity we need to feed the growing population of the world.

2.3. How to reform agricultural support?

Agricultural subsidies are always a touchy political issue, especially when recipients of support view it as “acquired rights”, and reform is a challenging task, but, given the negative effects we have discussed, sooner or later it will become unavoidable for governments to undertake it.

Numerous researchers have proposed different alternatives to reform the most harmful types of agricultural support. In general, it is considered a fact that some forms of subsidization are more detrimental than others, and some can actually have beneficial effects.

One alternative to reduce the detrimental effects of highly distorting subsidies is to provide them in a targeted manner, so that they are focused on small farming businesses. Citing the example of crop insurance support in the US, Mosquera (2018) affirms that 4% of farmers, the largest landowners, take over 30% of the benefit. These larger farms are "in a better position to pay higher premiums than smaller farms, as signaled by higher annual gross sales, higher return on equity, and higher ability to service debt", and would continue to be profitable even if they received limited amounts (Mosquera, 2018).

For example, governments could provide low-interest loans to farmers for buying agricultural land, as long as the property meets a maximum size requirement. Subsidies could be used to motivate small farmers to acquire new technology that helps make their activities more environmentally friendly (Mosquera, 2018).

Another policy suggestion is to eliminate or reduce specifically certain subsidies that animal agriculture receives. Current crop insurance schemes and disaster relief programs may well be de-linked from production and in that way are not trade-distorting, but they do tend to isolate animal agriculture from the consequences of the natural disasters caused by climate change. For animal agriculture to assume the cost of the environmental externalities caused by their activities, it should not be supported by taxpayers through subsidies (McCormack, 2021).

This could also have the effect of making animal agriculture less profitable for farmers, therefore incentivizing the production of healthier food crops, which could reduce emissions by 80% according to certain estimates (McCormack, 2021). Redesigned subsidies could also, in the long run, also incentivize consumers to opt for healthier, plant-based foods with a lower environmental impact (Mosquera, 2018).

The joint report by FAO, UNEP and UNDP suggests a more uncompromising approach, and recommends that the most harmful types of subsidies are phased out, and converted into entirely different subsidies, that are delinked from production decisions and from the use of specific factors of production.

According to the report, public funds currently provided through these types of subsidies should only be channeled through the following two kinds of support:

-General sector services and public goods, such as research, training, technical assistance, inspection, safety and quality control services, infrastructure (roads, irrigation, electrification, storage), public stockholding, marketing, and trade promotion.

-Cash transfers and food subsidies for poor households and vulnerable groups, including smallholders and women-led farms.

This kind of support is also beneficial to producers, but, as the report points out, the benefits can take longer to materialize than with fiscal subsidies (FAO, UNDP and UNEP, 2021).

As we detailed earlier when discussing how the WTO views agricultural support, subsidies such as these would fit into the green box category of domestic support, as they are decoupled from agricultural production decisions and therefore have reduced potential for distortion.

As we have seen above, different types of green box subsidies are often recommended as an alternative to highly distorting, environmentally adverse amber box subsidies. In the context of the agricultural negotiations in the WTO and the debates in the Committee on Agriculture (CoA), WTO Members are also continually exhorted to reform their agricultural support schemes in favor of green box options.

In a way, this is the experiment we will try on our model economy of Ecuador in Part II of this work, thanks to the possibilities afforded by CGE modelling. But before that, and in order to set the stage for our experiments, we need to acquaint ourselves with the agricultural sector of Ecuador.

3. AGRICULTURAL TRADE AND POLICIES IN ECUADOR

Before we carry out our simulations, we need to look into the economy of Ecuador in more detail, with the aim of familiarizing ourselves with its main characteristics, and to better appreciate the effects of the simulations that we will be carrying out.

In the following sections, we will look at Ecuador's products and producers, agricultural trade, and the current state of the country's agricultural policies, including the composition of Ecuador's agricultural support.

3.1. Main agricultural products

Even though Ecuador's economy is mainly based on oil, agriculture has long been the second largest source of income for the country, and since 2014, due to the fall in oil prices, Ecuador's agricultural exports have surpassed oil in terms of value[9].

The comparative advantage of the country in this sector, particularly in its more traditional exports, is well established: fertile soils, a variety of climatic conditions that are favorable to a wide array of crops, short distances to ports on account of the small size of the country, good road infrastructure, and the expertise acquired along the decades by producers and exporters.

In 2021, agriculture's share of Ecuador's GDP was 8%, twice as much as the global contribution of agriculture to world GDP (FAO, 2021), while the total value added generated by agriculture in the country was almost USD 5,5 billion[10] (Ministerio de Agricultura y Ganadería del Ecuador, 2022d).

The agricultural trade balance has been positive every year since 1985 (Maiguashca, 2021). In 2021, Ecuador's agricultural exports reached USD 7,4 billion (FOB[11]), while agricultural imports were valued at USD 3,7 billion (CIF[12]), for a trade balance surplus of USD 3,7 billion (Ministerio de Agricultura y Ganadería del Ecuador, 2022d).

Agriculture is strongly linked to the manufacturing sector: in 2020, 40% of the total value added of manufactures in Ecuador (USD 7,9 billion) came from agroindustry (USD 3,1 billion) (Ministerio de Agricultura y Ganadería del Ecuador, 2022d).

One important indicator to look at is the Agricultural Productivity Index (IPA) of the Ministry of Agriculture and Livestock of Ecuador, which aggregates the yields per hectare[13] of 31 selected crops in a single value, in order to observe their behavior over time, with 2015

[9] On average, since 2014, agricultural products have made up 61% of all annual exports (Arboleda & Bermúdez-Barrezueta, 2022)

[10] In 2007 US dollars.

[11] The FOB (free on board) price of exports and imports of goods is the market value of the goods at the point of uniform valuation, (the customs frontier of the economy from which they are exported) (OECD, 2003).

[12] The CIF (cost, insurance and freight) price is equal to the FOB price, plus the costs of transportation and insurance charges, between the customs frontier of the exporting (importing) country and that of the importing (exporting) country (OECD, 2003).

[13] The hectare (ha) is the preferred metric unit of area for measuring land in Ecuador, equal to 10 000 m^2.

as the base year (IPA2015 = 100). The crops in the set were selected for their economic relevance and their role in the country's food security and food sovereignty.
With the recovery in the prices of agricultural products in 2021, the IPA reached a value of 128,56, presenting an increase of 6% compared to the value of 121,22 for 2020. For this period, the total harvested area of the 31 crops analyzed showed an increase of 0,36%, totaling 1,98 million hectares nationwide. Similarly, production showed an increase of 7,7%, totaling 26,4 million tons (Ministerio de Agricultura y Ganadería del Ecuador, 2021a).

While there is some overlap, in Ecuador some agricultural products are important because they are the country's main exports, while others are important because they are directly linked to domestic consumption and to the food security of the population of the country.
The most important crops for the domestic market are avocado, sugar cane, fruit (lemon, mango, orange, pineapple, tree tomato, passion fruit), rice, peas, barley, onion, beans, flint corn, maize, peanut, potato, quinoa, soy, tobacco, tomato, wheat, and cassava (Ministerio de Agricultura y Ganadería del Ecuador, 2022d).
On the other hand, Ecuador's main agricultural products for export are bananas, plantain, roses and other ornamental flowers, raw and processed wood, cacao beans, palm oil (crude and refined), coffee (unroasted and roasted, coffee-based preparations) and frozen broccoli (Ministerio de Agricultura y Ganadería del Ecuador, 2022d).

Crop	*Area (ha)*	*Production (mt)*	*Productivity (mt/ha)*
Cacao	543 547	330 872	0,61
Rice	317 400	1 697 353	5,35
Flint corn	291 435	1 678 255	5,76
Oil palm	225 575	2 418 855	15,86
Banana	167 893	6 684 916	40,74
Sugar cane	130 677	11 372 505	87,21
Plantain	128 861	763 455	6,81
Maize	51 408	42 813	0,92
Beans	31 350	17 717	0,60
Coffee (Robusta)	14 760	9 823	0,71
Coffee (Arabiga)	14 720	7 341	0,50

Table 2. Ecuador's main crops, 2021 (Ministerio de Agricultura y Ganadería del Ecuador, 2022d)

In Table 2, we can see that sugar cane is by far Ecuador's most productive crop per hectare, with a yield of 87,21 tons per hectare, and a total of 11,4 million tons per year. In terms of planted area, the winner is cacao, with plantations occupying more than half a million hectares, followed by rice, flint corn, oil palm and bananas.

In terms of foreign trade, Ecuador's main export is bananas, which in 2021 represented a full 43% of the value of agricultural exports (FOB). Bananas and plantain first reached their boom in the 1980s and 1990s, and have since consistently remained the most important Ecuadorian agricultural export. In 2016, banana exports fell by 3% due to the international dip in commodity prices, but they bounced right back in 2017 (Arboleda & Bermúdez-Barrezueta, 2022).

As we can see in Table 3, bananas are followed by roses at 10% of the value of exports, cacao at 9%, and wood and wood products at 8% (Ministerio de Agricultura y Ganadería del Ecuador, 2022d). Cut flowers started surging in the 1980s, reaching their peak in 2014 (USD 918 million). Since 2015 they have experienced ups and downs, but remain a mainstay of the Ecuadorian export offer (Maiguashca, 2021).

Crop	*2021 (Jan-Aug)* USD FOB	*2022 (Jan-Aug)* USD FOB	*Share of 2021 total agricultural exports*
Bananas	2,1 billion	2,03 billion	43%
Roses	444 million	466 million	10%
Cacao beans	428 million	437 million	9%
Wood / wood products	386 million	391 million	8%
Oil palm	87 million	109 million	2%
Other cut flowers	176 million	176 million	4%
Coffee[14]	42 million	60 million	1%
Frozen broccoli	102 million	95 million	2%
Others	897 million	1 billion	21%
TOTAL AG EXPORTS	4,75 billion	4,77 billion	100%

Table 3. Main crops for export (Ministerio de Agricultura y Ganadería del Ecuador, 2022d).

[14] Includes both roasted and unroasted beans, instant coffee and other preparations.

The products summarized in the “Others” category include canned vegetables and edible parts of plants, milled rice, taro, abaca, dry beans, fruits like pitahaya, granadilla and blueberries, and other minor crops.
In Table 4, we can compare with the main agricultural products that Ecuador imports:

Crop	*2021 (Jan-Aug)* USD CIF	*2022 (Jan-Aug)* USD CIF	*Share of 2021 total agricultural imports*
Wood pulp and paper	207 million	365 million	12%
Soyabean oilcake	479 million	632 million	20%
Latex and rubber	236 million	270 million	9%
Wheat	336 million	384 million	12%
Soybean oil	94 million	153 million	5%
Preparations for beverages	65 million	62 million	2%
Preparations for infants	29 million	30 million	1%
Seeds for various crops	37 million	42 million	1%
Others	903 million	1,1 billion	38%
TOTAL AG IMPORTS	2,38 billion	3,11 billion	100%

Table 4. Main imported crops (Ministerio de Agricultura y Ganadería del Ecuador, 2022d).

As we can see, among Ecuador’s main imports we find soy derivatives, wheat, latex, natural and synthetic rubber, wood pulp, paper and cardboard; we also import nutritional supplements, fruits and cereals, among others (Ministerio de Agricultura y Ganadería del Ecuador, 2021a).
Soybean oilcake and wheat together represent a full third of Ecuador’s agricultural imports. These commodities are used as inputs in the manufacture of different products, such as wheat flour, but not only for domestic final consumers. They are also used in the production of feed for animals, particularly aquaculture, which is also an important source of Ecuador’s exports. Exports of shrimp in 2021 accounted for USD 5,39 billion (FOB), which represented an increase of 40% compared to 2020 (Ministerio de Agricultura y Ganadería del Ecuador, 2021a).
As we will see in more detail later, a large share of expenses in the cost structure in agricultural production in Ecuador comes from imported manufactures, and much of that is agrochemical inputs (phytosanitary protection products and fertilizers), that are essential for

agricultural production. According to the Central Bank of Ecuador (*Banco Central del Ecuador* – BCE), import of this type of input during the year 2020 amounted to approximately USD 733,8 million for a volume of 1,3 million tons (Ministerio de Agricultura y Ganadería del Ecuador, 2021a).

In Table 5, we see a summarized historical evolution of the production of different crops in Ecuador, from 1965 to 2010. The table shows the ups and downs of many of the country's agricultural products, bearing testimony to the different challenges that they have faced.

Some products have known immense success, such as palm oil, which in 1965 represented less than 0,1% of agricultural production, and by 2010 it had grown to 14,3% (Maiguashca, 2021). Meanwhile, products such as soy have failed to take off, mainly due to the difficulties in competing with other countries with higher productivity and better agricultural technology[15].

Crop	*1965*	*1975*	*1985*	*1995*	*2000*	*2005*	*2010*
Bananas	20,3	22,1	22,3	47,9	42,1	35,3	37,0
Cacao	0,4	0,6	1,5	0,8	0,5	0,5	0,8
Coffee	2,3	3,1	3,8	1,3	0,2	0,2	0,1
Sugar cane	73,7	66,3	56,5	35,1	41,7	49,2	44,1
Passion fruit	ND	ND	ND	ND	2,1	0,6	0,1
Oil palm	<0,1	0,8	5,2	8,9	9,6	10,6	14,3
Plantain	3,2	7,1	10,7	6,0	3,8	3,4	3,7
Rice	21,7	23,8	26,6	49,5	51,8	53,6	48,9
Broccoli	ND	ND	ND	ND	2,0	ND	ND
Flint corn	11,8	10,8	18,9	18,8	21,4	29,2	34,4
Maize	5,5	4,8	2,3	4,8	4,8	3,0	3,5
Potato	35,9	26,4	28,3	18,1	10,0	10,0	11,2
Soy	<0,1	0,6	4,2	3,5	3,9	ND	ND
Tomato	2,0	2,0	4,3	2,5	2,5	2,2	0,4
Cassava	23,1	31,6	15,3	2,9	3,5	2,3	1,5

Table 5. Crop percentages of total agricultural production for each year (Maiguashca, 2021).

[15] In the case of soy, the Constitution of Ecuador forbids the use of transgenic seeds, hampering the country's ability to compete with other producers that do have access to varieties that offer higher yields and resistance.

In Ecuador the government has tried to promote both subsistence agriculture and export-oriented agriculture (Erazo Villegas, 2017). Nonetheless, as in many other developing countries, there has been a concentration of resources in export crops, to the detriment of subsistence agriculture and the foods that the country eats. This leads to increased vulnerability of rural communities to external shocks, and increased dependency on trade partners for the supply of key foods (Betge, 2016).

3.2. Agricultural producers

According to the most recent agricultural census conducted in Ecuador, the III National Agrarian Census (*Censo Nacional Agropecuario*), carried out in 2000 by the National Institute of Statistics and Census (*Instituto Nacional de Estadística y Censos* – INEC), 40% of the population of the country resided in rural areas (INEC, 2000) [16]. Current estimates of rural population by the World Bank place it at 36% of the country's 18 million inhabitants (World Bank, 2023a).

The participation of agricultural employment in total employment at the national level has been growing in recent years, reaching a share of 23,2% in 2014, 27,5% in 2018 and 28,7% in 2021. Nowadays, at least 29% of all employment in Ecuador is linked to agricultural activity (Ministerio de Agricultura y Ganadería del Ecuador, 2022d).

This consolidates the agricultural sector as the largest employer in Ecuador, followed by vehicle trade and repair activities (18,5%) and manufacturing industries (10,8%)(Ministerio de Agricultura y Ganadería del Ecuador, 2021a).

The percentage of the employed rural population working in agriculture has also been increasing: the 2000 Census showed it to be at 62%; nowadays, it is 82% (Ministerio de Agricultura y Ganadería del Ecuador, 2022d).

Taking into consideration that most agricultural jobs (79%) are within the informal sector, and that most workers in agricultural activities are men (59%), while 41% are women, when employment data is viewed disaggregated by gender, we see that adequate or full employment rate for men is 16,7%, while for women it is 4,8%. The indicator with the

[16] Preparations for the IV National Agrarian Census in 2023 are currently underway; the resulting updated agricultural data are expected to become available by 2024. The full results of the 2000 National Agrarian Census in Ecuador can be found at https://www.ecuadorencifras.gob.ec/censo-nacional-agropecuario/.

largest gap between men and women is found in the rates of unpaid employment, where the share for men is of 12,6%, while for women it is at 42%, representing the majority of female agricultural employment. In the case of men, the majority is underemployed[17], with a value of 36,7% (Ministerio de Agricultura y Ganadería del Ecuador, 2021a).

Peasants in Ecuador come from multiple ethnic backgrounds: most of them (71,7%) are Mestizo[18], followed by 20,9% of members of the various indigenous nations and communities, 5,5% of whites, 1,5% of afro-descendants, and 0,35% of other ethnicities (INEC, 2000).

Poverty in Ecuador is heavily concentrated in the rural areas. While the national poverty rate is 25%, the rural poverty rate is 42,9%. As for extreme poverty, the rural rate is 22,7%, compared to 10,7% for the national rate (Ministerio de Agricultura y Ganadería del Ecuador, 2022d)[19]. Most agricultural producers in Ecuador have limited access to productive inputs and capital goods, as well as to health, to education, and to non-agricultural work in the countryside.

When analyzing the level of poverty by area in the year 2021, a gap of 22 percentage points can be observed between the urban population (20,8%) and rural population (42,4%), which shows the existing inequality between different areas of the country. Interestingly, in rural areas, the poverty rate is lower (29,5%) when the head of household is a woman than when there is a male head of household (34,3%) (Ministerio de Agricultura y Ganadería del Ecuador, 2021a).

