Master in Economics: Empirical Applications and Policies

University of the Basque Country UPV/EHU

Master Thesis

The Fiscal Implications of Energy Transition in the Transport Sector: A Case Study of the Basque Country

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Abstract

This Master Thesis analyses the socioeconomic and fiscal challenges that arise from the transition towards a climate-neutral economy by 2050 in the Basque Country. The research focuses on the gradual elimination of fossil fuels in the transport sector and evaluates the socioeconomic and fiscal implications of the decarbonization policy proposed. The study also highlights the importance of sensitivity analysis and household's consumption patterns in analyzing the socioeconomic and fiscal impact of the energy transition. Overall, this Master's Thesis provides valuable insights into the fiscal implications of the energy transition in the transport sector and offers policy recommendations for a sustainable and climate-neutral economy.

Key words: Fiscal implications, net-zero GHG emissions, electrification, decarbonization, Basque Country, sensitivity analysis, transport sector.

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1. Introduction

With growing scientific evidence on the causes and consequences of climate change, many policy institutions and markets are moving towards a zero-carbon emission transition at global, state, and regional level. The European Union (EU) aims to position as the first carbon-neutral continent by 2050 (European Commission, 2019); i.e., an economy with net-zero greenhouse gas (GHG) emissions. Member states and regions are also committed to this goal, making great efforts to implement new laws and measures for specific climate and energy targets. The Basque Country is no exception and has established a legal framework to meet the target of net-zero emissions by 2050, and to achieve the balance of carbon neutrality. In this context, the Basque Country aims to gradually eliminate the use of fossil fuels (Gobierno Vasco, 2022).

The Basque Country has a long history in energy and industrial policies that have positioned it as a benchmark region in these matters. Due to the strong industrial nature of the Basque economy, which is close to a 40% contribution of industry and advanced services related to GDP (EUSTAT, 2023), industrial policy stands as an essential tool to direct the transition towards climate neutrality, with the ambition that the Basque industry becomes an accelerator and engine of change, innovation and sustainable growth (Gobierno Vasco, 2023).

Moreover, around 25% of global GHG emissions come from the transport sector (Zhang and Fujimori, 2020), which is one of the sectors where emissions are still increasing, and accounts for 43% of final energy consumption in the Basque Country (EUSTAT, 2023). Road transport is the largest contributor to these emissions, accounting for over 50% of all GHG emissions in the transport sector. The use of electricity as a replacement for traditional fuel sources in road transport is a significant method for reducing direct CO2 emissions and addressing the imbalance between oil supply and demand. Several governments have established objectives for the substitution of diesel and gasoline engines by 2050, as electric vehicles are viewed as a promising technology and an appealing solution for low-carbon private transportation (Weiss et al, 2012; Kihm and Trommer, 2014).

However, the transition to clean energy sources arising from international policies could have considerable impact on state and regional economies, in general, and on government finances and fiscal policies, in particular; since fossil fuels are a major source of revenue and support public services at all levels. Therefore, the international political and market mechanisms of the energy and climate change regimes can be an opportunity to rebalance domestic and regional political economies to advance clean energy initiatives.

In this context, this Master Thesis aims to provide a comprehensive analysis of the socioeconomic and fiscal impact of the gradual elimination of fossil fuels and the electrification in the transport sector. The study proposes specific policies to address the socioeconomic and fiscal challenges that arise from the transition towards a climate-neutral economy by 2050. The research hypothesis behind the final fiscal impact is not clear. On the one hand, the revenue from the transport sector would fall, as fossil fuels would be replaced by electricity, since electricity is more efficient and taxation would be lower. On the other hand, the revenue from value added taxes on other goods and services would rise, as the increase in income from lower expenditure in transport would lead to higher consumption of other goods and services. This Master Thesis aims to evaluate this effect precisely.

Additionally, this research highlights the importance of sensitivity analyses and local consumption patterns in assessing the total fiscal impact of energy transition, and offers valuable insights into the fiscal implications of energy transition in the transport sector, providing policy recommendations for a sustainable and climate-neutral economy.

The sensitivity analysis is thus a crucial aspect of this study, as it allows for a comprehensive evaluation of the socioeconomic and fiscal implications under different electricity prices, given their variability depending on the assumptions on the development of commodity prices, the electricity mix and flexible electricity demand. Therefore, after conducting socioeconomic and fiscal evaluations, in the sensitivity section, two sensitivity analysis on various electricity prices will be performed. The first assessment compares the outcomes of the baseline with those of the electrification scenario with different electricity prices. The second analysis is focused on the electrification scenario, and the response of different agents to fluctuations in electricity prices is examined. These analyses are essential to provide a more accurate assessment of the implications of energy transition and to develop effective policies to address the fiscal challenges that arise from the transition towards a climate-neutral economy.

This Master Thesis contributes to the literature in several ways. First, there is not any recent research that integrates the electrification of private cars as a measure of reaching the European objective of net-zero GHG emissions by 2050 (Zhang & Fujimori, 2020), and the analysis of the fiscal implication of a low-carbon transition (OECD, 2020). Second, this study makes a significant contribution to the literature by providing a comprehensive analysis of the fiscal implications of energy transition in the transport sector in the Basque Country. Finally, the study integrates the latest research on climate change and energy transition, and it proposes specific policies to address the fiscal challenges that arise from the transition towards a climate-neutral economy by 2050. Finally, this Master Thesis is in line with the United Nations 2030 Sustainable Development Goals, to be more specific, with Goal 9 on industry, innovation and infrastructure, Goal 12 on responsible consumption and production, and Goal 13 on climate action.

The rest of the document is structure as follows. Section 2 provides an overview of the current context of the region, including the fiscal, energy, and economic context, as well as the transport sector. The methodology and data description are presented, along with the limitations of the approach, in Section 3. Section 4 evaluates the socioeconomic and fiscal impact of the proposed decarbonization policy: the gradual elimination of fossil fuels in favor of electrification in the transport sector. Additionally, Section 4 also highlights the importance of sensitivity analyses in assessing the socioeconomic and fiscal impacts of the energy transition. Finally, Section 5 concludes with a summary of the main findings and policy recommendations.

2. Current context of the Basque Country

This section provides an overview of the current context of the Basque Country, including a description of its fiscal system (Section 2.1) , the evolution of the emissions (Section 2.2), and the transport sector under an energy transition context (Section 2.3).

2.1. Fiscal context

The Basque Country not only is a very interesting case study due to the weight that energy specifically has in the Basque industry and revenue, but also because is the region with the highest tax autonomy in the EU (Erkoreka, 2019). In this subsection the fiscal system and context are explained.