Now it is important to review the concept of the "agricultural productive unit" (*Unidad Productiva Agropecuaria* – UPA), which is what official statistics in Ecuador use, as well as much of the research based on them. According to the INEC, a UPA is "any estate, ranch, hacienda, farm, homestead or property dedicated totally or partially to agricultural production"[20]. More precisely, a UPA is an extension of land of 500m^2 or more[21], dedicated

[17] These are employed people whose income was below the minimum wage and/or who worked less than 8 hours per day and have the desire and availability to work additional hours.
[18] Persons of mixed white and indigenous ancestry.
[19] These rates show that conditions are going back to normal, after poverty and extreme poverty rates spiked in 2020 and 2021, as a result of the COVID-19 pandemic. For comparison, 2018 data can be found in https://www.ifad.org/en/web/operations/w/country/ecuador.
[20] "… [T]oda finca, hacienda, quinta, granja, fundo o predio dedicados total o parcialmente a la producción agropecuaria" (INEC, 2000). Translated by the author.

totally or partially to agricultural production, considered as an economic unit, which develops its activity under a single management, regardless of its form of ownership and its geographical location.

Based on data from the 2000 Census, the Economic Commission for Latin America and the Caribbean (ECLAC) described three types of UPAs in Ecuador (Parada & Morales, 2006):

-Family subsistence units: In these farms, the productive activity is run by the farmer and his family, who live on the land, hire no laborers, use no machinery, and have less than 3 hectares of land. According to the 2000 Census data, 52,7% of all UPAs in Ecuador are family subsistence units. Current government studies estimate that family subsistence agriculture nowadays could represent up to 75% of UPAs, and that approximately 60% of food sold to consumers in the country is grown by these producers (Órgano de Examen de las Políticas Comerciales, 2019a).

-Intermediate entrepreneurial units: These are larger properties, from 3 to 50 hectares of land, where the productive activity is run by the farmer, his family, and some hired laborers, using some machinery. This sort of agricultural "middle class" makes up 40,8% of UPAs in Ecuador according to the 2000 Census.

-Corporate units: These are the large exploitations, upwards of 50 hectares of land, where the productive activity is run by specialized professionals, who hire agricultural workers and use technical assistance, who own machinery and have access to financing. Only 6,4% of UPAs in Ecuador are the corporate kind.

UPA categories	*No. of units (2000)*	*Hectares (2000)*
National total	842 882	12 355 820
% total	100	100
Family subsistence (<3 ha)	52,7%	3,6%
Intermediate (3-50 ha)	40,8%	35,7%
Corporate (>50 ha)	6,4%	60,8%

Table 6. Agricultural land distribution in Ecuador (Maiguashca, 2021); (INEC, 2000).

[21] Areas less than 500m^2 were also considered as UPAs by the 2000 Census, but only if during that year any of the products grown in it was offered for sale (INEC, 2000).

As we see in Table 6, farmland ownership is highly concentrated in Ecuador: according to the 2000 Census, more than half of the agricultural producers in the country own only 3,6% of the land, while 60,8% is owned by relatively few, very large agricultural exploitations in the hands of only 6,4% of all landowners.

This has been the case since colonial times, when the large majority of peasants, mostly indigenous and Mestizo, owned no land at all, until the laws of agrarian reform in the 1960s and 70s[22] allowed millions of peasants, who until then had been practically serfs, to become landowners for the first time, while millions of others became salaried agricultural workers.

Corporate agriculture tends to concentrate the production of crops that participate in industrial value chains (flint corn, rice, sugar cane, soy) and those that are destined for export (cacao, oil palm, banana, plantain, coffee). The same is observed in mid-sized agriculture, with a smaller concentration of crops for export. On the other hand, small farms tend to concentrate on foods that are sold directly to the final domestic consumer, such as maize, beans, cassava, etc. (Maiguashca, 2021).

In Ecuador, most of the profit stays on the opposite ends of the agricultural productive chain: the manufacturers of seed and fertilizers at one end, and the distributors and exporters at the other. In the case of rice, for example, only 6% of the price paid by the consumers ended up in the pocket of the producer, while in the case of potatoes, it is only 1% (Maiguashca, 2021).

Having said that, the index of producer prices, calculated by the Ministry of Agriculture of Ecuador, has been showing a constant growing trend in recent years. This index shows the prices received by the first link in each production chain, so its increase means better incomes for producers. Throughout 2021, the index showed constant growth, reaching pre-pandemic values by the end of the year (Ministerio de Agricultura y Ganadería del Ecuador, 2021a).

3.3. Main agricultural trade partners

In 2021, agricultural exports represented 27,9% of Ecuador's total exports (FOB), while agricultural imports were 14,6% of total imports (CIF). If we exclude trade in oil products, agriculture represented 41,1% of total exports (FOB) and 18% of total imports (CIF) (Ministerio de Agricultura y Ganadería del Ecuador, 2022d).

[22] Ley de Reforma Agraria y Colonización (1964); Ley de Reforma Agraria (1973).

As it was mentioned earlier, the agricultural trade balance of Ecuador has been largely positive for decades. In the period 2014 – 2020, it showed an average annual growth rate of 9%, rising from USD 2,9 billion to 4,8 billion in those seven years (Ministerio de Agricultura y Ganadería del Ecuador, 2021a). Nonetheless, as we will see, the agricultural trade balance is not positive with all trading partners.

According to data provided by the Ministry of Agriculture of Ecuador, in 2021, the country engaged in agricultural trade with 157 other countries and territories; its main trading partners are the US, China, and European countries, mostly those in the EU, as well as Latin American countries (Ministerio de Agricultura y Ganadería del Ecuador, 2021a).

The US is an example of a country with which Ecuador maintains an agricultural trade surplus. Ecuador exported USD 1,7 billion (FOB) worth of agricultural products to the US in 2021, with a surplus of USD 1 billion. Ecuador's agricultural exports to the US consist of roses and other cut flowers (23%), bananas (22%), cacao (11%), and other goods. Our agricultural imports from the US, which amount to USD 713 million (CIF), are mainly products such as soybean cake (45%), wheat (17%) and others (Ministerio de Agricultura y Ganadería del Ecuador, 2021a).

On the other end of the spectrum is Canada. It is an important trading partner with which Ecuador maintains a large trade deficit of USD 287 million. Of the USD 93 million (FOB) exported by Ecuador in 2021, cut flowers made up 29%, 28% was cacao, and 10% was broccoli, among others. On the other hand, we imported USD 381 million (CIF), mainly wheat (91%) and lentils (5%) (Ministerio de Agricultura y Ganadería del Ecuador, 2021a).

In 2021, Ecuador placed 26% of its agricultural exports in the former North American Free Trade Agreement (NAFTA) made up of Canada, the US and Mexico, with goods such as flowers, bananas, cacao, wood, etc. The EU received 23% of our agricultural exports; the Netherlands, Germany, Italy, Belgium, Spain, Sweden, Poland, Greece and Slovenia, are the EU member states with the highest demand for Ecuadorian agricultural products (Ministerio de Agricultura y Ganadería del Ecuador, 2021a).

Another 12% of Ecuador's agricultural exports, mainly bananas and flowers, go to the Russian Federation, along with the rest of the Eurasian Economic Union (Armenia, Belarus, Kazakhstan and Kyrgyzstan). Southeast Asian countries, mostly China, Japan, Indonesia and Malaysia, receive 10% of Ecuadorian agricultural exports, mainly products such as cacao, bananas, raw and processed wood, broccoli and others. The remainder 29% of exports go to

a variety of other trade blocs and countries (Ministerio de Agricultura y Ganadería del Ecuador, 2021a).
The COVID-19 pandemic caused economic and social losses on a global scale in the year 2020, and world trade was upended. Nonetheless, while trade in services was profoundly stricken, agricultural trade suffered less of an impact and bounced back faster[23]. As a result, 2020 was actually an excellent year for Ecuadorian foreign trade of agricultural products: the agricultural trade balance reached a record surplus of USD 4,8 billion (Ministerio de Agricultura y Ganadería del Ecuador, 2021a).
However, the subsequent increase in the prices of fertilizers, the rise in maritime freight costs and the shortage of containers and shipping space, all affected Ecuadorian exports negatively. These factors, combined with a slight reduction in exports and a moderate increase in imports, caused the trade balance to contract by 23% in 2021, sliding back to 2019 values, so that the agricultural surplus reached only USD 3,7 billion, one full billion dollars less than in 2020 (Ministerio de Agricultura y Ganadería del Ecuador, 2021a)
For the near future, the growing demand for agricultural products in China, and the increasingly unfavorable climate conditions for agricultural production in certain areas of the world, which reduce their capacity to grow food, are likely to create opportunities for Ecuadorian agricultural exports (Ministerio de Agricultura y Ganadería del Ecuador, 2021a).

3.4. Agricultural policy in Ecuador

Throughout the 1970s and early 1980s, Ecuador centered its efforts on import substitution and industrialization, and agriculture was relegated to a supporting role in the economy. The main aim of agricultural policies was to provide the population with affordable food, through price controls to protect consumers from international fluctuations, and heavy subsidization to compensate the farmers. The domestic market was favored, with duties on agricultural exports for most products (Maiguashca, 2021).
Agricultural producers became dependent on government support, and since they were shielded from competition, they did not strive to become more productive and competitive.

[23] In April 2020, agricultural trade remained at a similar level to that of 2019, or even increased (World Trade Organization, 2020), while it took until the second quarter of 2022 for services trade volume to surpass its pre-pandemic peak (World Trade Organization, 2022).

Highly protected and isolated from international market price signals, agricultural production was inefficient and a considerable drag on the country's public resources (Maiguashca, 2021)[24].

The final years of the 1980s and the 1990s were marked by changes in agricultural development policies, which became increasingly trade-oriented, a trend that was further strengthened by the process of accession of Ecuador to the WTO, culminating in 1996. This process came with new priorities in terms of both access to external markets and defense of domestic markets, as well as the need to modernize the agricultural productive system with the aim of increasing trade competitiveness (Maiguashca, 2021).

The new WTO rules went beyond tariffs: they also meant quantitative and qualitative limitations in the support to agricultural products, as well as restrictions in the application of policies oriented towards food security, incentives to production and the stabilization of the internal market[25].

The country started the transition from administered markets with strong governmental intervention, to open and free markets, within the framework of Ecuador's new WTO commitments, as well as other integration processes that were reactivating, mainly the Andean Community (*Comunidad Andina de Naciones* – CAN)[26] and other trade agreements with Latin American countries, within the framework of the Latin American Integration Association (*Asociación Latinoameriana de Integración* – ALADI)[27].

Progressively, Ecuador removed or limited different forms of direct government intervention in the domestic market, to reduce the distortions created by high levels of protection: price controls disappeared, quantitative restrictions were reduced or eliminated, while tariffs were

[24] It is important to point out that, despite these positive transfers to producers, the indirect negative impact from currency overvaluation (creating an implicit subsidy for imports) was constantly increasing and tended to significantly offset the protection afforded by agricultural subsidies. Studies show that, after adjusting for the distortions of the exchange rate, the positive protection would disappear or even become negative (Proyecto Multinacional para la Promoción del Agrocomercio de la Comunidad Andina, 1997).

[25] Trade liberalization was also one of the components of structural adjustment, which led to drastic and often abrupt reform in every area of public life where government intervention was deemed to be unnecessarily large, not only in Ecuador but in all of Latin America. These reforms also included financial deregulation, privatizations, and labor flexibilization.

[26] Ecuador is one of the signatories of the 1969 Cartagena Agreement, which created the Andean Community. The commitments acquired by Ecuador in the context of Andean integration were mainly about harmonization of policies between the member countries, harmonization of border measures, elimination of barriers to interregional trade, and reduction of the use of protective measures within the region, taking into consideration the differences in individual WTO commitments.

[27] Similarly, Ecuador is one of the signatories of the 1980 Montevideo Treaty, which created ALADI.

decreased[28] and non-tariff restrictions were trimmed down. The large agricultural subsidies of the 1970s and 80s were considerably reduced, not only on account of the effort to liberalize trade, but also due to increasing fiscal difficulties (Maiguashca, 2021).
When the country started on its process of trade liberalization, the market- and trade-oriented agricultural reforms greatly modified the landscape for farmers. The openness offered opportunities to some sub-sectors of the agricultural economy, which benefitted from new markets and advantageous relative prices, while in the case of other crops the withdrawal of protections devastated producers. An example of is wheat: the new openness was not supported by real competitive advantages, and as a result it exposed vulnerable producers to tremendous losses, turning Ecuador from a wheat exporter into complete dependency on imported wheat to meet its domestic consumption needs (Proyecto Multinacional para la Promoción del Agrocomercio de la Comunidad Andina, 1997).

In 1999 Ecuador experienced one of its worst economic crises, when the financial system came close to a complete collapse, and the economy became dollarized, in an effort to stabilize the country. As the first years of the millennium passed, the unprecedented surge in oil prices helped the country's finances to recover (Valle Arancibia & Aguirre Sigcha, 2020).
The oil boost to Ecuador's public revenue was invested in expenditures such as the creation of infrastructure, social programs, and subsidies, especially for fuel. It also financed the implementation of the National Development Plan, which among other objectives tried to incentivize national production of food through the reintroduction of certain protectionist measures, such as taxes on imports, import restrictions, safeguard measures, etc. (Valle Arancibia & Aguirre Sigcha, 2020)
Unfortunately, in the second decade of the millennium, the steep fall of the oil prices combined with continuous growth in spending, brought down government income in Ecuador, causing fiscal and current accounts deficits to rise while international reserves all but disappeared. Between 2011 and 2017, Ecuador registered a fiscal deficit every year. In 2017, the fiscal deficit reached 4.5% of GDP (Órgano de Examen de las Políticas Comerciales, 2019c).

[28] For the Andean Community in general, average tariff levels went from 44.6% to 13.1%, while maximum tariffs went from 83.7% to 41% (Proyecto Multinacional para la Promoción del Agrocomercio de la Comunidad Andina, 1997).

In the last few years, the economy has struggled to recover, and when the COVID-19 pandemic hit, it delivered a severe blow to the country. To help families and businesses deal with the consequences of the pandemic, the government implemented new programs to sustain the most vulnerable population and introduced tax deferrals, which further reduced fiscal revenue.

Within strict budget limitations, the government has continued its efforts to combat poverty and extreme poverty, which, as we pointed out earlier in this work, are especially prevalent among rural populations. Agricultural policy has remained focused on helping farmers improve their economic conditions, by providing them with the inputs, the infrastructure, and the support they need to produce. To this aim, Ecuador maintains a number of programs to improve their working conditions and their access to the market, to modernize agriculture and to support small producers.

We will now look at the current volume and structure of agricultural support in Ecuador, based on information publicly available on government websites, on the WTO Secretariat and government reports for Ecuador's latest Trade Policy Review in 2019, on Ecuador's most recent notifications to the WTO Committee on Agriculture (CoA), on press reports and research.

3.4.1. Domestic agricultural support

According to Article 285 of the Constitution of Ecuador, one of the objectives of the country's fiscal policy is "*[t]he redistribution of income through transfers, taxes and appropriate subsidies*[29]" (Constitución de la República del Ecuador, 2008).

The Constitution also devotes its entire third chapter to the obligation of the State to promote food sovereignty (Constitución de la República del Ecuador, 2008), in order to ensure that individuals and communities become self-sufficient with regard to healthy foods[30].

In compliance with these constitutional mandates, Ecuador grants fiscal incentives for productive development in general, as well as for specific sectors like agriculture, through its

[29] "[…l]a redistribución del ingreso por medio de transferencias, tributos y subsidios adecuados". Translated by the author.

[30] Food sovereignty is a local and national issue, linked to small-scale and subsistence production, while food security is more of a global issue, linked to trade-oriented and large-scale production (Betge, 2016). It is important for governments to promote both, in an integrative approach to food security.

Ministries and other public institutions, with a focus on investments in technology, quality seeds and chemical fertilizers (Erazo Villegas, 2017).

The Ministry of Agriculture of Ecuador sums up its mission in one statement: "*To promote family agriculture while ensuring food sovereignty*"[31]. This mission is articulated through the priority objectives guiding the Ministry's policies, which can be summarized as follows:

-Supporting small and medium producers in general, and family farming in particular

-Fomenting rural development, to reduce extreme poverty and improve the quality of life of agricultural producers and rural communities

-Ensuring food sovereignty, expanding access to affordable and nutritious food

-Developing agricultural competitiveness

-Increasing agricultural exports

-Fostering sustainability and environmental responsibility

-Modernizing agriculture, through innovation, services, and infrastructure (Ministerio de Agricultura y Ganadería del Ecuador, 2023)

In order to reach these long-term goals, the government maintains a coordinated national strategy that combines multiple components[32]. Under the umbrella of this national agricultural strategy, a diversity of public policies and instruments seek to improve competitiveness and productivity; to facilitate access to the national and international markets, as well as to financial services, means of production and agricultural technology; to strengthen associative cooperation and alternative circuits for fair trade of agricultural products; to provide producers with technical assistance and capacity-building (technical, organizational and commercial); to create rural employment opportunities, etc.

We will now look at some of these programs and tools used by the government to incentivize and support agricultural producers[33].

[31] "Impulsar la agricultura familiar garantizando la soberanía alimentaria." Translated by the author.

[32] This strategy has been known as the "Great National Minga" (*Gran Minga Nacional Agropecuaria* – GMNA). Minga is a word derived from the Kichwa language, which designates voluntary, collective work undertaken by a community to everyone's benefit.

[33] Like most other countries, Ecuador has many different types of policies in place to foster agriculture, and also employs various trade instruments. Nonetheless, as this work is centered on subsidies, we will look only at pertinent policies, while border measures and other such tools will not be analyzed.

Access to inputs, fertilizers, and improved seeds:

As part of the strategy of the Ministry's National Seed Project for Strategic Agricultural Chains[34] (*Proyecto Nacional de Semillas para Agrocadenas Estratégicas* – PNSAE), the Ministry of Agriculture provides small producers and family farmers with certified seeds, fertilizers, and other agricultural inputs at subsidized prices. This type of assistance is known as the “technological package” (formerly the "agricultural kit") (Ministerio de Agricultura y Ganadería del Ecuador, 2022e).

Technological packages are aimed at improving farmers’ yields and reducing their production cost; they usually consist of different combinations of fertilizers, high-quality, high-yield seeds, and phytosanitary products for pest and disease control, according to the needs of small producers (Ministerio de Agricultura y Ganadería del Ecuador, 2022c).

The Ministry enters into public-private partnerships with private companies, who provide the inputs to small farmers for a fraction of the price, while the Ministry covers the remainder. The level of support varies according to the product, the region, and the particular recipient. For example, for small tomato and avocado producers in the highlands, the subsidy granted by the Ministry in 2022 was approximately 70% of the total value of the package. The co-payments by the producers fluctuated between USD 19,33 to 109,99 per package (Ministerio de Agricultura y Ganadería del Ecuador, 2022e).

To be able to purchase these packages, farmers must register with the Ministry, either at the nearest District Office or through the Technical Field Facilitators (TFC) who visit rural communities. Beneficiaries also receive technical assistance for the proper use of these packages (Ministerio de Agricultura y Ganadería del Ecuador, 2022b)

The maximum size of the property than can qualify for this type of support depends on what the farmer produces: for tropical pastures, the farmed area can be up to 30 hectares; for yellow flint corn, rice and highland pastures, up to 10 hectares; for potato, tree tomato, tomato, pepper and *naranjilla*, from 0,5 to 5 hectares, in no more than two plots (Ministerio de Agricultura y Ganadería del Ecuador, 2022b).

In order to support farmers through the winter season, from January 22 to February 8, 2022, the Ministry provided 4 703 technological packages, with an investment of USD 1, 2 million (Ministerio de Agricultura y Ganadería del Ecuador, 2022c).

[34] Formerly known as the High Performance Seeds Plan (*Plan Semillas de Alto Rendimiento*).

Minimum prices in certain products:

The government mediates in the marketing of certain basic agricultural products by establishing minimum support prices, which guarantee that the producer is fairly paid by the intermediaries and exporters. The products to which minimum support prices are generally applied are cotton, rice, bananas and plantains, coffee, sugar cane, pork, corn, milk, quinoa, soybeans, and wheat. The Ministry of Agriculture fixes these prices, taking into account production costs plus a profit margin for the producer[35] (Órgano de Examen de las Políticas Comerciales, 2019c).

Minimum support prices are the prices that intermediaries and exporters must pay farmers. For some of these products, specifically rice, corn, quinoa, soybeans, wheat and coffee, the Ministry monitors the annual balances of the main national food chains, with a view to ensuring that the food demand is satisfied with an appropriate assortment between national production and imports, coordinating the country's resources with availabilities in the international market (Órgano de Examen de las Políticas Comerciales, 2019b).

Minimum support prices are usually set by Consultative Councils, meetings facilitated by the Ministry in which the producers, the exporters and the agro-industrial sectors negotiate and agree on the minimum support price for the following year.

For example, in the case of bananas, in September 2022 the Consultative Council, formed by the representatives of both banana producers and exporters, set the minimum support price for a box of bananas at USD 6,50. This price will be valid between January 1 and December 31, 2023 (Ministerio de Agricultura y Ganadería del Ecuador, 2022f).

Agricultural state trading enterprises:

From 2013 to 2020, Ecuador had a publicly owned company attached to the Ministry of Agriculture, the National Storage Unit (*Unidad Nacional de Almacenamiento* – UNA) [36].

The UNA was responsible, among other things, for the temporary storage and internal marketing of certain agricultural products, the administration of the strategic reserves of food,

[35] Since 2018, the Ministry has also set maximum prices for corn and rice, in order to counter speculation (Órgano de Examen de las Políticas Comerciales, 2019c).

[36] Amid the government’s efforts to find resources to fight the COVID-19 pandemic, in 2020 the UNA went into liquidation by decree of then President Lenín Moreno. The liquidation process closed on October 12, 2022, and all of the UNA’s infrastructure, assets and liabilities were transferred to the Ministry of Agriculture.

and support for the marketing and distribution of inputs. The UNA did not engage in foreign trade of its stocks (Comité de Agricultura, 2022).

The UNA bought and sold mainly rice, yellow flint corn, cereals, and soybeans, at the minimum support price, acting as an intermediary between the agricultural producer and the agro-industrial sector, in order to assist farmers to sell all of their harvest at a fair price throughout the year. The UNA bought preferentially from small and medium producers, whose harvest met the required technical criteria of quality (Órgano de Examen de las Políticas Comerciales, 2019c).

It is important to clarify that the UNA did not buy entire production surpluses, but only small percentages. For example, in 2017, for rice and corn, it only bought 2% and 3% of the surplus, respectively, for strategic reserve purposes (Órgano de Examen de las Políticas Comerciales, 2019b).

Export promotion:

Ecuador does not grant any subsidy to the export of agricultural products, according to the latest information provided by the government to the WTO (Comité de Agricultura, 2019).

Over the years, Ecuador has implemented different mechanisms to promote exports. One of the programs currently in place is a duty drawback regime, that is, a conditional refund of taxes on inputs incorporated into export goods (*Devolución Condicionada Ordinaria de Tributos de insumos incorporados a bienes de exportación*).

All registered exporters can obtain the total or partial refund of foreign trade taxes paid for the import of goods used as raw materials, inputs, or packaging for exports. The refund can reach up to 5% of the exported value, depending on the exported product and the imported material used (SENAE, 2022).

The rebate percentage of 5% reflects Ecuador's weighted tariff from 2010 to 2014. Banana and flower exporters are among those who have benefited the most from this mechanism (Órgano de Examen de las Políticas Comerciales, 2019c).

Preferential financing mechanisms:

Financing facilities have been established for small and medium agricultural producers in Ecuador, in order to improve access to inputs and capital goods, with a view to boosting productivity in the agricultural sector. Financing for the agricultural sector is mainly provided by BanEcuador, one of the financial institutions of the public sector.

BanEcuador was created in 2016 to replace *Banco de Fomento*, with the aim of providing financing to individuals, as well as to family, communal and associative productive units, and to MSMEs (Órgano de Examen de las Políticas Comerciales, 2019c).

BanEcuador offers different products for farmers, with different interest rates and conditions. For example, the CCMA loan (*Crédito CCMA*), which is especially for producers of coffee, cacao, corn and rice; or the Super Rural Woman loan (*Súper Mujer Rural*), which is only for women who run a family farm (crops and/or animals).

The amounts that can be requested range from USD 500 to 10 000 for individuals and micro-enterprises, and start at USD 5 000 for SMEs. Repayment installments and deadlines are tailored to the particular needs of the producer, and various types of guarantees are accepted. Interest rates vary according to the type of loan, but are usually at 12,25% for agricultural producers (BanEcuador, n.d.).

The National Finance Corporation (*Corporación Financiera Nacional* – CFN) also supports agricultural producers, in particular those MSMEs who cannot present the necessary guarantees to back a loan request in the financial system.

For these cases, CFN has the National Guarantee Fund (*Fondo Nacional de Garantías* – FNG). The FNG issues guarantees for eligible MSMEs, in order to facilitate their access to productive financing through the financial system. Through the FNG, the financial institution that receives the guarantee mitigates its risk up to 50% of the value of the loan. The maximum loan amount that can be covered is USD 250 000 for agricultural productive activities (Corporación Financiera Nacional, n.d.).

<u>Crop insurance</u>:

The government also provides support to farmers, particularly small and medium producers, through subsidized crop insurance. In 2015, the Ministry of Agriculture created the AgroSeguro Project, now known as "CampoSeguro", a subsidized agricultural insurance system aimed at protecting small and medium agricultural producers from the adverse biological and natural effects caused by climate change (Ministerio de Agricultura y Ganadería del Ecuador, 2022a).

Through this program, the government provides agricultural insurance against natural phenomena, pests and diseases that may affect or destroy production. This allows the farmer to recover the direct production costs invested and to stay in business even after a considerable loss.

Insurance used to be provided by the state insurance company, Seguros Sucre (Órgano de Examen de las Políticas Comerciales, 2019c), but now the Project works with private insurers Hispana de Seguros for crops, and Zurich for cattle.

There are two separate insurance policies, one for producers of a variety of crops, and another one for cattle farmers. In both cases, the government subsidizes 60% of the cost of the insurance premium, while the farmer pays the remaining 40%, plus taxes (Ministerio de Agricultura y Ganadería del Ecuador, 2022a).

The Agricultural Insurance protects farmers in case of droughts, floods, freeze, hail, unmanageable diseases, unmanageable pests, high winds, fire, unusual low temperatures, landslides, excess humidity, and ash fall. The insurance is available for a variety of agricultural products, both destined for export and for the domestic market, including some forestry products like beechwood, balsa, bamboo and teak. The cultivated area must be at least 5 000 m^2 (0,5 ha) for most crops; for potato and red onion, a minimum area of 2 500 m^2 (0,25 ha) is allowed.

The Livestock Insurance is for cattle ranchers, and protects the rancher's investment in case of death of the animals by accident (including during transport), illness, forced slaughter, wild animal attack, and snake bites.

It is estimated that a total of US$51.5 million was disbursed during the period 2011-2017 for premium subsidies for insurance (Órgano de Examen de las Políticas Comerciales, 2019c).

In 2020, 59 207 hectares of land were insured under Agricultural Insurance policies, which represents an insured value of USD 66,7 million. The insurance premium subsidy paid by the State in that year totaled USD 2,1 million. The number of claims paid was 2 273, amounting to USD 2,3 million in compensations. As of April 2021, the total insured land had reached 377 040 hectares, representing an insured value of USD 418,5 million (Ministerio de Agricultura y Ganadería del Ecuador, 2021b).

As for Livestock Insurance, in 2020, 128 ranchers insured 907 heads of cattle, an insured value of USD 817 291. The insurance premium subsidy paid by the State totaled USD 22 066, and no claims were recorded or paid out that year. By April 2021, the number of insured ranchers was 418, with 2,835 cattle, which is equivalent to an insured amount of USD 3.1 million (Ministerio de Agricultura y Ganadería del Ecuador, 2021b).

Green box agricultural support measures:

While some of the programs above would correspond to the amber box or to the development box, according to WTO criteria, Ecuador also maintains a series of green box support measures for agriculture, related to pest and disease control, research, marketing and promotion services, inspection services and infrastructure services. These programs, in general, do not benefit specific products, and fit the criteria to be considered green box support, according to the specifications in paragraphs (a), (b), (e), (f) and (g) of "General Services", and in "Domestic Food Aid", in Annex 2 of the WTO AoA.

The following are the programs detailed in Ecuador's most recent notifications to the WTO CoA (Comité de Agricultura, 2020), along with the amounts spent on each of them by the government, corresponding to the fiscal year 2018:

a. General Services:

-Investigation: Support for the development of research and transfer of agricultural technology, to increase productivity, competitiveness, value addition and the promotion of sustainable agriculture (USD 17,2 million).

-Control of pests and diseases: Support for actions to prevent and control animal and plant diseases that may affect agricultural production and food safety (USD 9,65 million).

-Inspection services: Support for improved quality and safety of agricultural products, through the monitoring and control of contaminants, pests and diseases that affect production (USD 1,49 million).

-Marketing and promotional services: Support for the promotion of sustainable agricultural products to improve competitiveness and foster fair trade (USD 30 000).

-Infrastructure services: Support to expand coverage and improve the efficiency of irrigation and drainage systems (USD 3,97 million).

b. Domestic food aid:

-Delivery of food with high nutritional content to boys and girls who attend public educational institutions (USD 198 million).

The government's investment in these programs in 2018 amounted to USD 230,34 million.

The WTO Secretariat, in the report written for Ecuador's latest Trade Policy Review in 2019, stated that the recent growth of the agricultural sector was possible, to a large extent, thanks to those policies that have facilitated greater access to agricultural inputs and technology, and have created favorable market conditions for the producer. Among the programs implemented by the Ministry of Agriculture, the WTO experts singled out the High Performance Seeds Plan (now PNSAE), the Ecuadorian Coffee Reactivation Program (*Proyecto de Reactivación de la Caficultura Ecuatoriana*) and the Ecuadorian Cacao Sector Reactivation Program (*Proyecto de Reactivación del Cacao Nacional Fino y de Aroma*), as particularly effective in boosting agricultural productivity (Órgano de Examen de las Políticas Comerciales, 2019c).

3.4.2. Ecuadorian agricultural subsidies in the Latin American context

Back in 1997, a study by IICA found that, in general, agricultural subsidies in Ecuador constituted weak transfers of resources, due to their low impact on productivity and modest effects on the distribution of income between different producers (Proyecto Multinacional para la Promoción del Agrocomercio de la Comunidad Andina, 1997). According to IICA, subsidies were just too small to be significant in terms of generating important distortions.

Nowadays, according to the Inter-American Development Bank (IDB) and its Agrimonitor tool, the situation has not changed much in that sense (Inter-American Development Bank, 2023).

The Agrimonitor is a country-level database of Producer Support Estimates (PSE) and related indicators for Latin America and the Caribbean, maintained by the IDB. Its aim is to facilitate the task of monitoring of agricultural policies in the region, in particular with regard to magnitudes and composition of agricultural support. Agrimonitor applies the OECD's methodology to allow comparability of different agricultural policies across diverse countries (Inter-American Development Bank, 2023).

There are three main categories of OECD support estimates: support to the producer (PSE), support via General Services (GSSE), and support to consumers (CSE). PSE, in turn, consists of the Market Price Support (MPS)[37] and budget transfers to producers (BT). And all of these constitute the Total Support Estimate (TSE).

The TSE in percentage (TSE%) indicates what percentage of a country's GDP is represented by public support to the agricultural sector. This indicator reflects and includes all the effects of public policies that differentially affect the agricultural sector, from support to the sector (for example, subsidies) to penalties (for example, taxes).

According to this database, the TSE of Ecuador for 2016, the latest year available, was 1,15%, lower than the 1,37% that is the average for Latin America and the Caribbean.

The Producer Support Estimate in percentage (PSE%) indicates the percentage of producer revenue that is due to the support provided by agricultural policies. The PSE of Ecuador for 2016 is 11,94%, also less than the Latin American average of 12,48%.

The General Services Support Estimate in percentage (GSSE%) measures the percentage of total support that is provided to agricultural producers through general support (this refers to research, agricultural health services, infrastructure, among others). The GSSE of Ecuador for 2016 is at 8,94%, significantly less than the Latin American average (22,75%).

The Consumer Support Estimate in percentage (CSE%) indicates how agricultural policies affect the cost of the basket of agricultural products. In the case of Ecuador, the CSE for 2016 is at -12,06%, slightly less than the LA average at -13,83%.

As we have seen, the agricultural sector has enormous importance in Ecuador, not only economically but also socially. The size of agricultural GDP relative to other sectors, means that any policy shock to agriculture, such as the removal or the restructuring of support, will have a large impact on the rest of the economy, and especially on the millions of people whose livelihoods revolve around agriculture, most of whom are poor.

Upon this groundwork, and given the specificities that characterize Ecuador's agricultural sector, what would be the effects of different types of subsidies on the country's economy? Do these effects give us important clues about policy alternatives? We will now explore these questions in detail, in Part II of the present work.

[37] The MPS measures both the benefit perceived by domestic producers by the effect of border measures (tariffs, quotas, among others) and domestic price support resulting in a price above its competition from imports. Calculations are performed for a basket of products representing at least 70% of the gross value of agricultural production on average during the three years prior to the study.

In the following chapter, we will explore our methodological framework, and the design of the simulation that we will apply to our model of the economy of Ecuador, in order to finally attempt to answer the question of what would happen if Ecuador introduced different types of agricultural subsidies.

PART II

4. METHODOLOGY

The methodological framework we will use for this research is CGE, specifically the GTAP-AGR model. Let us now have a look at the main characteristics of CGE models in general, as well as the specific features of the GTAP-AGR model.

4.1. Overview of CGE and the GTAP-AGR model

CGE models harness general equilibrium theory to try to achieve a more realistic representation of an economy, in all the complexity of its behavior, by modelling the interaction between the agents as they react to exogenous shocks and endogenous adjustments.

CGE models are very useful for subsidy policy analysis because they can quantify their efficiency and welfare effects, which lets us measure how beneficial a subsidy actually is, and to which sectors and agents.

We will now look briefly at the main elements and key assumptions of CGE models in general, as well as the features that are specific to the GTAP model variation that I will be using, in order to better understand the theoretical underpinnings of the model and how it works.

4.1.1. Basics of CGE models

CGE models are an attempt at representing complex interdependent economic systems in a simple way, in order to analyze policy implementations and their effects. They go beyond what partial equilibriums can show us, because they link all the agents and markets in the economy, and even to other economies connected by trade flows (Burfisher, 2016).

Having said that, general equilibrium models share some characteristics with partial equilibrium models. Fundamentally, they are based on same demand, supply, and market-clearing equations from economic theory, with both endogenous and exogenous variables. As a result, after a shock is applied to one of the exogenous variables, all the equations of the model will be solved simultaneously, and endogenous variables will adjust until markets clear again, adhering to macroeconomic constraints[38] (Burfisher, 2016).

CGE models allow researchers to run controlled experiments, and to quantify what happens to an economy's agents and to the relationships between them, after a shock in the model. This is possible because CGE models are based on real data and elasticities estimated to reflect real behavior, in such a way that results are relevant to policy-making decisions.