Under the foral financing system, the Basque Country and Navarre operate under a completely different and independent regime with respect to the common financing regime which governs the rest of the Autonomous Communities. Based on historical and political circumstances, both territories conserve a singular and privative financing regime of a federal nature, which is linked to the pre-constitutional historical rights of the foral territories. Unlike the common regime Autonomous Communities, the Basque Country and Navarre exercise broad fiscal, financial and budgetary autonomy. The foral treasuries manage and collect in their territories practically all direct and indirect taxes.

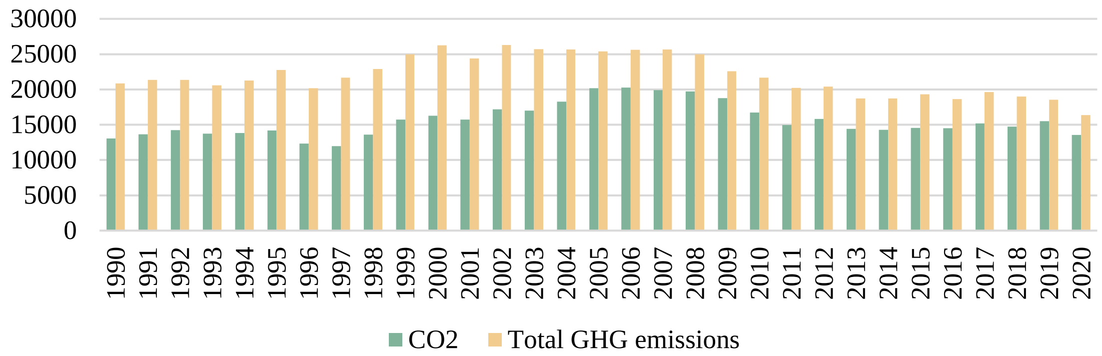
The tax system in the Basque Country is ruled by the Basque Economic Agreement, which establishes that the General Assemblies of the Basque historical territories establish their own tax system (Armetia, 2015). The competent institutions of the Historical Territories may "maintain, establish and regulate the tax regime"; therefore, they collect, inspect and manage all taxes (Art 41.2.a. Statute of Autonomy for the Basque Country). According to the Basque Economic Agreement, "it is the responsibility of the Foral Deputations to collect, manage, settle, review and recover taxes that make up the tax system of the historical territories", and for these powers, "they will have the same powers and rights as those held by the Spanish Treasury". Therefore, the Basque Foral Treasuries function as an integral public finance that controls the entire tax cycle and are located among the sub-central bodies of Europe's major tax and financial powers (Erkoreka, 2019).

The level of quality and quantity of public services offered in the Basque Autonomous Community is completely dependent on the tax collection of the provincial governments since they finance the budgets of the Basque institutions through tax collection, almost without receiving extraordinary transfers and after paying the state for the Quota. The Quota is a political agreement on a technical issue: how much the Basque Autonomous Community must pay to support the general charges of the State in the following five-year period. Therefore, the foral financing system assumes a high degree of fiscal responsibility and is governed by the principle of unilateral risk. Under this principle, the foral institutions assume the risk of a possible lower collection, either as a consequence of the economic situation or as a result of their fiscal or budgetary policies, or for any other exogenous or endogenous reason (Rubí, 2016). Since the basis of the quality of life of the inhabitants of the Basque Autonomous Community is the tax collection of the Basque institutions, the fiscal risk they face is also greater.

2.2. Emissions and taxes

The effort by the Basque institutions to improve the competitiveness and modernization of the industry has been and still is considerable. The promotional activity can be found in a wide range of fields, from simple investment support to the implementation of new technologies, including the creation of industrial infrastructures or actions in the energy field. However, the industrial and economic activity also generates significant GHG emissions, which is an important concern, as will be examined in this subsection.

Figure 1. Evolution of total greenhouse gas emissions by type and year in the Basque Country (CO2-eq, 1990-2020)



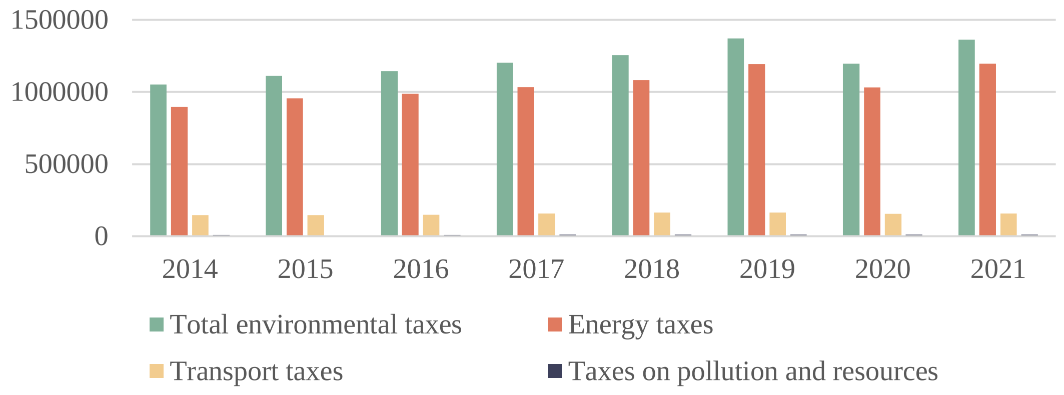
Source: Eustat

As depicted in Figure 1, the peak of emissions occurred prior to the 2007 economic crisis. In the Basque Country, there was a period of economic expansion before the crisis. Subsequently, total GHG emissions decreased and were expected to begin recovering from 2014, when economic expansion resumed. However, the COVID-19 pandemic in 2020 led to lockdowns and an economic recession, causing emissions to decrease once again. At present, we find ourselves in another period of economic recovery, which is driving a corresponding increase in emissions.

While Figure 1 does not show any progress in 2021, the latest reports indicate that emissions have, in fact, increased in 2022. Emissions in Spain were 289MtCO2eq in 2021 and 299MtCO2eq in 2022, a 3.6% increase (BC3, 2022). The 12% increase in the electricity sector stands out, mainly due to drought and the increased use of combined gas cycles, so it could be a cyclical increase. The evolution of emissions from petroleum derivatives (mostly linked to the transport sector) is worrying, as they continue to rise (5%) despite the sharp increase in prices.

It is worth noting that the collection of environmental taxes is also subject to economic cycles, as illustrated in Figure 2. This is because fluctuations in emissions levels affect the taxable base, resulting in a corresponding increase or decrease in the amount of tax collected. It is important to emphasize that these fluctuations in revenue are not attributable to changes in the tax rates of environmental taxes.