The economic data for a CGE model comes from a database of the national accounts of the country or countries to be studied (in this case, Ecuador), arranged into a Social Accounting Matrix (SAM), the structure required by the CGE model.

SAMs are derived from input-output transaction tables, which capture all the circular transactions that take place in an economy, both between the different sectors of that economy, and inside of each sector, organized in balanced square matrices. SAMs are subject to microeconomic and macroeconomic constraints, in that for each agent and for the total economy, income must equal expenditure (Burfisher, 2016).

CGE models use the SAM of a given year as an initial equilibrium, in order to introduce a shock for the model to solve and generate a new equilibrium and a new SAM.

The general equilibrium framework is based on a neoclassical walrasian model, with the following characteristics (Burfisher, 2016) (Křístková & Habrychová, 2011):

– Fixed supply of all production factors: capital, labor, and land; this makes CGEs most suitable for experiments on the short or medium-run horizon, where there is not enough time for changes in the endowment of factors.

– Full factor employment.

– Households are utility maximizers and cost minimizers, while firms are profit maximizers.

– Governmental consumption is modelled as a fixed proportion of the GDP.

– Perfect competition, so firms are price-takers on goods and factor markets, and there are zero economic profits.

– Constant returns to scales (CRS) production technology, an assumption that is particularly appropriate when working with agriculture.

[38] Standard CGE models are static models: they will not show the adjustment process after a shock, only the final result after all the adjustments have taken place.

– Prices are flexible and adjust until all markets clear.
– Equilibrium is reached when the available goods are allocated, and the prices are set in such a way that excess demand is zero in each market.
– The initial equilibrium reflects the most efficient input choices.

4.1.2. GTAP and GTAP-AGR

GTAP stands for Global Trade Analysis Project, coordinated by the Center for Global Trade Analysis, in the Department of Agricultural Economics of Purdue University, USA[39].

The Project maintains a detailed global database, that describes bilateral trade patterns, production, consumption and intermediate use of commodities and services; in its 11th version, it includes data for 151 countries and regions. Additionally, the Project is also the creator of the GTAP Model, which is a multi-region and multi-sector CGE model, that is formulated and solved using the economic modelling software GEMPACK. The GTAP model has been developed and improved by the researchers in the Center for Global Trade Analysis, and its main characteristics can be found in various essential publications such as "Global Trade Analysis: Modeling and Applications" (Hertel, 1996) and "The Standard GTAP Model, Version 7" (Corong et al., 2017).

The GTAP model differs in a few significant ways from other CGE models, and it is important to point them out as they are relevant to the construction of the model that will be used for the simulations in the present work.

One important feature that GTAP has, is the Regional Household account. This is a kind of macroeconomic account, which collects all the income in the economy, and distributes it back to the individual agents in order to buy goods and services, that is, to the private households, the government, and also the savings and investment account, in the form of savings (Keeney & Hertel, 2005). All the tax expenditures in the economy go to the regional household, as well as all the net factors' income[40]. The regional household has its own utility function (Cobb-Douglas).

Regarding macroclosure, the GTAP model is savings-driven, meaning that savings are exogenous, and investment adapts. The consequence is that capital goods are more sensitive

[39] The Project's homepage can be found at https://www.gtap.agecon.purdue.edu/default.asp.
[40] In a way, it is similar to GDP, but not exactly, as it does not include depreciation, which is accounted for in the savings and investment account of the SAM.

than consumption goods to income changes; in other words, they react more strongly to shocks.

Prices in GTAP are normalized to one in the initial equilibrium. This procedure converts most of the initial prices in the model into $1, which does not affect results in any way, and allows us to distinguish changes in prices and quantities from value changes.

Since we assume perfect competition, firms are price-takers on goods and factor markets, and there are zero economic profits. For that reason, in GTAP firms are cost minimizers, as opposed to profit maximizers.

Elasticities are usually hardwired into the production function of choice for the CGE model, but GTAP allows for changes in elasticities.

GTAP has a special utility function called Constant Differences of Elasticity (CDE), which is non-homothetic, meaning that budget shares change with income.

With regard to the solution of models, the GTAP model offers different multi-step solution options, such as Euler and Gragg, which break the problem up into steps and greatly reduce the incidence of linearization error that is common in the old Johansen one-step solution, yielding more accurate solutions. There is a built-in consistency check, that ensures that solutions to equations produce a balanced database.

GTAP offers results in percentage changes, which other than ease of interpretation, has the added advantage of needing no calibration, making it easier to solve large models.

While most CGE models have only two factors of production (capital and labor), the GTAP model also has land, and has a global price index for factor returns.

Subsidies in GTAP:

Subsidy rates[41] in a GTAP model are part of the taxes, only they are a "negative" tax, where instead of collecting payment, the government transfers resources to the productive activity. The types of subsides that are covered in the model are export subsidies, output subsidies, factor subsidies, intermediate input subsidies, and income subsidies (Burfisher, 2016).

In general, any tax that appears as a negative in the SAM is a subsidy, including export taxes, production or output taxes, sales taxes, factor use taxes, etc. For example, subsidies on land

[41] Subsidy rates are reported as percentages of the value of output (*ad valorem*).

and capital use would show up as negative factor use taxes. The only exception are output subsidies, which appear as positive numbers in the base data.
As mentioned above, CGE models translate value data into price and quantity data by normalizing prices. However, in the case of subsidies, some prices in the model may be adjusted to include them from the start, and these initial prices do not equal one. Similarly, generally export subsidies are already embedded in the value of exports in the SAM (Burfisher, 2016).

GTAP has been used for modelling of agricultural trade policy since its introduction in 1993, getting better as researchers have fine-tuned the instrument to better reflect agricultural realities. In the version of the database that I will be using, the GTAP-AGR, important modifications have been introduced by Purdue University researchers Keeney and Hertel (2003), in order to bring into the model certain specific features of the relationship between trade and agriculture.
Particularly relevant to the present work, GTAP-AGR modifies the factor supply and demand equations, to better show the responsiveness of the factor market to subsidization. It also modifies consumer demand, to separate food and non-food commodities, and separates farmer income from non-farmer income. It also includes a supplementary exogenous variable (*greenbox*), which allows us to model decoupled agricultural support, in addition to the other types of subsidies mentioned above.
Changes such as these contribute to make the model respond in a more realistic manner to the agricultural policy experiments. The improvement in the model's performance after introduction of these changes is the subject of a paper by Keeney and Hertel, in which they compare responsiveness to policy experiments both in the original framework and in the GTAP-AGR version, and evaluate how close each of them come to actual observed effects in the economy (Keeney & Hertel, 2005).
It is important to point out, nonetheless, that as much as GTAP-AGR has been adapted and modified in order to better capture the specificities of agriculture, a model is still only a model, and there will always be some limitations that constrain our research possibilities to a certain extent.
In order to answer our research questions for the present work, some choices needed to be made on how to represent the behavior of the agents and the relationships between them in

our model economy of Ecuador as close as possible to reality, but some inadequacies simple come with the territory and we have to work with them.

For instance, the production parameters ESUBT and ESUBVA, which we will discuss in detail below, are set according to ranges that come from a six-country 2001 OECD report, which does not necessarily reflect what supply and substitution elasticity values might be for a small developing country such as Ecuador. In GTAP-AGR, the parameter values for all non-OECD countries are simple set equal to those of Mexico, the only developing country of which estimates were available at the time (Keeney & Hertel, 2005).

Another example is how the farm income is calculated in GTAP-AGR, on the basis of the assumption that incomes for farm households tend to be on par with median incomes of regular, non-farm households. This assumption, which is clearly not adjusted to the realities of developing countries, again comes from studies of incomes in OECD countries (Keeney & Hertel, 2005).

Finally, another important limitation is that GTAP-AGR is not ideal for modeling all types of green box subsidies. For experiments concerning such types of support as research, infrastructure, capacity-building and technical assistance, the model would need a series of alterations that are currently not reasonably achievable for the present work, hence our choice of setting up our second comparison scenario involving only direct payments to land.

Having said this, doubtlessly GTAP-AGR remains a powerful tool for the analysis of the effects of different types of instruments of governmental support for agriculture, and will continue to be perfected and refined, as more researchers use it and find ways to update the model to reflect the specific characteristics of agricultural economics in developing countries.

I will now describe how the model used for the present work was constructed, by tailoring the GTAP-AGR model to the needs of this particular research.

4.2. Construction of the general equilibrium model

Let us now look in detail at how the different elements of our model have been set up.

Aggregations and data: The model was built on the base an aggregated SAM sourced from the pre-release of GTAP 11 for the year 2017, which includes data from both Ecuador and its main trading partners. The raw input-output data pertaining to Ecuador comes from the country's Central Bank (Aguiar et al., 2019).

Even though the data is 5 years old, it is still useful, because the structure of an economy does not change so fast, and the main strength of CGE models is to capture the linkages between the sectors of an economy (Burfisher, 2016).

Regions set: The GTAP database that will be used covers 151 countries and regions, which have been aggregated into the following 20 countries and regions, which represent Ecuador's main trading partners and trading interests:

No.	Code	Country/region
1	oce	Rest of Oceania
2	chn	China
3	jpn	Japan
4	kor	Korea
5	xas	Rest of Asia
6	can	Canada
7	usa	United States
8	mex	Mexico
9	bra	Brazil
10	chl	Chile
11	col	Colombia
12	**ecu**	**Ecuador**
13	per	Peru
14	pan	Panama
15	xmc	Rest of Americas and Caribbean
16	eur	European Union
17	rus	Russian Federation
18	xwa	Rest of Western and Central Asia
19	afr	Africa
20	xtw	Rest of the world

Tradeable commodities set: The GTAP database that will be used covers 65 economic sectors, between agriculture, manufacture and services.

Because of the intended focus of the model on agriculture and the impact of agricultural policies, the agricultural production and commodities will be aggregated in various accounts, while all non-agricultural production sectors will be aggregated into two accounts only, namely Manufacture and Services. Sectors are aggregated as follows:

No.	Set	Code	Product(s)
1	*Farm level sectors*	*pdr*	Rice
2		*wht*	Wheat
3		*gro*	Other grains
4		*v_f*	Vegetables, fruits, tubers, and pulses
5		*osd*	Oil seeds and fruits
6		*c_b*	Sugar crops
7		*pfb*	Fiber crops
8		*ocr*	Other plant goods[42]
9		*ctl*	Bovines and horses
10		*oap*	Other animal products, including pigs and poultry
11		*rmk*	Raw milk
12		*wol*	Raw animal materials used in textiles
13		*frs*	Forestry
14		*fsh*	Fishing and aquaculture
15		*omg*	Mining, oil and gas
16	*Food processing sectors*	*cmt*	Meats and offal (bovine, sheep, goats, etc.)
17		*omt*	Meats and offal (pigs, poultry)
18		*vol*	Animal and vegetable oils
19		*mil*	Dairy products
20		*pcr*	Milled rice
21		*sgr*	Sugar
22		*ofd*	Other processed foods
23		*b_t*	Beverages and tobacco
24		*mfc*	Manufactures
25		*ser*	Services

Although certain researchers and institutions include them in an ample definition of "agriculture"[43], the Forestry (*frs*) and Fishing and aquaculture (*fsh*) sectors are not part of what will be considered agriculture for the present work. This corresponds to the framework of the WTO, which specifically excludes both sectors from the scope of the AoA.

[42] One disadvantage of GTAP-AGR is that sectors are sometimes too broad. Such is the case with other plant goods (*ocr*), which is quite a wide category which includes, for instance, cut flowers, an important export commodity for Ecuador, and rubber, one of the country's main agricultural imports.
[43] Such as FAO. Cf. (FAO, 2021)

The Mining, oil and gas account (*omg*) aggregates GTAP sectors 15 to 18. The Manufacture account (*mfc*) aggregates GTAP sectors 27 to 45, while the Services (*ser*) account aggregates sectors 46 to 65[44].

Endowments set: Regarding the factors of production, capital is split into capital proper and natural resources, while different labor accounts have been aggregated into one account, leaving only unskilled agricultural labor by itself.

No.	Factor
1	Land
2	Agricultural unskilled labor
3	Other labor
4	Capital
5	Natural resources

Model closure: Exogenous variables for this model are the following[45]:

Variable	Name
aendw[46]	augments the endowment of i used in sector j
afcom	intermediate tech change of input i, worldwide
afsec	intermediate tech change of sector j, worldwide
afreg	intermediate tech change in region r
afall	intermediate input i augmenting tech change by j in r
afecom	factor input tech change of input i, worldwide
afesec	factor input tech change of sector j, worldwide
afereg	factor input tech change in region r
afeall	primary factor i augmenting tech change sector j in r
amsirs	import i from region r augmenting technical change in region s
amsxreg	import-augmenting tech change for i exported by r
aosec	output tech change of sector j, worldwide
aoreg	output tech change in region r
aoall	output augmenting technical change in sector j of r
apurchsec	purchases input tech change of sector j, worldwide
apurchreg	purchases input tech change in region r
apurchall	purchases input augmenting technical change in sector j of r
atm	tech change in mode m, worldwide

44 The full table with the aggregation used in found in Appendix 3.
45 The names of variables give an indication as to what they denote: all p variables are prices, all q variables are quantities and volumes, and all t variables are taxes; regarding prices, everything is in nominal millions of US dollars.
46 Variable *aendw* is a tech change variable for approximating land set aside.

atf	tech change shipping of i, worldwide
ats	tech change shipping from region r
atd	tech change shipping to s
au	input-neutral shift in utility function
avasec	value added tech change of sector j, worldwide
avareg	value added tech change in region r
cgdslack	slack variable for qcgds(r)
dpgov	government consumption distribution parameter
dppriv	private consumption distribution parameter
dpsave	saving distribution parameter
endwslack	slack variable in endowment market clearing condition
endwslackagr	slack variable in market-clearing (agriculture) for i in region r
endwslacknagr	slack variable in market-clearing (non-agriculture) for i in region r
greenbox / greenboxp[47]	tax on primary factor LAND
incomeslack	slack variable in the expression for regional income
mps[48]	shocks the market price support for a given commodity
pfactwld	world market price index of primary factors
pop	regional population
profitslack	slack variable in the zero-profit equation
psaveslack	slack variable for the savings price equation
qo	(ENDW_COMM,REG) fixed national supply of labor in Ecuador[49]
tf	tax on primary factor i used by j in region r (only exogenous for agricultural commodities)[50]
tf_2[51]	tax on primary factor i used by j in region r
tfslack[52]	tax on primary factor i used by j in region r
tfd	tax on domestic i purchased by j in r
tfm[53]	tax on imported i purchased by j in r
tfunit_2[54]	specific tax on primary factor
tm_2[55]	source-gen. change in tax on imports of i into s
tms	source-spec. change in tax on imports of i from r into s
to	output (or income) tax in region r
tp	comm.-, source-gen. shift in tax on private cons.

[47] Variables *greenbox* and *greenboxp* allow the researcher to shock land subsidies at the same rate over different agricultural program commodities.
[48] Variable *mps* allows the user to shock both *tx* and *tm* at the same rate.
[49] The model assumes labor to be fully employed; since there is no unemployment, it is the real wage that adjusts to shocks. Similarly, foreign savings and the fiscal deficit are exogenous; as a result, exchange rates and government spending will adjust with shocks.
[50] For NAGR_COMM (non-agricultural commodities), variable *tf* is endogenous.
[51] Variable *tf_2* is equivalent to *tf* for agricultural commodities.
[52] Variable *tfslack* makes the ad valorem *tf* wedge the active one for land in agriculture.
[53] Variables *tfd* and *tfm* are normally condensed out of the model but are needed for domestic support shocks.
[54] Variable *tfunit_2* applies the specific tax on land in agriculture.
[55] Variable *tm_2* is equivalent to *tm* from gtap.tab in its version 6.2.

tradslack	slack variable in tradeables market clearing condition
tx_2[56]	dest.-gen. change in subsidy on exports of i from r
txs	dest.-spec. change in subsidy on exports of i from r to s

A few variables that are included in this list were created for convenience, so they can be swapped and shocked with more ease for our simulations. All other variables are endogenous.

This model has also been modified in a way that it includes a set of specific variables that describe the income of the farm household. The new variables are:

Variable	Name
yf	farm income
yfon	farm income from farming activities
yfoff	farm income from non-farming activities
yf	real farm income
yfon	real farm income from farming activities
yfoff	real farm income from non-farming activities

Elasticities: This is how the different types of parameters and elasticities are set up for Ecuador in this model:

c. INCPAR parameter: This is a parameter related to income elasticity of demand (Burfisher, 2016). The goods in our model are all normal goods, and therefore set at values of more than 0, as is typical for CGE models. INCPAR is set at its lowest (0,138) for Ecuador's staple foods and most basic agricultural products, such as paddy rice (*pdr*), wheat (*wht*), grains (*gro*), vegetables and fruits (*v_f*), as they are necessity goods; this means that there is not a lot of income price elasticity for agriculture products, so their consumption grows proportionately less than income. For sugar (*sgr*) and processed foods (*ofd*), it is set at 0,390; at 0,496 for meats (*cmt* and *omt*) and dairy products (*mil*); at 0,893 for manufactures, and at 1,22 for services, indicating that services are luxuries.

d. SUBPAR parameter: This parameter is related to the own and cross-price elasticities of substitution (Burfisher, 2016). SUBPAR is set close to 1 for most agricultural goods, between 0,713 and 0,887, which indicates that agriculture is relatively

[56] Variable *tx_2* is equivalent to *tx* from gtap.tab in its version 6.2.

sensitive to price changes. For manufactures and services, on the other hand, it is set at 0,590 and 0,520, so that they are less sensitive in general. Goods become substitutes as SUBPAR becomes smaller.

e. Substitution of factors (ESUBVA): Each sector in agriculture has specific elasticities of substitution in the value-added "nest" (factor composition). For the most basic agricultural products, it has been set at 0,5, a value that indicates the producer does not have much flexibility to switch between factors. For other goods, such as dairy products (*mil*), meats (*cmt* and *omt*), animal and vegetable oils (*vol*), sugar (*sgr*), and processed foods (*ofd*), the value is set at 1,12, with the highest values for manufactures (1,26) and services (1,38). The higher the flexibility, the easier for the producer to substitute and keep production costs low.

f. Input substitution (ESUBT): For the intermediate bundle of inputs, in standard GTAP it is normally set at 0, due to the assumption of a Leontief production function with fixed proportions. However, in the GTAP-AGR version, basic agricultural products have the value set at 0,5, while for manufacturing and services it is 0. This allows farmers some flexibility to substitute between farm-owned value added and a composite intermediate bundle.

g. Factor mobility (ETRAE): This parameter indicates how much the sluggish factors can move between sectors if relative returns change. It is set at -0,4 for land; there is no parameter value for other factors since they are all either mobile or fixed.