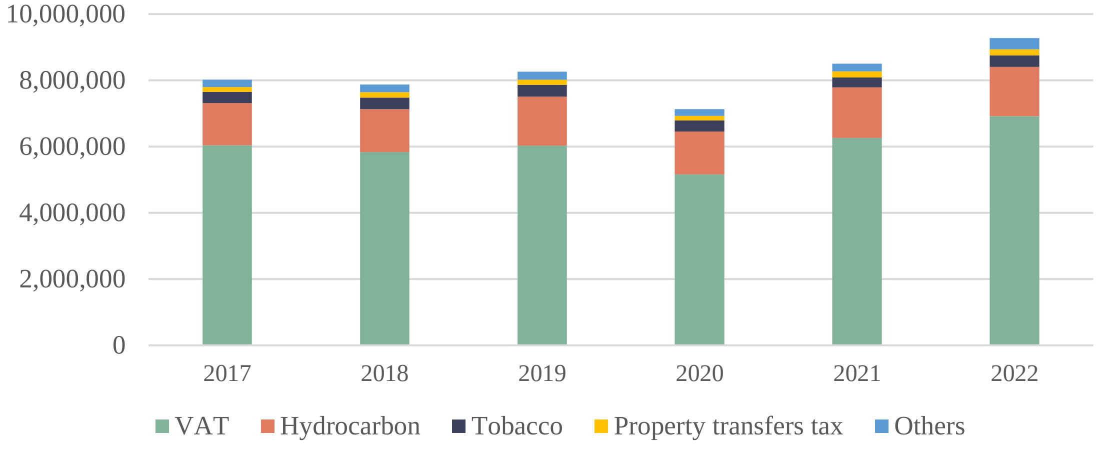
Figure 2. Environmental tax collection in the C.A. of the Basque Country by environmental nature (€, 2014-2021)



Source: Eustat

However, environmental taxes represent only a small portion of the total revenue generated by indirect taxes in the Basque Country. The taxes that generate the largest revenue in terms of indirect taxes are primarily the Value Added Tax (VAT), followed by the Hydrocarbon Tax (see Figure 3).

Figure 3. Distribution of indirect tax collection in the Basque Country (%, 2018)



Source: Eustat

VAT and the Special Tax on Hydrocarbons are the taxes with the greatest collection weight in the indirect tax collection of the Basque Country (Figure 3). The Special Tax on Hydrocarbons is a concerted tax that is governed by the same substantive and formal rules established in Law 38/1992 of the State. However, the Historical Territories may establish the tax rates within the limits and under the conditions in force at any given time in the common territory. It is levied by the respective Provincial Councils when the accrual occurs in the Basque Country.

2.3. Transport sector and energy transition in the Basque Country

One of the most important keys of the Basque Country's energy policy for 2050 is based on producing and consuming more renewable energies to replace fossil fuels, in a way that is compatible with the preservation of the natural environment, preparing for a long-term future in which renewable energies will be the only ones available (Gobierno Vasco, 2017). In this sub-section, the analysis of the transport sector and the energy transition in the Basque Country is further explored.

The long-term vision of the Basque Energy System includes a progressive evolution of the socioeconomic model, especially regarding industry, buildings and transport, towards a new model of lower energy consumption, this consumption being oriented towards the progressive incorporation of renewable energies, and with electrical energy as the main energy vector. The long-term objective indicators are the following:

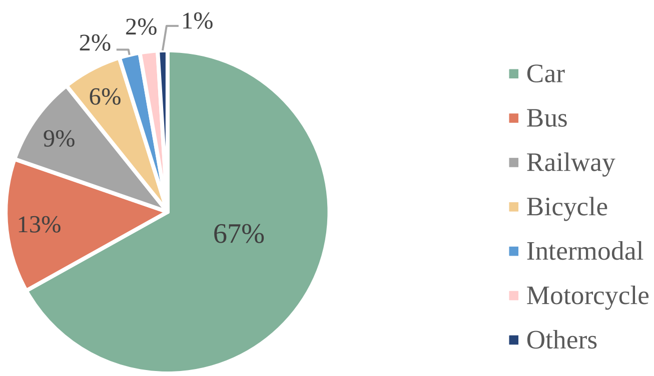
- Contribute to the objectives of the Basque Climate Change Strategy 2050:

- Reduce Euskadi's GHG emissions by at least 40% by 2030 and by at least 80% by 2050, compared to 2005.
    - In 2050, reach a renewable energy consumption of 40% of final consumption.
- Total decoupling of fossil fuels and zero net GHG emissions throughout this century, with renewable energy as the only energy supply.
- Zero petroleum consumption for energy uses in 2050, which requires a structural change in the transportation system.

This latter point is of great importance since the transport sector accounts for a crucial part of the global GHG emissions and represents close to 40% of final energy consumption in the Basque Country, compared to less than 25% twenty years ago.

Due to their high usage and the emissions resulting from the combustion of fossil fuels, cars are a significant mode of transportation that must be considered in addressing environmental concerns. Although the use of cars has decreased in absolute terms in recent years, it remains the most common mode of transportation for meeting mobility needs, excluding walking. It is followed by buses, trains, and bicycles, in that order (see Figure 4).

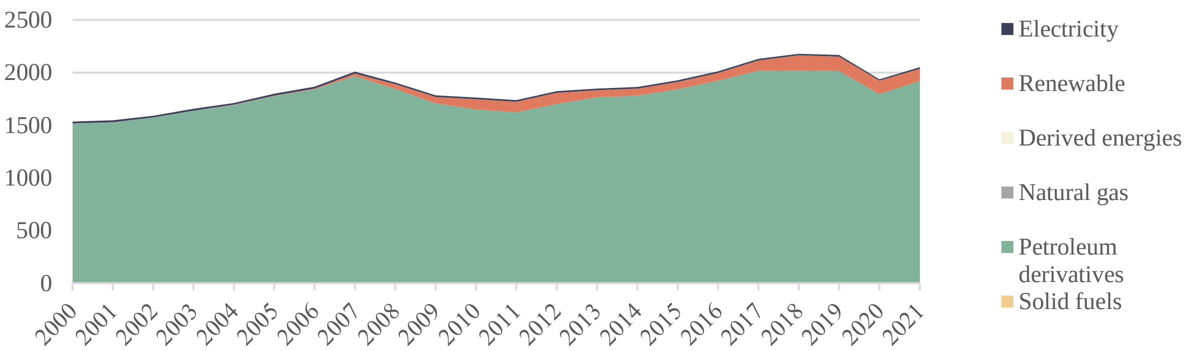
Figure 4. Distribution of the transportation used in the Basque Country (2021, %)



Source: Irekia

The main resource for transport energy in the Basque Country is petroleum derivatives, followed by renewables such as biofuels or hydrogen produced from renewable sources, and electric vehicles, which account for around 6% and 1% respectively, as shown in figure 4. The distinction is important because it should be noted that rechargeable batteries of electric vehicles can be powered by renewable or non-renewable sources.