   A value of -0,5 means a factor is partly mobile, only moving if the price differential is strong (to cover the transition cost). The value of -0,400 set in this model makes it a partially mobile factor, which means it is relatively easy for land to be repurposed, when farmers change crops often to plant whatever is paying better.

h. Trade elasticities: The elasticity of substitution between imports and domestic goods (ESUBD), is set at 6,45 for animal textile materials (*wol*), at 5,05 for paddy rice (*pdr*), 4,45 for wheat (*wht*), and 4,40 for meats (*cmt* and *omt*), which means consumers will more easily substitute the imported product for the domestic one. For manufactures, the elasticity is 3,50, and for services, the least elastic, it is 1,94.

   The elasticity of substitution between different sources of imports (ESUBM) is twice the value of ESUBD by default, so it is again at its highest for the same products: 12,9 for animal textile materials (*wol*), 10,1 for paddy rice (*pdr*), 8,90 for wheat (*wht*), and 8,80 for meats (*cmt* and *omt*). This means consumers will not particularly care about the origin of their imports when it comes to these products, and will easily substitute.

i. Export demand and supply elasticities: They do not apply in the present model, because it has two Armington parameters which govern the demand for imports.

Finally, let us review the data at base year in the model economy of Ecuador, so we can better appreciate the results of the shocks later.
To begin with, we find that the GDP of Ecuador at the base year amounts to USD 104,29 billion, which is consistent with what the World Bank reports for 2017.
Let us now define the subsidy structure of Ecuador as it appears in our model, by looking at the base-year values of the main tax/subsidy variables in GTAP-AGR.

<u>Output (or income) tax</u> (*to*): In our base year, 2017, the government made no net transfer of resources on account of output to any of the factors of production, nor to any sector in the economy. On the contrary, for all factors and all sectors, the government has collected net taxes from the output of each factor and each productive sector of the agricultural economy.
From land and capital, the tax rate is at 7,57%; for labor, both skilled and unskilled, it is at 13,2%. Regarding the productive activities, the figures differ from sector to sector; the lowest rate is applied to the meat sector, with a 0,141% rate for bovine meats and related products (*cmt*), and a 0,139% rate for pork, poultry, and related products (*omt*). The rates for other agricultural products range from 0,232% for milk (*rmk*), to 0,698% for beverages and tobacco (*b_t*) and 1,29% for sugar (*sgr*) at the highest level. For manufactures the rate is at 1,05%, while for services it is at 0,568%.
If we were to quantify Ecuador's output/income taxes, they would come down to USD 10,22 billion, or 9,79% of the country's base year GDP.

<u>Taxes on primary factors</u> (*tf*): In this case, we also find that in our base year no net transfers of resources were made to the factors of production, and instead we find net taxes collected by the government.

In this instance, the value does not change for each productive sector, which means that the rate remains the same regardless of what crop or type of animal the agricultural producer maintains.

For labor, across the board we find a uniform rate of 8,05%, both for skilled and unskilled. For capital, the rate is of 2,66% in all sectors. For land, we find the same rate of 2,66%, but only for the farm-level sectors 1-12 (primary agricultural products); for the food processing sectors, such as meats (*cmt* and *omt*), dairy products (*mil*), sugar (*sgr*), beverages and tobacco (*b_t*), and processed foods (*ofd*), there is no land tax.

Ecuador's taxes on primary factors amount to USD 4,51 billion, or 4,32% of the country's base year GDP.

<u>Taxes on firms' domestic purchases of inputs</u> (*tfd*): For this tax rate, once again we find that a majority of purchases of intermediate inputs by firms are taxed by the government instead of subsidized, for all agricultural products[57].

Ecuador's taxes on domestic purchases of inputs amount to USD 1,388 billion, or 1,32% of the country's base year GDP.

<u>Taxes on firms' imports of inputs</u> (*tfm*): For all agricultural products, we find some net taxes, and very small amounts of subsidization for manufactures and for services. In terms of value, some products such as beverages and tobacco (*b_t*) appear with negligible amounts of net subsidies, but what exists is mostly taxes from imported manufactures, and some from foreign service providers.

If we check the value of these taxes, we see that the government is not collecting much: Ecuador's taxes on imports of agricultural inputs amount to USD 77,05 million, or 0,07% of the country's base year GDP[58].

The total dollar amount of all four taxes comes down to USD 16,19 billion, or 15,52% of Ecuador's base year GDP.

[57] When we calculate the value of these taxes, the only sector that appears to receive a net subsidy is fisheries, which is not part of our study, as it is not considered to be an agricultural product. All agricultural products on the other hand are generating net taxes for the government.

[58] This may be explained by the fact that a considerable share of Ecuador's imports come from the country's main trade partners, with which trade is largely free, under different trade schemes and agreements.

The small amounts of subsidization we find in our model confirm the values we found in the IDB's Agrimonitor, which, as mentioned above, placed Ecuador's levels of agricultural support for 2016 at only 1,15% of GDP (Inter-American Development Bank, 2023).

Now let us look at the production structure of Ecuador in the model. Finding out the intermediate input intensity and factor intensity of agriculture in Ecuador is useful, in order to identify which factor subsidies or input subsidies would most benefit producers. Conversely, it also allows us to predict which activities would benefit the most from different types of subsidies.

For this, we will look at the NVFA coefficient, that will show us the cost structure of firms, that is, the purchases that each sector in the economy makes from all the factors, and from all the other sectors as inputs, both domestic and imported. The inter-sector linkages that NVFA shows are important when analyzing policy shocks on the supply side in GTAP.

The production structure varies for different agricultural goods, becoming more complex depending on the amount of processing their production involves.

1. Basic crops (sectors 1-8):

Products such as paddy rice (*pdr*), wheat (*wht*), grains (*gro*), vegetables and fruits (*v_f*), sugar crops (*c_b*) and other plant goods (*ocr*) are labor-intensive, with an average of 38,89% of production costs for these activities coming from labor (24,81% on average from unskilled labor and 14,08% from other types of labor). Land contributes 23,15% of the costs, while capital is responsible for an average 20,68% of them.

There is hardly anything at all by way of domestic inputs from agriculture. Domestic manufactures only represent an average of 3,69% of production costs, while 13,21% cover domestic services providers.

Similarly, there are practically no imported inputs from agriculture used, with the exception of the wheat (*wht*) sector, in which 13,9% of production costs come from purchasing imported wheat. The largest contrast comes from imported manufactures, which account for an average of 91,65% of imported production costs. As for services, payments to foreign providers represent only 4,34%.

2. Animal agriculture (sectors 9-12):

In terms of production factors, live animal rearing (*ctl* and *oap*) and other basic animal sectors, such as milk (*rmk*) and animal textile materials (*wol*), are also labor-intensive, up to 18,3% of production costs in the case of cattle rearing, two-thirds of it from unskilled labor. Land has a reduced participation, contributing a maximum of 10,9% of the costs, while capital is responsible for a maximum of 9,7%.

In these sectors, there is slightly more use of domestic agricultural inputs, mainly feedstuffs, such as oilseeds (*osd*), (39,2% of costs for animal textile materials (*wol*)) and processed foods (*ofd*) (30,7% for milk (*rmk*)). The participation of domestic manufactures in the costs remains low, at a maximum of 4,1%.

The lion's share of domestic production costs in these sectors comes from services: 35,7% in the case of cattle (*ctl*), 22,9% for milk (*rmk*), 29,3% for animal textile materials (*wol*), and 48,4% for other animal products (*oap*).

In these sectors, the share of imported inputs from agriculture skyrockets: 60,7% of the costs of farming cattle come from imported wheat (*wht*) (45,7%) and other imported agricultural processed products (15%). For the sector of processed foods (*ofd*), the share of imported agricultural inputs rises to 86,1% of the production costs.

Imported manufactures also make up a larger share of production costs: 22% for milk (*rmk*), 25,6% for cattle (*ctl*), and 59,4% for animal textile materials (*wol*). Foreign service providers are only a large portion of costs in animal textile materials (*wol*) production (25,3%), while for the other three sectors its importance remains small.

3. Higher value-added agricultural products (sectors 16-23):

For products such as meats (*cmt* and *omt*), animal and vegetable oils (*vol*), dairy products (*mil*), sugar (*sgr*), beverages and tobacco (*b_t*), and processed foods (*ofd*), production becomes capital-intensive, with capital taking up to 45% of the costs in the case of beverages and tobacco (*b_t*), and around 25% in the other sectors. Meanwhile, the participation of land in the production cost structure is reduced to zero, and skilled labor overtakes unskilled labor.

Here in the domestic cost structure, we see the use of more agricultural inputs: 26,9% of production costs of milled rice (*pcr*) comes from domestic paddy rice (*pdr*), 33,9% of costs in the production of sugar (*sgr*) is domestic sugarcane (*c_b*), and 78,5% of costs in the pork and poultry meats sector (*omt*) is also domestic inputs.

The participation of domestic manufactures in the costs remains low in these sectors, while domestic services contribute with around 22% of the costs, depending on the product.
Regarding the imported side of production costs, imported inputs from agriculture take up a large share in certain cases, like imported wheat (*wht*) in processed foods (*ofd*) (12,1%) and beverages and tobacco (*b_t*) (15%), imported cattle in the bovine meat sector (*cmt*) (20,8%), imported oils in the animal and vegetable oils (*vol*) sector (65,9%) and in the dairy products (*mil*) sector (20,6%).
Imported manufactures take up a very large share of costs in these sectors, from 30,5% in the animal and vegetable oils (*vol*) sector, all the way up to 86,9% in milled rice (*pcr*). The participation of foreign service providers in the cost structure, on the other hand, is small.

Another important thing to look at, in order to understand the economy of Ecuador, is the cost structure of private consumption, for which we will now look at the NVPA coefficient. This shows the base budget shares of each commodity in household expenditure.
NVPA tells us that services represent the largest share of what Ecuadorian households consume, at 61,7%. Agricultural products come next, with 20,8%, and manufactures are last, with 17,3%. Ecuador's 20,8% is slightly under the average budget share that homes in developing countries destine to consumption of agricultural products in our model (21,75%). The average for developed countries, on the other hand, is 9,52%, as families in poorer countries must devote more of their income to feeding themselves.
Let us look in more detail at the differences between domestic and imported products that households consume from each agricultural sector.
When we look at consumption of domestic commodities, we see that services dominate the private expenditure, taking up most of the family's budget, at a share of 67,7%.
Domestic manufactures amount to 10,6% of household expenditures, while many primary agricultural products represent a very small portion of Ecuadorian homes' expenditure. The only products that amount to 1% or more are milled rice (*pcr*) (1%), meats (*cmt* and *omt*) (average 1,8%), dairy products (*mil*) (2,4%), processed foods (*ofd*) (4,6%) and beverages and tobacco (*b_t*) (3,6%). The sector of grains other than wheat (*gro*) represent a mere 0,2%, and vegetables and fruits (*v_f*) only 0,4%.
On the other hand, in the consumption of imports it is manufactures that take the lead, at 72,4% of total expenditure, followed by services at 12,7%. As with domestic consumption,

most products make up less than 1% of household expenditure. The products that amount to 1% or more are beverages and tobacco (*b_t*) (1%), vegetables and fruits (*v_f*) (1,4%), animal and vegetable oils (*vol*) (4%), and processed foods (*ofd*) at 6,8%.

5. EXPERIMENTS AND RESULTS

5.1. Description of the shocks

In order to compare the effects that different types of subsidies would have for the economy of Ecuador in general, two different scenarios will be created and simulated in our GTAP model regarding the support that the farmers would receive.

5.1.1. Scenario 1: Raising agricultural subsidies to OECD levels

For this simulation, Ecuador's agricultural subsidies will be raised to a level corresponding to a weighted average of all OECD countries.

To construct this experiment, we started with the 2017 benchmark equilibrium. First, a new regional aggregation was created with the countries in the GTAP database. This new aggregation contains only two regions, one for OECD countries, and another one for the rest of the world (ROW).

Using this new aggregation of the database, subsidy rates for all OECD countries were then obtained. These are the variables we looked at to ascertain subsidy values in OECD countries:

Variable	Name
to	output (or income) tax
tf	tax on primary factor
tfd	tax on firms' domestic purchases of inputs
tfm	tax on firms' imported purchases of inputs

Once the subsidy rates were obtained, we went back to the initial aggregation for this model, and set up the experiment as a shock to the same variables, to bring up Ecuador's subsidy rates to the OECD weighted average level.

As this is a complex simulation, in order to be able to view separately each variable shock and its effects, we used the GTAP utility SUBTOTAL. This will show the individual results that each type of subsidy generates in the economy.

5.1.2. Scenario 2: Complementing the current subsidy scheme with direct payments

For this second simulation, I started again with the 2017 benchmark equilibrium. Instead of raising all subsidies to OECD levels, Ecuador's subsidies were left at their base levels, and supplemented by green box decoupled direct payments to land. These payments have been chosen due to their positive effects on farmer income, as well as other beneficial outcomes that researchers have identified.

As mentioned above, decoupled land payments are also effortlessly simulated in GTAP-AGR, with no need to drastically alter the model, thanks to the specific variables already included in it.

The direct payments would be provided on the basis of land area, similar to the direct payments that the EU grants to farmers[59], only without the environmental, sanitary or welfare conditionalities that the EU imposes for receiving the payments[60]. Since this type of direct payment is generally considered to fall within the scope of Annex 2 of the WTO AoA, we will refer to them as "green box subsidies".

For Scenario 2, our goal is to achieve the same level of farm income that resulted from the application of the first experiment, but only through minimally distorting agricultural support. For this reason, the variables shocked in Scenario 2 will be different from those in Scenario 1. To build the experiment, we take the value of real farm income that resulted from Scenario 1: this value will be the target level for the second shock. To find out the value for green box subsidies that produces this target level of real farm income, we need to change the closure of the model, so that real farm income (*yfreal*) in Ecuador becomes an exogenous variable that can be shocked.

We then swap real farm income (*yfreal*) with the exogenous variable *greenboxp*[61], which is the direct land payment subsidy rate, and shock *yfreal* to bring it up to the target value

[59] Direct payments in the EU constitute decoupled support that is granted to agricultural producers with no link to the amount of agricultural production. They are provided to farmers as a uniform amount per unit of agricultural land, or more specifically per hectare, for the newly accessed EU member states (Křístková & Habrychová, 2011).

[60] This is due, on the one hand, to the limitations inherent to the model we are using, which does not allow for proper modelling of such conditionalities. On the other hand, adding environmental requirements for receiving subsidies is not realistic for a country like Ecuador, as it may hurt the poorest farmers, who do not have the resources to adapt to, and comply with, new regulations (Mosquera, 2018).

[61] We only increased *greenboxp* for one endowment (Land), and only in Ecuador.

obtained in Scenario 1. We finally go back to the original closure, and a second shock is set up, to increase *greenboxp*.

The impact of these two shocks will then be compared to each other, as well as to the benchmark equilibrium in 2017, which I briefly described earlier, in order to facilitate the comparison with the results of the two aforementioned simulations.
Given that each agricultural activity is characterized by its specific cost structure and would get a different level of support, the impact of the different subsidies will vary per sector. It is also important to remember that, as was discussed in an earlier chapter, the majority of agricultural producers in Ecuador are medium and small producers, who are, more often than not, poor. Sometimes, as we discuss gains and losses to the different sectors, the dollar amounts mentioned in the results may sound minor, but for those medium and small producers in struggling agricultural sectors, those amounts could be very significant.

5.2. Results of Scenario 1 - OECD agricultural subsidy levels

As stated above, the first simulation consists of bringing up agricultural subsidies in Ecuador to the levels of OECD countries. Having run our experiment and obtained our results[62], we will first look at what the effect has been on the country's GDP.
The model's core data calculations after the shock show us a value of USD 104,66 billion, both for *gdpsrc*, GDP from the sources side, and for *gdpexp*, GDP from the expenditures side; this represents an increase of USD 370 million with regard to the pre-shock GDP.
The variable *qgdp* shows us the change in Ecuador's GDP quantity index, the real GDP, before and after the shock. This result shows us that the positive effect of our first experiment on the country's real GDP amounts to USD 17,84 million.
Now that we know the new value of GDP, we will quantify the four tax rates that we have shocked, in order to compare their dollar values with what they were at base year.

[62] The relevant simulation results for Scenario 1 can be found in the tables in Appendix 1. For each of the variables, the *Sim* column shows the change that has taken place as a result of the simulation. For some variables, there is also a *Pre* column, which shows the value of the variable before the shock, a *Post* column that shows its value after the shock, and a *Ch/%Ch* column shows this change in percentage points. GTAP gives results in percentage changes, but the amount values can also be viewed after a shock.