Figure 5. Transport energy consumption in the Basque Country (ktoe, 2000-2021)



Source: Entre Vasco de la Energía (EVE)

Policies promoting the use of alternative fuels to petroleum have great potential for development and some limitations as a response to uncertainties such as instability and high prices, supply security, capacity to meet demand, and their effect on global warming in the future supply of petroleum derivatives. Natural gas is presented as one of the most attractive alternatives to reduce the dominance of oil in the transport sector. However, the high investment required for infrastructure development remains a significant obstacle to its widespread adoption. In contrast, electric vehicles (EVs) have been shown to offer numerous benefits apart from reducing GHG emissions, such as lower operational costs, improved public health, and increased energy security by reducing reliance on fossil fuels (Yuan et al., 2021). As a result, the adoption of EVs has increased significantly over the past decade.

Indeed, EVs have now reached a stage of development where they are becoming a practical solution for an increasing number of private and public transport drivers. Although there is still significant room for improvement, in many cases, the total cost of ownership over the vehicle's lifetime has already become comparable to that of internal combustion engine vehicles.(Paulo et al, 2018). The impact of environmental and population pressures, coupled with growing awareness of pollution problems, has led some countries and cities to announce measures aimed at transitioning to electrified mobility. In response, car manufacturers are increasingly announcing new electrified models, including both hybrid and pure electric options.

The goal of having 10% of vehicles sold be electric (pure or plug-in hybrids) by the year 2020 was established in the Basque Country, but the reality of market development and electric vehicle costs has led to sales figures indicating that this goal has been far from being achieved. The strategy to promote electric vehicles in the Basque Country is based on developing a charging point infrastructure, creating a critical mass of vehicles in circulation, adapting the regulatory framework, and promoting technological development in this area.

In terms of charging infrastructure, the Basque Country has over 65 public charging points, three of which are fast-charging (located in Donostia-San Sebastián, Vitoria-Gasteiz, and Barakaldo). Also, the Basque Government has introduced the Plan Renove initiative, which aims to decrease GHG emissions and encourage the modernization of the transportation sector in the region by promoting the acquisition of more efficient and environmentally friendly vehicles in the Basque Country.

3. Methodology and data description

In this section, the methodology used to evaluate the socioeconomic and fiscal implications of energy transition in the transport sector in the Basque Country is presented (Section 3.1). The data sources and variables used in the analysis are also described (Section 3.2). Finally, some of the limitations of the approach are mentioned (Section 3.3).

3.1. Methodology

In this analysis, the DERIO model has been used as a multisectoral macroeconomic model for the Basque Country, with a dynamic econometric Input-Output approach aimed at analyzing the socio-economic implications of different decarbonization policies and scenarios. The macroeconomic model developed follows the dynamic econometric input-output (DEIO) model approach. This type of model is a hybrid between econometric input-output models and computable general equilibrium (CGE) models. The model is inspired by the European Commission's FIDELIO (Fully Interregional Dynamic Econometric Long-term Input-Output Model) model described in Kratena et al. (2013, 2017). This model has been used by the European Commission for the assessment of the economic impact of the Clean Air Package according to Arto et al. (2015) or the analysis of protectionist policy effects in the United States (Salotti et al., 2019). A model of these characteristics -adapted to Spain- (DENIO), has recently been used for the economic impact assessment of different plans and strategies designed by the Spanish Government such as the integrated National Energy and Climate Plan, PNIEC 2021-2030 (González-Eguino et al. 2020), the Long Term Decarbonization Strategy, ELP 2050 (MITECO, 2020) or the Long Term Strategy for Energy Rehabilitation in the Building Sector in Spain, ERESEE 2050 (Arto et al., 2019).

In the Basque Country, there is already a model (DERIO) developed by BC3 that was initially used for the evaluation of the 2050 Climate Change Strategy of the Basque Country. This model, whose development was funded by the Bizkaia:talent program of the Foral Deputation of Bizkaia, includes some of the key elements of a complete macroeconomic model such as households, productive sectors, energy use or the labor market, but in the first version lacked specifications for international trade or government. Moreover, in the case of households, the model had only one representative consumer.

The DERIO model has been updated and developed in the context of the BIDERATU project (Aclima, 2023). Specifically, in addition to updating the model data to the base year 2018, the Households module has been extended and updated to include a total of 2000 household types, a Public Sector module has been developed, and the Production module and the representation of energy use and production has been improved (see the Appendix for a more detailed explanation of each module).

DERIO's main characteristics are the following:

- Development of the Household module, which includes modeling income, wealth, and consumption of 2,000 representative households of the Basque population.
- Development of the Production module that describes the behavior of 104 sectors and 126 products through an Input-Output approach, linking their production structures with the demand for production factors (capital, labor, energy, and other intermediates).
- Development of the Public Sector module that links government account components with other parts of the economic model through a series of equations describing their interactions with households and enterprises.

- Integration and validation of the macroeconomic model.

The DERIO model employs a precise econometric methodology to simulate the economy's overall output and demand, enabling it to incorporate a broad spectrum of factors that can affect the output trend. DERIO analyzes the impact of policies on a series of socio-economic variables such as employment, gross domestic product (GDP), trade balance, household income/expenditure/wealth and its distribution, savings accounts of public administrations, among others (see Table 1). By analyzing socio-economic variables such as employment, GDP, and inflation, DERIO can help policymakers better understand the economic consequences of their decisions and design more effective and sustainable policies.

Table 1. Summary table of main socio-economic variables calculated by DERIO

GDP and prices	Employment	A.A.P.P. accounts	Income, households' income	Households' consumption
GDP: demand	Total jobs	Public Sector Revenues	Income: quintiles	Consumption: quintiles
Household consumption	Women	Taxes on income, wealth, etc.	Quintile 1	Quintile 1
General government consumption	Men	Taxes on production, products	Quintile 2	Quintile 2
Gross capital formation	Agriculture	Social Security contributions	Quintile 3	Quintile 3
Exports	Mining	Other income	Quintile 4	Quintile 4
Imports	Industry	P.A.P. Expenses	Quintile 5	Quintile 5
Energy imports	Construction	Transfers	Income: components	Consumption: categories
Non-energy imports	Energy	Debt interest	Wages	Food
GDP: supply	Services	Gross capital formation	EBE, mixed income	Clothing
Agriculture		Consumption	Property income	Household
Mining		Other expenses	Income tax, wealth	Health
Industry		Cap.-Nec. financing	Contributions	Communications
Construction		Cap.-Nec. financing / GDP	Benefits	Education
Energy		Public debt	Other transfers	Hospitality
Services		Public debt / GDP	Number of households	Insurance, Fin. Serv.
Taxes on products			Vulnerable	Other services
GDP: income			Non-vulnerable	Electricity
Wages			Gross savings	Heating
EBE, mixed income			Net loans	Fuel
Production tax			Household debt	Transportation
Consumer Price Index			Household assets	Household appliances
				Housing
				Vehicles

Source: Own elaboration.