The first thing we see is that they are still all net taxes; in other words, even though tax revenue has decreased, the government is still earning revenue from these sectors and factors more than it is transferring to them through the subsidies provided.

Output (or income) tax (*to*): The output tax value amounts to USD 10,21 billion (9,75% of post-shock GDP), down USD 12,82 million from what was collected pre-shock.
If we look at the values sector by sector, some remain net taxes that the government still collects, but we also see some net subsidies for basic agricultural products.

Taxes on primary factors (*tf*): The factor tax value is of USD 3,98 billion (3,8% of post-shock GDP) for all the factors, down USD 524,9 million from what was collected pre-shock.
Land was the only factor of production that was shocked, but we see here the other factors have been affected as well: the net taxes that the government is collecting from both types of labor and from capital, have increased compared to what they were before the shock.
Specifically for land, the value of the tax is now negative, meaning there is a net subsidy, which amounts to USD 505,36 million. Before the shock, the government of Ecuador earned USD 47,79 million from land taxes; after the shock, not only is this amount no longer collected, but on top of that USD 457,57 million are transferred to landowners.

Taxes on firms' domestic purchases of inputs (*tfd*): The value for the tax/subsidy on domestic inputs is at USD 1,27 billion (1,21% of post-shock GDP), down USD 121,45 million from what was collected pre-shock. When we look at the amounts sector by sector, we see net subsidies for paddy rice (*pdr*), grains (*gro*), oilseeds (*osd*), sugar (*sgr*), and fiber crops (*pfb*), as well as processed foods (*ofd*).

Taxes on firms' imports of inputs (*tfm*): The value for the tax/subsidy on imported inputs is now at USD 44,76 million (0,04% of post-shock GDP), down USD 32,29 million from what was collected pre-shock. Looking at the amounts sector by sector, we find net subsidies for practically all imported inputs for agriculture, especially wheat (*wht*) and processed foods (*ofd*), except for manufactures and services, where the values indicate net taxes.

The value of all four taxes in total comes down to USD 15,51 billion (14,82% of Ecuador's post-shock GDP), which means that Ecuador's government revenue has decreased by USD 691,4 million (0,66% of post-shock GDP). This is the cost of the subsidies provided to farmers in Scenario 1 to the government of Ecuador.

Let us now look in detail at how the variables have changed, and what these changes mean in terms of the impact of this first experiment on the production activity in agriculture, on the production factors, on agricultural output, on the income of farmers' households, on foreign trade, and on GDP. We will begin with our price variables.

a. Price effects

There are different price variables that are relevant for what we are examining, and each is a piece of the puzzle to understand the effect of the shock. The variable *ps* shows us the percentage changes in the agricultural producer supply price of different commodities in Ecuador, where producer supply price equals the cost of production plus production taxes (Burfisher, 2016). It also shows us the land rent, the labor wage, and the capital rent.

The variable *pp* tells us the price that the private consumer pays for a good, while the variable *ppd*, more specifically, shows us the changes in the prices that private households pay for *domestic* agricultural products. The variables *pf* and *pfd*, on the other hand, show us the change in the price that *firms* pay for the use of agricultural products in industry, specifically the domestic variant of these products in the second case.

The variable *pr* shows us the change in the ratio of the domestic to the imported variants of a product, and the variable *pxw* shows us the aggregate export price of agricultural products from Ecuador.

In theory, introducing production subsidies to agriculture, which in Ecuador is a labor-intensive activity, should cause wages to rise, as well as demand for farmlands and land rental prices. Equally, purchase prices of agricultural products to private households and firms should be reduced. (Burfisher, 2016).

In our case, when examining all the prices mentioned above, even though there are some slight differences between different types of prices, we can see general trends. We see above all that the new subsidies from our first experiment have resulted in an enormous increase in the price of land, an increase of more than 33.7%, which is largely a product of the *tf* shock, the factor subsidy to land, as we see in Subtotal 2 for all these prices[63].

In contrast, labor wages hardly increase at all: less than 1% for unskilled labor, which is farm labor, and slightly over half a percent point for other labor. The rent of capital also barely increases, by slightly over half a percentage point.

In general, changes in relative input prices affect final prices, so when the inputs of an industry or sector become cheaper, the production price will go down. In this case, when subsidies are given to farmers, the effect of the subsidy should reduce the production costs for the farmer, allowing for prices to go down as well. Let us examine whether this has happened in this case.

We will look at the variables *pf* and *pfd*, which show us the change in the price that firms pay for agricultural products in general and, in the case of *pfd*, specifically for domestic agricultural products to be used as inputs for industry.

The variable *pf* shows us drops in prices for all inputs from agriculture, sometimes as large as 10, 12 or 15%. There are a few exceptions, particularly in the prices of certain inputs for the meat and dairy industries, as well as processed foods (*ofd*), but these few increases are invariably small.

When we observe the prices of the domestic inputs from agriculture, through the variable *pfd*, we see the same results, with equal or even larger price drops depending on the product.

Nonetheless, when we look at the prices of the same commodities for the *private* consumer, as shown by the variables *pp* and *ppd*, the results are less convincing. We see only a slight decrease in prices of wheat (*wht*), other plant goods (*ocr*), live animals (*ctl*, *oap*) and meat products (*cmt*, *omt*), animal fibers (*wol*), milk (*rmk*), dairy products (*mil*), milled rice (*pcr*).

Meanwhile, for a number of other products there is a slight *increase* in price, of up to 2,3 percentage points. Such is the case for paddy rice, (*pdr*), grains in general (*gro*), fruits, vegetables, pulses and tubers (*v_f*), oilseeds (*osd*), animal and vegetable oils (*vol*), sugar (*sgr*), processed foods in general (*ofd*), beverages and tobacco (*b_t*), as well as for manufacturing and services.

[63] For example, from the subtotals of variables *pfactreal* and *pfe* we can see that the increase in the factor subsidy is responsible for 31,35% of the 33% increase. The variable *pfe* shows us the nominal change in factor returns, while *pfactreal* shows us the ratio of the returns to the primary factors to Consumer Price Index.

For more detail, we look at the subtotals for these products. Our first subtotal, which corresponds to our output subsidy, shows that in general it has driven prices down for most products, except for grains in general (*gro*), meat products (*cmt*, *omt)*, animal and vegetable oils (*vol*), processed foods in general (*ofd*), and beverages and tobacco (*b_t*).

Our intermediate input subsidy, captured by Subtotal 3, has an even more mixed effect. It also tends to bring the prices down, but, again, not for everything: for wheat (*wht*), oilseeds (*osd*), sugar crops (*c_b*), animal and vegetable oils (*vol*) as well as for other plant goods (*ocr*), milled rice (*pcr*), sugar (*sgr*), processed foods (*ofd*) and beverages and tobacco (*b_t*), the intermediate input subsidy results in an increase in prices.

On the other hand, our second subtotal, which is the effect of the land subsidy, shows an increase in prices, practically across the board, with the notable exceptions of wheat (*wht*), plant fibers (*pfb*), and other plant goods (*ocr*).

For some of the products that end up with a net increase in price, the increase is caused by the dominant effect, which is the effect attributable to the land subsidy: paddy rice, (*pdr*), grains in general (*gro*), and fruits, vegetables, pulses and tubers (*v_f*). For oilseeds (*osd*) and sugar (*sgr*), the increase is caused by the combination of the effects of the land subsidy and the input subsidy. Lastly, for animal and vegetable oils (*vol*), processed foods in general (*ofd*), and beverages and tobacco (*b_t*), subtotals show that *all three subsidy increases* have the effect of pushing prices up.

When we look at these results in prices, nonetheless, the key is that in general the increases and decreases are very small. In some cases, it is an increase or decrease of 0.1% for products that are already quite cheap.

When it comes to purchases by firms, and also in the case of exports, small decreases in price can still make a difference, because of the large volumes at which these products are traded. For consumers, who buy very small amounts of these products, the impact of such minimal price drops will also be significant, since, as mentioned earlier, agriculture accounts for 20,8% of household spending in Ecuador. For the poorest families, even small price variations will be noticeable.

In a number of sectors, both the output subsidy and the intermediate input subsidies do have the effect of bringing the prices of agricultural products down, but this effect is offset almost completely in some products, by the increase in the price of land, which outweighs the decrease in input prices. The depth of the impact of the land subsidy is different for each specific sector depending on how intensively they use land.

Another reason why prices do not go down as much as would seem possible thanks to the subsidization, is that changes in final prices affect consumer decisions, and may end up driving prices up again. In our model, with perfect competition conditions and constant returns to scale, lower production costs that result in lower final goods prices, normally would stimulate demand for the good, and also for the necessary inputs. That increased demand for goods and for inputs would drive prices up again, dampening up to a certain point the price effect for consumers. We will verify if this is happening when we check the results of our quantity variables next.

Finally, we should also remember that, as we have provided support for agriculture with subsidies, we have also increased agricultural costs of production by driving wages up, even if only slightly. This also increases production costs, which are passed on to consumers through higher prices of food.

From what the theory tells us, subsidies can cause structural change. A large change in relative factor prices, such as we are seeing here with land prices, can lead different sectors to change the factor intensities in their production technologies (Burfisher, 2016). The hike in land rents that has resulted from this type of subsidization, in the long run, could stimulate agricultural production to become more capital-intensive and hire more labor (especially given that wages did not increase much), in order to be less land intensive.

Price variables only tell a part of the story, so let us look now at our quantity variables[64].

b. Agricultural production

Agricultural subsidies are generally supposed to stimulate production, by making it cheaper for farmers to produce, through lower prices for the inputs they need, or payments linked to production (Burfisher, 2016).

Much as with prices, the results show similarly mixed results.

The variable *qo* (production quantity) shows us the difference in agricultural output after our shocks. In terms of percentages, both the increases and the decreases are extremely small, in

[64] Here it is important to clarify that traded quantities in GTAP are expressed in value terms (USD millions). Pre- and post-shock quantities are both valued at the same initial prices, so the change in import value that we see in *q* variables is actually measuring quantity changes (Burfisher, 2016).

most cases smaller than 1%, but if we look at the dollar value, we find some winners, as well as losers.

Most products increase in output, with the best results in percentages for wheat (*wht*) which increases by 4,22% (USD 2,59 million worth of production), and other plant goods (*ocr*), for which the 6,08% increase means a jump of USD 91,62 million worth of output, making it the largest increase also in terms of value. Other notable increases in terms of value are USD 8,23 million for poultry and pork meats (*omt*), USD 10,7 million for oilseeds (*osd*), and USD 12,96 million for live poultry and pigs (*oap*).

Meanwhile, we see a *decrease* in output for vegetables and fruits (*v_f*), sugar crops (c_b), animal and vegetable oils (*vol*), sugar (*sgr*) and processed foods (*ofd*). In terms of value, these decreases are mostly large, going down USD 11,6 million for animal and vegetable oils (*vol*), USD 20 million for vegetables and fruits (*v_f*), and USD 32,62 million for processed foods (*ofd*). Manufacturing output also falls tremendously, by USD 165,35 million.

Here as well we look at the subtotals to identify the effects of the three subsidies separately, and we see that in general the output subsidy had the most positive effect in terms of stimulating production, bringing output down only for grains (*gro*), animal and vegetable oils (*vol*), and processed foods (*ofd*). The intermediate input subsidies, on the other hand, stimulated production in 11 out of 20 agricultural sectors, while for the other 9 they brought output down.

The land subsidy, as it did for prices, had the most negative effects on output, bringing it down in 16 out of 20 sectors. The only sectors that it helps are wheat (*wht*) and other plant goods (*ocr*).

In the case of animal and vegetable oils (*vol*) and processed foods (*ofd*), *all three* types of subsidies cause the output to fall. And even though we are looking at agricultural products, it is interesting to point out that the same happens in the case of manufactures.

One possible explanation for these output declines in some sectors is that producers have switched to other products, those that are perceived as doing better or growing more as a result of the subsidies.

These drops in output could explain the poor increase in labor wages for agricultural workers. If output in some agricultural sectors is decreasing, labor demand in those sectors could be decreasing too, depressing overall wages.

As we can see, agricultural output was very unevenly stimulated across the different sectors; now let us check whether consumption of agricultural products, either by households or by firms, has grown. When we were looking at prices, we already foresaw that private consumption of food would not have grown much in general, because when it comes to agricultural products, even large price drops do not bring a correspondingly large spike in purchases.

c. <u>Household demand for agricultural products</u>

Let us check the results of the shock on the variable *qp*, which is the consumer composite commodity quantity; that is to say, it shows the changes in household consumption of each agricultural product in the market in Ecuador. The results for *qp* show very small increases (less than 1% across the board) for private household demand of agricultural products, which means that homes are consuming practically the same amounts as before[65].

But what would be interesting to see is whether the subsidies have changed the *composition* of that household consumption, in terms of the quantities demanded of domestic products versus imports.

For this, we will look at another interesting pair of variables, *qpd* (consumer domestic quantity) and *qpm* (consumer import quantity). In this case, our results show that the demand for domestic agricultural products has increased in practically all sectors, with the biggest percentage jump to be found in the case of wheat (*wht*), for which demanded quantities grow by 8%[66]. This is by far the highest growth in percentages, compared to all the other domestic sectors, for which demand only grows between 0,003%, in the case of oilseeds (*osd*), and 1,78% in the case of plant fibers (*pfb*). However, in terms of value, 8% of USD 80 000 worth of domestic wheat is clearly a very small amount, only USD 7 300 due to the small size of the sector in Ecuador.

The largest increases in terms of value are USD 1,62 million for milled rice (*pcr*), USD 2,5 million for milk (*rmk*), USD 5,88 million for dairy products (*mil*), USD 7,92 million

[65] One interesting thing to observe with the results for *qp* is that, in this case, our subtotals do show more clear positive effects of both the output *and* the intermediate input subsidies, while the land subsidy retains more often than not its negative effect (for 14 out of 20 sectors).

[66] In relation to what was mentioned in the preceding footnote, it is interesting to note that, when we look at the subtotals for this variable, we see that 6 out of those 8 percentage points of growth for wheat happen as a result of the land subsidy, a noteworthy positive effect.

altogether for live animals (*ctl* and *oap*), and USD 10,72 million for the meat sector (*cmt* and *omt*). These are the products for which we saw *pp* and *ppd* decrease in the earlier section on prices.

These results show that Ecuadorian households are taking advantage of the relatively lower prices and are, on the one hand, consuming more of the number one staple food in the country, which is rice. And on the other hand, they are consuming more milk, dairy and meats, which are traditionally the more expensive, more "luxury" products for poor families, and are now slightly more affordable.

Let us now look at the private demand for agricultural imports. The analysis of the results of *qpm* shows some increases in the private demand for imported products such as paddy rice (*pdr*), wheat (*wht*), grains (*gro*), vegetables and fruits (*v_f*), oilseeds (*osd*), animal and vegetable oils (*vol*), sugar (*sgr*), processed foods (*ofd*) and beverages and tobacco (*b_t*). In terms of percentages, all of these are slight increases are larger than the increases in *qpd*, the demand for the domestic product, with the exception of wheat. Nonetheless, in terms of *value*, the demand for the domestic product has increased more than the demand for imports, except in the case of vegetables and fruits (*v_f*), animal and vegetable oils (*vol*), sugar (*sgr*) and processed foods (*ofd*), where the demand for imports has grown more.

There is also a number of imported products for which private demand decreases, such as sugar crops (*c_b*), fiber crops (*pfb*), other plant goods (*ocr*), live animals (*ctl* and *oap*), animal textile materials (*wol*), milk (*rmk*), dairy products (*mil*), meats (*cmt* and *omt*), and milled rice (*pcr*). Sometimes, these drops in demand are as large as USD 303 000 and USD 440 300, in the cases of other plant goods (*ocr*) and poultry and pork meats (*omt*). For all of these imported products that display a drop in private demand, the corresponding increase in demand for the domestic variety is much larger, and more than compensates the fall in imports, which means there is more consumption of these goods in general than there was before the shock, and most of the new consumption is of domestic products.

This means that most of those modest increases in private demand for agricultural products that we saw in *qp*, are caused by an increase in the demand for the subsidized domestic products, and not so much for imports of those products.

One result of this shock that is not very encouraging is the demand for domestic manufactures, which falls by USD 24,16 million, while the demand for imported manufactures rises by USD 38,12 million.

d. Firms' demand for agricultural products

Now that we have looked at household consumption, we can compare it with how industries are consuming agricultural products as inputs, and check what the effect of the subsidies has been. For this, we will look at the variables *qfd* (firms' domestic quantity) and *qfm* (firms' import quantity), which show us the changes in firms' demand for the domestic and imported varieties of each agricultural product.

Most sectors of the domestic industry demand more domestic agricultural inputs after the shock, with the exception of the animal and vegetable oils (*vol*), the sugar (*sgr*) and the processed foods (*ofd*) sectors, where the demand mostly drops; the demand for domestic products also drops in the manufacturing sector. The products that see an increase in demand across the board are domestic wheat (*wht*), fiber crops (*pfb*), other plant goods (*ocr*), animal textile materials (*wol*). This reflects the sectors that saw an increase and a decrease in prices, respectively, as we described in the corresponding section above.

Regarding agricultural input imports, we see a more mixed picture of results, with most sectors reducing their demand of certain imported inputs, and increasing their demand of others. The sectors that see the most reductions in imports for most industries are animal textile materials (*wol*) and sugar crops (*c_b*), while most industries increased their imports of paddy rice (*pdr*) and beverages and tobacco (*b_t*), as well as their imports of manufactures.

e. Agricultural trade

The changes in prices that we saw earlier, would be expected to have a corresponding effect on the exports of agricultural products from Ecuador to other countries. This is even necessary, since price drops generally do not bring about a proportional increase in the amounts of agricultural products consumed by households, due to the inelastic nature of demand regarding price when it comes to these products, and, as a result, the income of farmers can suffer. One way for producers to avoid incurring loss, is if they can sell their production abroad, through export.