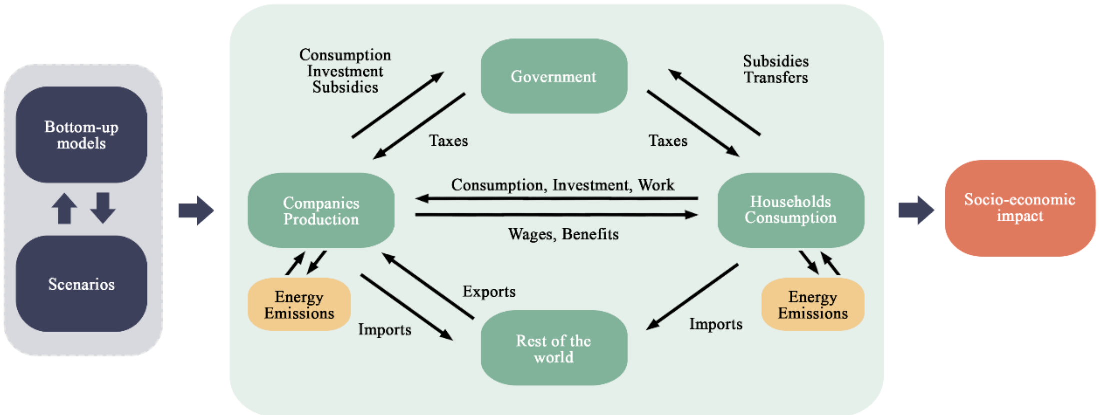
Economic growth in DERIO depends on the increase in total factor productivity, which corresponds to a path of prices and, therefore, export competitiveness. Exports are exogenous and are adjusted in the baseline scenario to the path of GDP growth. Imports are endogenous, and there is no equilibrium condition on the external balance.

The model's Input-Output core is based on Origin and Destination tables. The production model connects the production structures of 104 sectors and 126 products to a Translog model with four production factors, including capital, labor, energy, and other intermediate inputs (see Table 1). Additionally, the demand for energy factor is divided into 25 types that are linked to the model in physical units (Terajoules and tons of CO2). The input-output model is used to analyze the production network structure and its impact on productivity and the economy in general. In this model, it shows how the different sectors of the economy are related and how inputs and outputs are exchanged, being an important tool for analyzing the production network structure and its impact on the economy (Oberfield, 2018).

The modules in DERIO

Each module focuses on modeling different aspects of the economy, allowing for a detailed evaluation of the impact of different economic policies and strategies (see Figure 6). The Production module focuses on modeling the production and energy consumption of different economic sectors, as well as modeling the supply and demand of goods and services produced by firms. The Households module is designed to model household demand, which is divided into three levels and is based on 2,000 household types. The household demand is a way of understanding how people spend their income because it represents the total amount of goods and services that households are willing and able to purchase at different prices. By modeling household demand, the DERIO model can provide insights into how changes in prices, income, or other factors affect the consumption patterns of different types of households.

Figure 6. Simplified view of the Input-Output macroeconomic modeling



Source: BIDERATU

The Households module includes the modeling of income, wealth and consumption of 2,000 households representative of the Basque population (see Figure A.1 in the Appendix). On the one hand, the income equations compute the disposable income of the different groups of households, taking into account the heterogeneity in the sources of income of each type of household and the evolution of the stock of assets and debts, and access to credit.

The Government module is responsible for modeling government revenues and expenditures, as well as fiscal policy and income distribution. This Public Sector module integrates several components of endogenous revenues, such as income taxes (with variable rates based on household income), capital taxes, product and production taxes, and social security contributions. The Government module also models the payments of interest on public debt, which are endogenous and depend on the path of public debt.

The DERIO model considers the factors that determine the trend of output through its Production model, which links the production structures of the different sectors of the economy with a Translog model with four production factors: capital, labor, energy and other intermediate inputs. This Production module uses advanced econometric techniques to estimate the relationship between the different factors of production and the total output of the economy. In addition, the DERIO model also takes into account other factors that can influence the trend of output, such as aggregate demand, inflation, and government fiscal and monetary policies.

Finally, the Energy and Emissions module focuses on modeling the production and use of energy by different agents of the economy, including different branches of the energy sector, non-energy sectors, and households. The Energy module also models the mix of energy and electricity, energy intensity/efficiency, energy prices, and investments, among other variables. By modeling these aspects of energy production and use, the DERIO model can provide insights into the impact of different energy policies on various socio-economic variables, such as employment, GDP, trade balance, household income, savings, public and private debt, and emissions.

The set of energy categories in the model is directly linked to two parts of the model:

- the physical accounts (Terajoules) of energy by industry (74 + households) and energy type (25).
- the energy products and industries from the Origin and Destination tables in monetary units.

To achieve this, a series of implicit prices are used to link energy use/production in physical units (TJ) and in monetary terms. Therefore, the Energy module of DERIO describes the production and use of energy by different agents in the economy, including various branches of the energy sector, non-energy sectors, and households.

DERIO is characterized by the integration of institutional rigidities and frictions that cause fiscal policies and investments to have a different impact in the short term than in the long term. In the long term, the economy converges towards full employment equilibrium, and in that equilibrium phase, the model functions similarly to a CGE model. However, unlike a CGE model, DERIO explicitly describes an adjustment path towards this equilibrium, with two mechanisms determining the Keynesian feature of the model in the short term and the CGE feature in the long term:

- Heterogeneity of marginal propensity to consume with respect to disposable income, depending on the financial sector situation.
- Effect on wages/prices when the economy is at or below the equilibrium unemployment rate, with marginal propensity to consume also varying by income groups.

Some of the results that will be obtained using DERIO include:

- Changes in employment, GDP, trade balance, household income/expenditure/wealth and its distribution, savings in public accounts, private and public debt, inflation, among other socio-economic variables.
- Evaluation of the economic impact of electrification and different energy and climate policies such as the implementation of clean technologies, energy efficiency or environmental taxes.
- Analysis of the economic impact at a regional or sectoral level.
- Evaluation of the long-term (up to 2050) economic impact of different strategies and plans designed by the Basque government to address climate change and promote a more sustainable economy.

The sequences in DERIO

Given the complexity of the macroeconomic and energy models, a smooth link between the years them is proposed. Thus, after calibrating both for the base year (2018), the macroeconomic model runs for 2019 producing a series of variables that will be used as input in the energy model. In turn, the latter will be run for the year 2020 and will generate a series of variables that will feed the macroeconomic model for the simulation of the year 2021, and so on. This process will be repeated until the last year of the time frame adopted in the project, 2050. Given that there are historical data on macroeconomic and energy variables for some years after the base year, in the first years, and as long as data are available, constraints will be implemented to make the simulations as close as possible to reality. The exchange of data between models will be done through a script that intermediates between them in such a way as to call them successively. Finally, the scenario model connection will also be of a soft type. In this case, the information will only flow in one direction: from the scenario model to the macroeconomic and energy models.

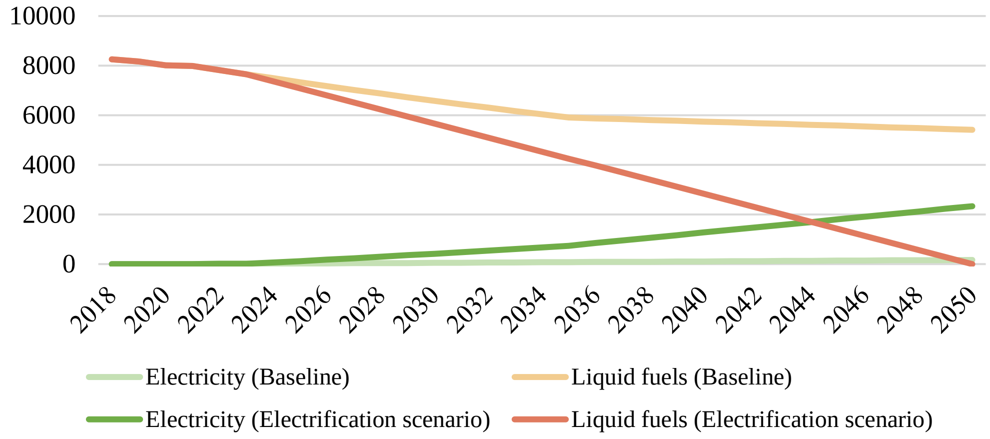
The baseline and the electrification scenario

To conduct a comprehensive analysis of the fiscal implications of decarbonization in the Basque Country, a *baseline* is established, and a scenario is applied to demonstrate the economic impact of the adapted electrification measure. In the proposed scenario, the principle of constant deficit is upheld, meaning that any reduction in revenue would need a corresponding decrease in Basque government spending on its competencies, since it does not receive transfers from the Spanish government.

Starting from the baseline where there are no policies and technological policy is proposed, that is, the electrification scenario. In the electrification scenario, decarbonization is achieved by replacing gasoline and diesel with electricity, that is, liters with kilowatt-hour. Only private vehicles are substituted with electrical energy, and the number of private vehicle users remains the same in both the baseline and scenario.

The substitution calculation results in a ratio of 0.4 liters per kilowatt hour (Annaratone, 2007). This is because, in terms of fuel efficiency, electric vehicles are more efficient than internal combustion vehicles since electric motors are more efficient at converting energy into motion than internal combustion engines. Therefore, electric vehicles can travel more kilometers with the same amount of energy than internal combustion vehicles, and, for that reason, the increase in household electricity consumption is smaller than the decrease in liquid fuels consumption (see Figure 7).

Figure 7. Household consumption of fossil fuels and electricity (€k, 2018-2050)



Source: Own elaboration based on data from Eustat (2018).

In addition, if the electricity used to charge electric vehicles comes from renewable energy sources, such as solar or wind power, the energy cost per kilometer can be even lower than that of internal combustion vehicles. Also, government incentives and support policies can make electric vehicles more affordable and attractive to consumers, as the total cost of ownership of an electric vehicle can vary.

It is assumed that in 2050 there will be no household consumption of fossil fuels. By 2050 consumption will be very close to zero for private combustion cars if climate policies continue along these lines, since freight transport or other types of vehicles do not apply in the electrification scenario, and the European regulation prohibiting the sale of new registrations of cars and vans with combustion engines in 2035. In addition, the useful life of cars is between 10 and 15 years, so that most of the last combustion models sold at the end of 2034 will reach the end of their life cycle by 2050.

3.2. Data description

The data used to construct the DERIO model come from Eustat (in combination with other data sources that will be described below) and they cover variables of the Household, Production and Government modules. The data is used as input in the baseline and in the electrification scenario.

The parameters of the Household module are estimated using microdata from the Household Budget Survey (HBS) and the Living Conditions Survey (LCS). These data have been reconciled with the Economic Accounts of Eustat. To this end, the data on expenditure, income, taxes, assets, debt, etc., of Basque households in the HBS and LCS have been scaled to the totals of the Economic Accounts. On the other hand, a methodological framework based on "statistical matching" techniques has been developed to link the different data sets, in particular the HBS (expenditure data) and LCS (income data). This database collects, for the year, for each of the 2,000 Basque households represented in the HBS, data on expenditure by COICOP category, income by LCS source (wages, benefits, subsidies, taxes, etc.), and sociodemographic characteristics (number of members, sex, age, marital status, country of birth, citizenship and residence, rural/urban, etc.).

The level that divides the other non-durable goods into 6 consumption categories follows a Quadratic Almost Ideal Demand System (QAIDS) specification. The resulting expenditure vector in the COICOP (Classification of individual consumption by purpose) classification at acquisition prices is transformed into a vector of final consumption by product (126 products, following Eustat's Classification of Products by Activity (CPA)) at basic prices using a bridging matrix and valuation matrices.

The Production module follows an Input-Output approach based on the Origin and Destination tables elaborated by Eustat. The production model links the production structures (Leontief technologies) of the 104 sectors and 126 products to a model with four production factors (capital, labor, energy and other intermediate inputs). The energy factor demand of each sector is divided into 26 energy types (electricity, gas, gasoline, diesel, fuel oil, etc.) is specified in monetary and physical terms, and in turn linked to the bottom-up models (TJ and tons of CO_2). The set of energy categories in the model is directly linked to two parts of the model:

- The physical accounts (Terajoules) of energy by industry and energy type.
- The energy products and industries from the Origin and Destination tables in monetary units.

This uses a series of implicit prices linking energy uses/production in physical units (TJ) and in monetary terms. The high level of detail in terms of branches of activity of the energy sector (15) and energy products (26), allows linking the macroeconomic model with the bottom-up energy model (WP2). In this way, the evaluation exercises benefit from the better representation of the technologies related to the energy policies of the bottom-up models and from the representation of the whole economy of the macroeconomic model.