The variable *qxw*, which registers what changes have taken place in the aggregate exports of each product from Ecuador at FOB prices, shows us a fall in the exports of paddy rice (*pdr*), grains (*gro*), vegetables and fruits (*v_f*), oilseeds (*osd*), animal and vegetable oils (*vol*), sugar (*sgr*), processed foods (*ofd*) and of beverages and tobacco (*b_t*), which are the sectors for which prices actually increased, as we saw earlier in the prices section.

Some of the falls in exports, however, are minimal in terms of value, such as USD 20 600 for grains (*gro*), and less than USD 1 000 in the case of paddy rice (*pdr*). The most significant falls, in terms of value, is USD 21,19 million worth of lost exports for vegetables and fruits (*v_f*), and USD 37,98 million for processed foods (*ofd*). The exports of manufactures and services also decrease by large amounts, USD 49,89 million and USD 33,98 million, respectively.

The remaining 12 agricultural sectors see increases in exports, which vary wildly depending on the product. For instance, for wheat (*wht*) exports increase by only USD 21 300, but for fiber crops (*pfb*) they go up by USD 1,67 million, and for other plant goods (*ocr*) they increase by USD 90,18 million. Other sectors have more modest increases, that do not reach USD 1 million individually.

The variable *qxs* (*,ecu,*), which reports changes in real quantities of Ecuador's exports to each individual trading partner, shows similar results for the same sectors.

Undeniably, producers would benefit greatly from the positive outcomes seen in the best-performing sectors; however, these are not necessarily the most interesting sectors for Ecuador from the point of view of exports, since they are still mostly basic commodities[67].

On the side of imports, the variable *qiw* shows us the change in the aggregate imports of agricultural products into Ecuador at CIF prices. Here too the changes are not very significant, and for some products, imports have increased instead of decreasing: paddy rice (*pdr*), vegetables and fruits (*v_f*), other plant goods (*ocr*), animal and vegetable oils (*vol*), sugar (*sgr*), processed foods (*ofd*) and beverages and tobacco (*b_t*). Once again, these are the products for which the domestic price has increased. Imports of manufactures and services also increase slightly.

The results of the variable *qxs* (*,*,ecu), which reports the changes in the quantities of Ecuador's imports of agricultural products from individual countries, are also consistent with this.

[67] Due to the fact that the *ocr* category is very broad, as we had mentioned before, it is not immediately clear exactly which products are driving the positive results for this sector; it is possible that it is roses and cut flowers, given that this is traditionally a very competitive sector for Ecuador. Without further disaggregation, it is not possible to know for certain.

Given the effect of the shock on the agricultural imports and exports of Ecuador, it would be interesting to check the variables that report the changes in a country's trade balance: *dtbal* for the general trade balance, and *dtbali* for each individual sector[68].

The result of the variable *dtbal* is negative: Ecuador's trade balance has fallen by USD 197,83 million. In this case, we see that all three subsidies are responsible for the negative effect, with the output subsidy costing Ecuador USD 72,97 million (Subtotal 1), and the intermediate input subsidies costing USD 123,86 million (Subtotal 3). The land factor subsidy, on the other hand, only reduces the trade balance by a little over USD 1 million.

To see this in more detail, *dtbali* shows us the sectors for which the trade balance has deteriorated. The worst off are processed foods (*ofd*), which loses USD 32,5 million, followed by vegetables and fruits (*v_f*), an extremely important sector for Ecuador, that employs hundreds of thousands of people along the value chain, which has lost USD 15,4 million. Animal and vegetable oils (*vol*) is also down by USD 3,5 million, while the manufacturing sector is down by USD 177,8 million, and the services sector loses USD 38,6 million.

While the sectors where the trade balance improves are the majority, the amounts are modest, often less than USD 1 million, with the notable exception of other plant goods (*ocr*), which ends up with a positive trade balance of USD 73,1 million.

It is interesting for this variable to look at the subtotals and see which of the subsidies has had the dominant effect. As we saw earlier with the prices, the factor subsidy to land (Subtotal 2) has a very strong effect, in most cases negative, and it often counteracts the positive effects of the output subsidy (Subtotal 1)[69], the intermediate input subsidy (Subtotal 3)[70], or both, as most notably in the case of vegetables and fruits (*v_f*), where the land subsidy effect is so strong it single-handedly sinks the trade balance, and in the case of other plant goods (*ocr*), where the land subsidy does the exact opposite.

Another variable that is relevant to understand the benefits and disadvantages of the subsidies in Scenario 1, is *vxwreg*, which shows the change in the value of Ecuador's aggregate exports. As a result of this first shock, this value has fallen by 0,19%.

[68] Both variables report results in USD millions.

[69] Sometimes to the point of nullifying those positive effects, as we see in the case of sugar (*sgr*) and paddy rice (*pdr*).

[70] As in the case of grains (*gro*), live poultry and pigs (*oap*), meats (*cmt* and *omt*).

The variable *vxwfob* presents the same information, but disaggregated for individual agricultural products. Here again we see the same mixed effects, with half of all sectors reducing the value of their exports, and the other half increasing in value. The sectors that benefit the most are wheat (*wht*), with an increase of 12,92% in value, milk (*rmk*) with 27,84%, and animal textile materials (*wol*) with 67,99%. For the sectors that decrease in value, the biggest loss is for animal and vegetable oils (*vol*), with -1,92%.

f. <u>Household income</u>

We can also look at the effect that our shock has had on household income. For this, we examine the variables *y* and *yf*, which show the changes in regional household income and in farm income specifically.

The regional household income grows by 0,34%, but for farm households the increase is much more significant: 8,9% for the nominal income (*yf*), and 8,57% for the income adjusted for inflation (*yfreal*). More specifically, we can also look at the real farm income for agricultural activities (*yfrealon*), as opposed to other rural activities that are not farming, and there we see an even larger increase in income: 11,05%. This would mean a very significant improvement in the livelihoods of rural households, bringing many families out of poverty and extreme poverty.

While the increase in farm income is indeed quite impressive, when we look at the subtotals we find that it comes mostly from the land subsidy (*tf*). This complicates the landscape of our results because, as was mentioned earlier, the land subsidy was the one dampening the price effects of the two other subsidies, pushing the prices of agricultural products up for consumers instead of down.

As we said at the beginning of the result analysis, aside from other effects it causes, the land subsidy is responsible for a gigantic increase in the price of land. It is essential to remember that land distribution in Ecuador is extremely unequal. As we mentioned in an earlier chapter, 60,8% of agricultural lands in Ecuador are owned by a mere 6,4% of landowners. This means that the bulk of the subsidies given on the basis of land property, would be going to the hands of wealthy landowners, and not to the small producers and poor families that actually need them the most.

This is important to consider, because as we have seen the wages of low-skilled agricultural workers did not increase much as a result of the shock, and all these families that are salaried farm workers but do not own land would not benefit directly from the land factor subsidy. There are many possible reasons for this; since these are low-skilled workers, they are more easily substituted, which may stifle any increase of the relative wage rate.

g. <u>Equivalent variation</u>

Finally, the GTAP model includes a welfare analysis utility that calculates the equivalent variation (*EV*) welfare effect of an economic shock. The variable *EV* shows us the difference in income that would be required after the shock, in order to attain the new levels of utility, valued at base-year prices (Burfisher, 2016); this difference is the decrease or increase in welfare. GTAP calculates the *EV* on the level of the regional household, so this includes the private household and the government, plus domestic savings (Burfisher, 2016). Welfare effects are reported in levels, in USD millions.

The GTAP utility disaggregates the total welfare effect into various components, of which two are particularly relevant to our study: the allocative efficiency effects, related to the balance of the taxes and the cost of the subsidies for the economy, and the terms-of-trade effects, which measure the price of the country's exports relative to its imports, in other words, the import-purchasing power of its exports[71] (Burfisher, 2016).

The value of *EV* for Ecuador after the first experiment is of USD 27,88 million, which means Ecuador is better off thanks to the shock. Opposite to what we have seen with a number of variables, in this case the subtotals all contribute positively to this effect, including the shock to the land factor subsidy (Subtotal 2). However, the biggest contributor to this value of *EV* is the intermediate input subsidy (Subtotal 3).

When we go to the decomposition of *EV*, we find a positive effect of USD 17,8 million in resource allocation, as well as a larger positive effect of USD 20,4 million in the terms of trade in goods and services, that is, the amount of imports that Ecuador can afford with its exports[72]. The likely explanation for the improvement in allocative efficiency despite the subsidies, is that the shock eliminated initial distorting taxes.

[71] The other components are endowment effects due to changes in factor supplies, technical change due to productivity gains or losses, the effects of population growth, changes in savings and investment flows, and changes in preferences (the structure of aggregate demand) (Burfisher, 2016). We will not be going into detail with these other components, as they are not the focus of the present research.

[72] What brings the total down to USD 27,88 million is a negative value of the investment-savings terms of trade, which will not be discussed further as it is not the focus of this work.

5.3. Results of Scenario 2 - Direct payments (green box subsidies)

We have seen that Scenario 1 had very diverse effects, some positive, some negative. With regard to real farm income, it resulted in a remarkable increase, which is an important socioeconomic result in a country like Ecuador, where such a large share of the poorest people are the farmers.

Nonetheless, the subsidies provided in Scenario 1 are exactly the type of support that, as we discussed in Part I, has the worst effects on the environment, and is the most production- and trade-distorting, according to researchers and international agencies and organizations.

For Scenario 2, we want to reach the same level of increase in farm income, but instead of the output, intermediate input and land subsidies given in the first experiment, Ecuador will be supporting its farmers by providing minimally distorting green box subsidies, specifically decoupled land payments. We will then compare the effects with Scenario 1, and see if this second shock improves in any way the negative effects, especially regarding the country's exports and trade balance.

After running our experiment and getting our results[73], we will first look at what the effect has been on the country's GDP. Both for *gdpsrc*, the calculation of GDP from the sources side, and for *gdpexp*, which is from the expenditures side, the value of GDP after the shock is of USD 104,03 billion, which implies a decrease of USD 260 million from our pre-shock GDP.

The result of the variable *qgdp* shows that the effect on the country's real GDP amounts to USD -79,81 million.

With this new value of GDP, we will also quantify the four taxes that we analyzed in Scenario 1, in order to compare their values with their base year levels[74]. In this case they are also still all net taxes, meaning that the government is still earning revenue from these sectors and factors more than it is transferring to them through the subsidies provided.

[73] All the relevant simulation results for Scenario 2 can be found in Appendix 2.

[74] Even though we have only shocked the factor tax of one factor of production, as we saw after the first experiment, shocking one factor tax will have an effect on the revenue collected from other factors, and from the different sectors of agriculture, which is why it is still important to compare all four taxes.

Output (or income) tax (*to*): The output tax value amounts to USD 10,26 billion (9,86% of post-shock GDP), up USD 36,75 million from what was collected pre-shock.
If we look at the values sector by sector, we see that in Scenario 2 we go back to having all negative values, like we had pre-shock, meaning that all sectors would be generating net revenue for the government as a result of output, given that no output subsidy is provided.
In Scenario 1, the government sees its tax revenue reduced by USD 12,8 million, while the Scenario 2 results in an increase in tax collection with regard to the base year, as a result of the stimulus to agricultural production.

Taxes on primary factors (*tf*): The factor tax value is of USD 3,65 billion (3,5% of post-shock GDP), which represents a staggering decrease of USD 862,75 million with regard to what was collected pre-shock.
For land, the value of the tax is now negative, meaning there is a net subsidy, which amounts to USD 801,31 million. The value of the resources transferred to landowners, on top of the loss of USD 47,79 million from land taxes that were collected pre-shock, amounts to USD 753,52 million. In Scenario 2, the land subsidy is therefore USD 337,84 million higher than in Scenario 1, making this shock much more costly for the country.
Tax revenue from the other factors has been affected as well: the net taxes that the government is collecting from both types of labor and from capital, have decreased between USD 3 and 6 million compared to what they were before the shock.

Taxes on firms' domestic purchases of inputs (*tfd*): The value for the tax/subsidy on domestic inputs is at USD 1,38 billion (1,32% of post-shock GDP), down USD 3,89 million from what was collected pre-shock. When we look at the amounts sector by sector, we also see here that all sectors are generating net revenue, given that no intermediate input subsidy has been provided.

Taxes on firms' imports of inputs (*tfm*): The value for the tax/subsidy on imported inputs is now at USD 76,79 million (0,07% of post-shock GDP), down USD 254 658 from what was collected pre-shock. Since our shock did not include intermediate input subsidies, the amounts sector by sector show us a similar situation as pre-shock, where hardly any taxes are earned from most of these inputs, except for manufactures sector.

The value of all four taxes in total comes down to USD 15,37 billion (14,77% of Ecuador's post-shock GDP), which means that Ecuador's government revenue has decreased by USD 830,14 million (0,79% of post-shock GDP). This is the cost of the subsidies provided to farmers in Scenario 2 to the government of Ecuador.

Now let us look at the full results from Scenario 2, and analyze its impacts on the production activity in agriculture, on the production factors, on agricultural output, on the income of farmers' households, on foreign trade, and on GDP. We will once more begin with our price variables, and with the market of production factors.

a. Price effects

The green box subsidies in Scenario 2 give us an even larger increase in the price of land: 46,65%. Labor wages, on the other hand, have decreased slightly, by 0,81% for unskilled agricultural labor, and 0,02% for other labor. The rent of capital increases by 0,05%, while for natural resources the increase is of 1,55%.

While the price of land increases dramatically, the prices to the consumer (*pp* and *ppd*) and the agricultural producer supply price (*ps*) of practically all agricultural products drop, clearly more so when it comes to the prices for the domestic products. In some cases, prices decrease by 9 to 10,5%, such as in the case of grains (*gro*), paddy rice (*pdr*), oilseeds (*osd*) and sugar crops (*c_b*). For other products, the decrease is less dramatic, with 6,5% for wheat (*wht*), 5,1% for animal textile materials (*wol*), 3,1% for milled rice (*pcr*), and 3,4% for sugar (*sgr*). Finally, for sectors such as live animals (*ctl* and *oap*), meats (*cmt* and *omt*), milk (*rmk*), dairy products (*mil*), processed foods (*ofd*) and beverages and tobacco (*b_t*), the decrease is of less than 1%. The prices of manufactures and services also decrease by 0,1%.

A few prices see an increase, namely 1,3% for vegetables and fruits (*v_f*), 1,5% for fiber crops (*pfb*), and 1% for other plant goods (*ocr*).

The prices of agricultural inputs for firms (*pf*) show a similar picture as we saw above: prices drop across the board, up to 10,6% for paddy rice (*pdr*), oilseeds (*osd*) and sugar crops (*c_b*), with a less pronounced drop for other products, and a slight increase for vegetables and fruits (*v_f*), fiber crops (*pfb*) and other plant goods (*ocr*). When we observe the prices of the domestic inputs from agriculture (*pfd*), we see the same results, with equal or sometimes larger price drops depending on the product.

Export prices (*pxw*) also show the same pattern, with big decreases especially paddy rice (*pdr*), wheat (*wht*), grains (*gro*), oilseeds (*osd*), and sugar crops (*c_b*), smaller decreases in most other products, and slight increases for the same sectors mentioned above. This result is also the same for *pr*, the price ratio of domestic to imported prices in each of these sectors.

As we mentioned earlier, one reason for some sectors to see a smaller decrease or even a slight increase in price is that price drops tend to stimulate demand, and in time higher demand will bring prices up again. Another reason that keeps some prices from falling is that Ecuador is not self-sufficient, and still needs to import agricultural consumer goods, whose prices have not changed, and bring up the average price of these goods in the domestic market; we can see this effect particularly when we examine the *pp* variable, that makes no distinction between domestic and imported products.

Finally, in Scenario 2 agricultural labor wages have dropped, which also lowers production costs, and result in a lower price for consumers.

Comparing the price effect here with the one we observed in Scenario 1, we can easily see the difference between the two shocks in terms of the effect on prices of agricultural products. The green box decoupled subsidies, since they are not given in different amounts to different products, seem to have had a much more homogenous, and largely positive, impact on prices across the board.

Let us now move to other variables, in order to see how the decoupled subsidies have affected agricultural output and demand, and which of our two scenarios had a better effect.

b. Agricultural production

The output variable (*qo*) shows an increase in 17 out of 20 agricultural sectors: the only sectors where output falls are fiber crops (*pfb*), other plant goods (*ocr*), and vegetables and fruits (*v_f*), which are also the sectors where prices have increased.

In percentages, the falls in output in the vegetables and fruits (*v_f*) and other plant goods (*ocr*) sectors may seem small in percentages, but in value terms they mean a loss of USD 78,69 million worth of output for other plant goods (*ocr*), and of USD 160,25 million for vegetables and fruits (*v_f*).