The Public Sector module comprises the main interactions between households, businesses and government. The core of the module is based on the Economic Accounts of the Public Administration sector (Eustat) which offers information that supports the estimation of the macro magnitudes of the public sector. On the one hand, the units that depend on the Basque Administrations are computed (the Basque Government, the provincial councils with their autonomous bodies, the common wealth and the municipalities), and on the other hand, those that depend on the State Administration (Central Administration and territorialized Social Security).

3.3. Limitations of the Approach

The methodological approach acknowledges several limitations. The analysis assumes that all other factors remain constant, which may not be the case in reality. Moreover, the analysis focuses on the transport sector and does not consider the broader implications of energy transition on other sectors of the economy. That is, the analysis assumes that the electrification of private cars will be the only decarbonization policy implemented in the transport sector. However, there may be other policies that could be implemented, such as the promotion of public transport or the use of alternative fuels, which could have different fiscal implications.

In addition, the analysis does not consider the potential differences in the adoption of electric cars across different socioeconomic groups. It is possible that the cost of electric cars may be prohibitive for some households, particularly those with lower incomes. As a result, the adoption of electric cars may be concentrated among higher-income households, which could have different fiscal implications than if the adoption were more evenly distributed across different socioeconomic groups. Therefore, it is important to consider the potential differences in the adoption of electric cars across different socioeconomic groups when analyzing the fiscal implications of decarbonization policies in the transport sector. This could involve analyzing the potential impact of different policy measures, such as subsidies or tax incentives, on different socioeconomic groups to ensure that the benefits and costs of energy transition are distributed fairly.

The fact that the data obtained from Eustat are at the level of the Autonomous Community means that the tax collection and public expenditure considered are figures at the level of the Basque Country and not by Historical Territory. In order to carry out a more exhaustive fiscal analysis, it should clearly differentiate the three Foral Deputations with their respective foral treasuries, since the current analysis does not consider that each Historical Territory has its own tax collection and expenditure in the competent services at the provincial level.

Despite these limitations, the study provides a valuable contribution to the literature on the fiscal implications of energy transition in the transport sector in the Basque Country.

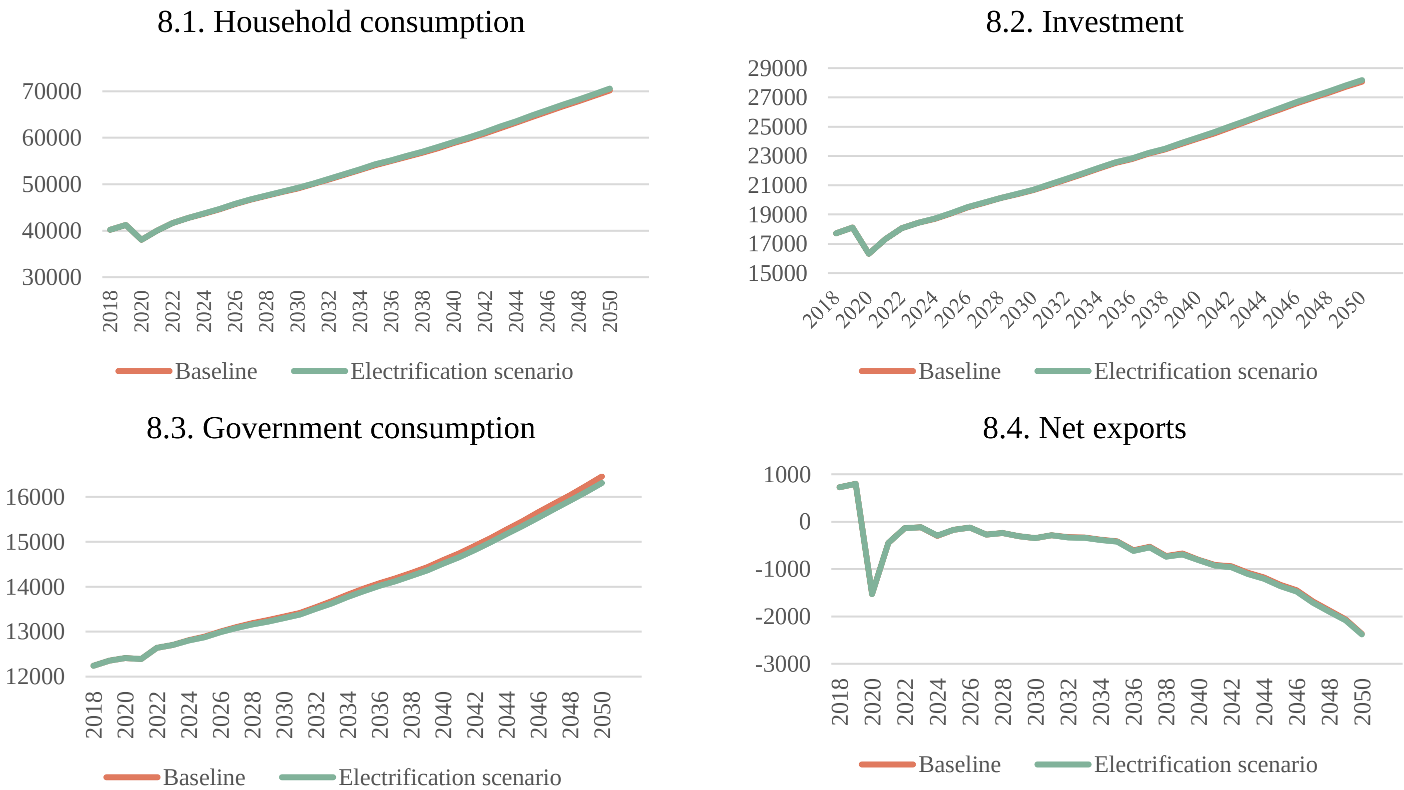
4. Socioeconomic and fiscal impact of decarbonization in the Basque Country

This section analyzes the socioeconomic and fiscal impact of decarbonization in the Basque Country from 2018 to 2050. Section 4.1 examines the behavior of the main macroeconomic variables and how agents change their behavior in response to the transition towards the electrification of household's private vehicles. Additionally, in Section 4.2 a specific fiscal analysis is conducted to evaluate the impact on the Basque public accounts and to determine the final fiscal impact, which was not clear in the initial hypothesis. Finally, in Section 4.3 a sensitivity analysis of prices is performed by comparing the impact of changes in electricity prices.