Four sectors that saw decreases in output in Scenario 1, are now seeing increases: sugar (*sgr*), processed foods (*ofd*), sugar crops (*c_b*) and animal and vegetable oils (*vol*). The most

dramatic increase in percentage is for wheat (*wht*), with 19,8% more output, and good results for oilseeds (*osd*), sugar crops (*c_b*) and animal and vegetable oils (*vol*).
In terms of value, the increases are quite encouraging: USD 4,92 million worth of additional output for live animals (*ctl* and *oap*), USD 5,43 million for meats (*cmt* and *omt*), USD 9,13 million for milled rice (*pcr*), USD 12,22 million for wheat (*wht*), USD 12,74 million for sugar crops (*c_b*), USD 16,89 million for grains (*gro*), USD 17,02 million for sugar (*sgr*), USD 34,18 million for oilseeds (*osd*), USD 47,44 million for animal and vegetable oils (*vol*), and USD 103,89 million for processed foods (*ofd*). There is also an increase of USD 39,89 million worth of output in the manufacturing sector.
For most of these products, the increases are larger than they were in Scenario 1. In other cases, the increase in output is smaller than it was with our first shock, specifically for live animals (*ctl* and *oap*), milk (*rmk*), meats (*cmt* and *omt*), and dairy products (*mil*).
In Scenario 2, we see that more products are positively stimulated by the subsidy. We find a particularly good result for sectors that are important for Ecuador, in terms of reducing our dependence on imports, such as wheat; the subsidization in this case seems to have reactivated this agricultural sector, fundamental for Ecuador's food security and food sovereignty, which has long struggled not to disappear completely. The decoupled direct payments also seem to stimulate crops more than they do animal agriculture, which is the type that causes more environmental harm.
As we pointed out in the analysis of Scenario 1, a possible cause for the shrinking of output in vegetables and fruits (*v_f*), fiber crops (*pfb*) and other plant goods (*ocr*) is that producers may be switching to other crops where there is growth, and as a result the sector becomes smaller. We also see more stimulus for higher value-added products, such as animal and vegetable oils (*vol*), milled rice (*pcr*), sugar (*sgr*), processed foods (*ofd*) and beverages and tobacco (*b_t*), as well as for manufactures, which is a positive development.

c. <u>Household demand for agricultural products</u>

Let us now look at private demand for agricultural products. Usually, if there is a relative income increase, consumer demand goes up for all goods, but substitution is increased for luxury goods, in this case, services. Agricultural products are usually necessity goods, which means consumption does not increase on par with increases in income or drops in prices, and the budget share of agricultural products may decrease.

For this reason, as expected, the variable *qp* shows no large increases in private consumption of agricultural products, and even some small declines.

Nonetheless, it is important to look in more detail and see whether households are consuming more of any domestic product, with *qpd*.

The variable *qpd* shows us slight increases in the demand for practically every domestic product, with the sole exception of vegetables and fruits (*v_f*), fiber crops (*pfb*) and other plant goods (*ocr*). Given the size of the sector, the 0,76% decline that vegetables and fruits (*v_f*) suffer is the largest drop in terms of value, as it represents USD 1,82 million.

The domestic product that shows the most improvement in percentage, by far, is wheat (*wht*), with demand climbing up 35,1%. The value shows us that the increase in quantity is only USD 30 000 worth of wheat, which is, of course, a very small amount, but would still be a positive and encouraging result for the struggling wheat producers in Ecuador. It is important to remember that wheat grains are not consumed directly as such in Ecuadorian diet, but mostly as flour, which is why the household consumption of wheat does not increase so much.

In terms of value, the best results are the increases of USD 4,21 million in demand for domestic manufactures, USD 4,61 million for processed foods (*ofd*), USD 5,46 million for sugar (*sgr*), and USD 8,01 million for animal and vegetable oils (*vol*).

The private demand for imports, on the other hand, as shown by the results of *qpm*, decreases in most cases, with the exception of vegetables and fruits (*v_f*), fiber crops (*pfb*) and other plant goods (*ocr*). The increase in the demand for imported vegetables and fruits (*v_f*) is the largest in terms of value, amounting to USD 1,44 million. On the other hand, the sharpest decreases in the demand for imports amount to USD 2,91 million for sugar (*sgr*), USD 3,58 million for processed foods (*ofd*), and USD 7,13 million for animal and vegetable oils (*vol*). Household demand for imported manufactures also falls by USD 14,78 million.

After analyzing private demand, we can look at what has happened with firms' demand for the domestic and imported varieties of each agricultural product, through variables *qfd* (firms' domestic quantity) and *qfm* (firms' import quantity).

d. Firms' demand for agricultural products

The sectors of Ecuador's industry that demand a higher amount of domestic agricultural inputs are mostly wheat (*wht*), oilseeds (*osd*), live poultry and pigs (*oap*), milk (*rmk*), animal textile materials (*wol*), meats (*cmt* and *omt*), animal and vegetable oils (*vol*), dairy products (*mil*), milled rice (*pcr*), sugar (*sgr*), processed foods (*ofd*), and beverages and tobacco (*b_t*), as well as manufacturing. The domestic products demanded across more sectors are paddy rice (*pdr*), wheat (*wht*), grains (*gro*), oilseeds (*osd*), sugar crops (*c_b*), animal and vegetable oils (*vol*) and sugar (*sgr*).

Reading this result along with that of the variable *qo*, analyzed above, we see that a portion of the increased output, is not being directly consumed or exported as such, as a primary product, but being bought up by firms, and processed into higher value-added products. As a result, those increases in agricultural output are feeding into the millions of dollars' worth of additional output we saw in sectors like milled rice (*pcr*), sugar (*sgr*), processed foods (*ofd*), as well as in manufactures.

An examination of the results for variable *qfm* shows us that, while a few sectors see an increase in demand for some imported inputs, in general the demand of firms for imported products is reduced. In sectors such as paddy rice (*pdr*), grains (*gro*), vegetables and fruits (*v_f*), sugar crops (*c_b*) and other plant goods (*ocr*) there is a reduction in imports of *all* agricultural inputs. Industries are of course still importing inputs, and there is still dynamic trade with our partners, but the share of domestic agricultural products that they are using has undisputedly expanded.

e. Agricultural trade

Since we have a drop in prices in almost every sector, combined with an increase in output, an effect on exports and imports of agricultural products should be expected. Let us now move to analyzing the results of variables *qxw* and *qiw*, as well as variable *qxs* (*,ecu,*) for exports, and (*,*,ecu) for imports.

Ecuador's agricultural exports in general increase for every product, except for the three sectors mentioned before, vegetables and fruits (*v_f*), fiber crops (*pfb*) and other plant goods (*ocr*). The percentages show remarkable growth for some products, such as 63,7% for oilseeds (*osd*), 81,7% for sugar crops (*c_b*), 96,3% for animal textile materials (*wol*), 71,7% for wheat (*wht*), and 205,6% for paddy rice (*pdr*). In terms of value, these increases are sometimes less impressive, amounting to USD 1,59 million for oilseeds (*osd*), USD 250 000 for animal textile materials (*wol*), USD 100 000 for wheat (*wht*), USD 40 000 for paddy rice (*pdr*), and only a few thousands for sugar crops (*c_b*).

In terms of value, the export increases are more impressive in other products: USD 1,79 million for grains (*gro*), USD 8,18 million for sugar (*sgr*), USD 25,46 million for animal and vegetable oils (*vol*), and USD 98,22 million for processed foods (*ofd*). Export of manufactures also increases by USD 15,88 million.

However, the falls in exports of two products are also quite large, with a loss of USD 77,65 million in exports for other plant goods (*ocr*), and a staggering USD 156,54 million for vegetables and fruits (*v_f*). As we suggested earlier, this may be a sign of producers switching away from these sectors, where some of Ecuador's traditional exports are found, to other products that seem more promising, now that domestic demand has gone up, and the price has made them more attractive for export. These other products, namely sugar (*sgr*), animal and vegetable oils (*vol*) and especially processed foods (*ofd*), are higher value-added products.

Regarding imports, the results for variable *qiw* show a drop in the aggregate imports of practically all agricultural products, with the exception of imported vegetables and fruits (*v_f*), fiber crops (*pfb*) and other plant goods (*ocr*), for which demand instead increases.

After examining both exports and imports, let us now check the changes in Ecuador's trade balance, as a whole and for each sector separately, with *dtbal* and *dtbali*.

In Scenario 2, the result for the variable *dtbal* is now positive; Ecuador's trade balance has improved by USD 63,69 million. When we examine the results of *dtbali*, we can see which sectors are responsible for this gain.

As we can imagine from the results already reported above, the vegetables and fruits (*v_f*) sector, loses USD 106,29 million and other plant goods (*ocr*) loses USD 64,33 million, but there is a gain in the trade balance for every other sector. The improvement amounts to USD 5,96 million for grains (*gro*), USD 12,82 million for wheat (*wht*), USD 11,22 million for sugar (*sgr*), USD 28,14 million for animal and vegetable oils (*vol*), and USD 82,39 million for processed foods (*ofd*). The trade balance for manufactures gains USD 77,03 million, and USD 12,54 million for services.

We can now also check the change in the value of Ecuador's exports of each agricultural product with *vxwfob*. This variable shows decidedly more positive results than with our first shock, with almost all Ecuadorian exports gaining in value, with the only exception of the same three sectors that we have seen contract consistently across different variables: vegetables and fruits (*v_f*), fiber crops (*pfb*) and other plant goods (*ocr*).

Due to how the different subsidies interact and sometimes offset each other, it is striking that when we provided three different types of subsidies in our Scenario 1, the land factor subsidy had the most negative effects, while when we provided only the land payments by themselves in Scenario 2, and in greater quantity, the effects turned positive, outweighing the positive effects of Scenario 1.

f. Household income

Since our real farm household income was our target variable with the second shock, we already know that our variable *yfreal* will be around 8,54%. Nominal farm income grows by 8,29%, and the real farm income for on-farm activities (*yfrealon*) increases by 11,07%, so the main goal of this agricultural support program for rural families is reached.

Nonetheless, the regional household income *falls* by 0,29%, which means that in this Scenario the increase in the income of farmers up to a certain point comes at the expense of non-farmers.

It is interesting to contrast this result, with the increase we found in household demand for domestic agricultural products. Normally, if there is a loss in income for a large part of the population, we would not expect to see household agricultural demand increasing. But we *did* see slight increases in private consumption of practically every domestic agricultural product. I believe this is best explained by the comparatively large increase in income for farmer families; as we mentioned earlier in this work, the agricultural sector is the largest employer in Ecuador, such that the families impacted by the rise in farm income are many. An increase in private consumption of domestic food is consistent with the increase in income for a large number of poor households, since, as we know, it is the poorest consumers who purchase more food when their income grows.

g. Equivalent variation

To conclude, let us check the value of *EV*, which for this second experiment is at USD -46,84 million, which means the country is worse off in this scenario than it was before the shock.

The decomposition of *EV* shows us a large positive effect of USD 29,23 million in the terms of trade in goods and services, larger than it was as a result of Scenario 1[75]. It is the allocative efficiency effect that brings down the total, as it is strongly negative: USD -79,81 million.

Despite the differences in their respective results, Scenarios 1 and 2 share one important downside: the way they both steeply increase the cost of land. In the case of Ecuador, due to the fact that land ownership in the country is plagued by inequality, this causes a series of problems.

First of all, those who would benefit the most from the land subsidy are those farmers who already own land, but not the millions of agricultural workers who are hired farmhands, and not landowners. For them, as we have seen, there is only an almost non-existent increase in wages that would have a very limited effect on their income.

Secondly, for peasants who would be in the market for acquiring land, especially for small landowners who would like to expand their holdings and for young farmers, land would become much less affordable, thereby making it more difficult for them to improve their economic situation.

Finally, as we had mentioned, a large percentage of agricultural lands (60,8%), are in the hands of a few corporate, wealthy landowners who own properties of 50 hectares or more, so it would be corporations who would end up benefitting the most from the support, taking the lion's share of the financial gains.

6. CONCLUSIONS

Along these pages, we have reviewed the advantages and disadvantages of different types of agricultural subsidies, we have examined the Ecuadorian agricultural sector in detail, and we have designed and run two shocks on the subsidy structure of a model economy of Ecuador, using GTAP-AGR.

For our experiments, we set ourselves the goal of increasing farm income, in order to fight poverty in rural areas, which is a policy priority in Ecuador. For this purpose, the mix of

[75] The terms of trade for investment and savings register a positive value of USD 3.74 million for this shock.

output, input and factor subsidies simulated in Scenario 1 was very successful. This shows us why amber box, coupled subsidies are so persistently used in different countries all over the world. They may have negative effects on the environment, distort production, prices and world trade, but in the country that provides them there are some clear benefits for the agricultural sectors that receive them, and especially for the income of the farmers.

Nonetheless, the results of Scenario 1 were otherwise heterogenous, boosting the sectors linked to animal agriculture in general, to the detriment of most basic crops and higher value-added agricultural products, so that the benefit to farmers would vary widely depending on the particular agricultural activity they were involved in.

It is important to remember that, for this experiment, we made the subsidy structure of Ecuador similar to that of an OECD country, which means we have "imported", with no adjustment, the subsidies that other countries, with vastly dissimilar levels of agricultural and industrial development, and largely more diversified economies than Ecuador, use for their farmers, for the products that they consider important for different reasons.

This may explain why we get these somewhat odd results, with unexpected sectors like other plant goods (*ocr*), fiber crops (*pfb*), and animal products come out on top, while others such as vegetables and fruits (*v_f*) benefit much more modestly, or not at all, as in the case of animal and vegetable oils (*vol*).

Scenario 2 also hit the farm income target, as the experiment was designed to do. But also in terms of prices, agricultural output, household and firms' demand for domestic products, terms of trade, and trade balance, the positive effects of Scenario 2 were more pronounced and more homogenous across agricultural sectors.

The decoupled payments in Scenario 2 seem to have had all-around better results, a clearer and more consistent positive effect as they stimulated output and lowered prices for most agricultural products, especially in sectors with higher value added, and also for manufactures. The direct payments also increased agricultural exports, which are essential for Ecuador to sustain dollarization.

The agricultural sectors that experienced loss were only three, including the most traditional Ecuadorian export sectors, vegetables and fruits (*v_f*), and other plant goods (*ocr*). This may indicate that agricultural producers feel emboldened to venture outside of the "safe zone" of bananas and flowers, and into other products with better perspectives and higher value added.

Another positive point of Scenario 2 is that, for a country like Ecuador, which like many developing countries faces institutional capacity challenges, the green box land subsidies implemented in Scenario 2, which are provided by hectare, are technically simpler to calculate and apply, as well as easier to monitor.

Nonetheless, Scenario 2 has an important disadvantage, which is its elevated cost to the taxpayers, who in the end are also the consumers. The green box subsidies given in Scenario 2, at a cost of USD 830,14 million, are USD 138,67 million more costly to the government than emulating OECD subsidies in Scenario 1, for the same increase in real farm income.

Policy recommendations:

One way of reducing the cost to the government would be to provide the land subsidy in a focalized manner. This means that the land subsidy should be targeted at medium and small holders, by establishing a maximum size of the agricultural property as a prerequisite to becoming a recipient. The maximum size could be 50 hectares of land, which would cover family subsistence UPAs and intermediate entrepreneurial UPAs, with an exception for community-owned and cooperative-owned lands, where many rural families collectively own and exploit an agricultural property.

Corporate farms and large estates over 50 hectares would receive no subsidy and would continue to pay taxes. In this way, large landowners would contribute to finance the subsidy for small and medium landowners, creating a redistribution of wealth. This could also discourage further accumulation of land for medium-sized farms.

Since approximately 60% of the land would not receive a benefit, appropriately targeting the green box land subsidy from Scenario 2 could arguably reduce the cost of the support to the taxpayers by that same percentage.

The rest of the funds could instead become a green box direct payment to labor, with the aim of reaching the agricultural workers who would not receive a land payment because they do not own a farm, and also in order to prop up the low-income non-agricultural households whose income decreased on account of the subsidies given in our second experiment.

This income supplement for farmer families could be provided through food aid programs, where food would be purchased by the government and then distributed to disadvantaged households either through direct delivery of food in kind, or through a type of food stamps.

This would help fight food insecurity while at the same time giving direct financial aid to struggling families. By extending such a benefit beyond agricultural workers to poor urban families, the effect of the subsidization would reach more people in need, and help to bolster non-farm household incomes as well.

The model that was used for the present research does not allow for the simulation of a targeted subsidy, where larger, corporate properties would not receive a payment. Future studies could further adjust the model in order to make such a simulation possible, with a view to observing the impact of such a differentiated policy instrument, more adjusted to the reality of agriculture in a country like Ecuador.

The two scenarios we tested, with coupled and decoupled subsidies, had both positive and negative effects. In both scenarios, reaching our goal of increasing farm income came at a price: the same policy that on the one hand can increase the income of peasant households, can also increase export prices, and negatively affect the agricultural trade balance, or incentivize the types of animal agriculture that cause the most damage to the environment, or indirectly cause a loss of income for other households outside of the rural setting.

Our experiments have shown us the realities of domestic support beyond the theories and beyond the anecdotical experiences. There is no "one-size-fits-all" solution, no recipe that will work in one country and can then be directly copied into another. It is necessary to take into consideration the unique economic and social characteristics of each economy, in order to modulate the support that will be provided to agriculture in each case.

Realistically, there is no ideal subsidy policy that will fulfill all of a country's objectives and yield good results in every aspect of the economy. It will always be necessary to place national objectives on a scale, to establish a hierarchy, in order to determine what is of paramount importance for the country, and adjust the subsidies towards those priorities. As a result, correctly calibrating the subsidy structure for a country to mitigate the negative effects as much as possible, is an extremely complicated task.

Earlier in this work I asked this question: "How best to reform agricultural support, in order to prioritize sustainable agriculture in a way that helps eradicate hunger and reach food security, contributes to mitigate the effects of climate change, and reduces inequality?"

The answer is that there is no single answer. Any policy reform project aimed at redesigning agricultural subsidies toward this goal, will depend on a range of factors and circumstances that are unique to each country.

That is the importance of conducting careful, detailed country-specific research, such as what I have attempted in this work. Hopefully, these observations will be of interest to policy analysts and advisors, government decision-makers and in general to professionals interested in the economic impacts that need to be foreseen and managed, when considering a transition from amber box subsidies to green box subsidies.

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8. APPENDICES

See attached pages.