4.1. Socioeconomic impact

Figure 8 presents for both for the baseline and the electrification scenarios the evolution from 2018 to 2050, in million euros, of the components of the aggregate demand: Household consumption (Figure 8.1), Investment (Figure 8.2), Government consumption (Figure 8.3) and Net exports (Figure 8.4). Although the transition from the baseline to the electrification scenario results in a reduction in government consumption (as shown in Figure 8.3), the path of the main macroeconomic variables remains roughly the same in both scenarios for private consumption, investment and net exports. In both scenarios, the trend of household consumption, investment, and government consumption is generally positive, with an unusual decrease in 2020 due to the COVID-19 crisis.

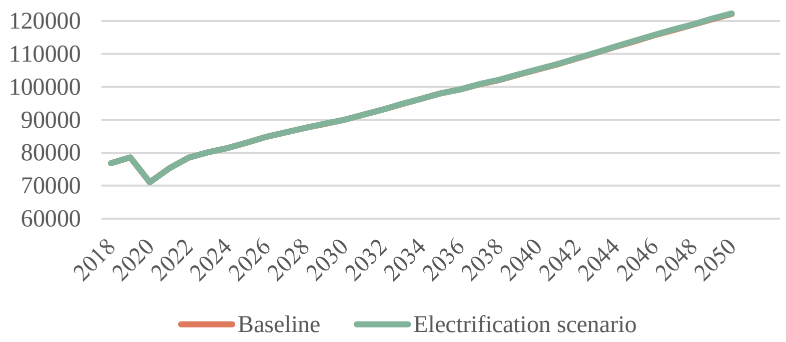
Figure 8. Components of aggregate demand (€m, 2018-2050)



Source: Own elaboration based on data from EUSTAT (2018).

The shift towards cleaner and more sustainable energy sources in the coming decades is expected to result in a decrease in the demand for fossil fuels, which will have implications for both exports and imports. This trend is already being observed in many countries, where policies are being implemented to promote the use of renewable energy and reduce greenhouse gas emissions. As a result, the global market for fossil fuels is likely to shrink, which could have significant implications for countries that rely on fossil fuels.

Figure 9. Expenditure on components of aggregate supply (€m, 2018-2050)



Source: Own elaboration based on data from Eustat (2018).

As shown in Figure 9, Expenditure on components of aggregate supply increases in a positive trend in the baseline and the electrification scenario. The transition towards electrification is carried out in a gradual and planned manner, allowing companies to adjust to changes in demand and production. As the transition progresses, it is expected that the aggregate supply will increase due to greater energy efficiency and the use of renewable energy sources. Furthermore, electrification involves a greater investment in infrastructure and technology, which in turn generates employment and increases productivity. All of these factors reduce production costs and increase the competitiveness of companies. This result indicates that climate policies can be compatible with economic growth.

Table 2. Expenditure variation between baseline and electrification scenario (%, 2030 and 2050)

	2030	2050		2030	2050
Household consumption (C)	0.22%	0.57%	Gross operating surplus	0.23%	1.03%
Government consumption (G)	-0.26%	-0.88%	Salaried compensation / Mixed income	0.00%	-0.79%
Net exports (XN)	0.72%	0.43%	Social benefits AAPP CAE	0.00%	-0.08%
Gross capital formation (I)	0.13%	0.36%	Debt-GDP Ratio	-0.17%	-2.02%
Net exports (XN)	0.72%	0.43%	Total consumption	0.08%	0.28%
Net final products taxes	-0.87%	-1.93%	Electricity	26.56%	66.29%
GDP supply (Y)	0.04%	0.13%	Gas	0.00%	0.00%
Refining	-1.18%	-2.94%	Fuel	-25.51%	-100.00%
Services	0.04%	0.1%	Non-durable (no energy)	0.16%	0.5%
Net Product Taxes	-0.59%	-1.34%	Durable (no energy)	0.07%	0.44%
GDP income	0.04%	0.1%	Other goods (no energy)	0.20%	1.3%

Source: Own elaboration based on data from Eustat (2018).

Broadly speaking, in Figures 8 and 9 an upward trend in product expenditure is observed, which can be attributed to the increase in disposable income of households resulting from the efficiency factor. Indeed, the annual energy bill would be reduced, mostly associated with the import of fossil fuels, which would help improve the competitiveness of companies and increase the spending capacity of households.

More specifically, household consumption (C) at basic prices increases by approximately 0.5 percentage points in 2050 relative to the baseline, indicating a rise in the consumption of domestic products, excluding taxes (see Table 2). In contrast, government consumption (G), which encompasses the consumption of the public administrations of the Basque Autonomous Community and the central government, declines due to lower revenue, as we adhere to the deficit rule.[1] Gross fixed capital formation (I) or investment increases in tandem with higher industrial production, as will be seen in more detail in the subsequent analysis. As for the GDP supply (Y), the rise in the value added of the energy and electricity sector is counterbalanced by a drop in net product taxes, which is attributable to the reduced demand for fuels. In fact, there is a reduction in fuel spending, owing to the decrease in fuel consumption.

[1] The deficit rule establishes that a ratio between the balance of public accounts and GDP must be maintained. If the ratio is above the target, government consumption and investment are reduced.

The gross operating surplus experiences an upswing, primarily due to the value added of the electricity sector (which is characterized by a high degree of capital intensity), while employee compensation declines, as a result of the decrease in government consumption, which has a pronounced influence on wages (the structure of the central government is highly labor-intensive). With respect to the accounts of the consumption of the Basque public administrations, the model offsets the reduction in revenue with a reduction in public spending and investment (an automatic adjustment mechanism to comply with the deficit rule). Nonetheless, the debt-GDP ratio increases due to the rise in GDP, and in the scenario, we assume that social benefits grow at the rate of GDP, with its negative sign being attributable to lower growth in the decarbonization scenario.

Refining does not decrease significantly compared to what was expected, as a portion of the fuels are exported. Nevertheless, total consumption increases, as does spending on electricity and gas. We assume that energy spending for heating/lighting and other modes of transportation remain unchanged, and changes in transportation spending are allocated to non-durable goods. Regarding prices, the model does not modify the products but rather the wages. The w/L ratio depends on productivity, which remains constant, and the consumer price index, which changes due to the reduction in prices resulting from cheaper electricity.

As households' disposable income rises, households tend to allocate a larger portion of their budget towards non-durable goods, which are typically consumed over a short period of time and are often considered essential for daily living. The tax rates will remain unchanged, but the cost of production will decrease, and households will adjust their consumption patterns by reducing their energy bills and increasing their spending. This increased spending will have a more positive economic impact than the negative impact of reducing fossil fuel consumption, which is largely imported. As a result, households will be spending more on restaurants and other local businesses instead of on fossil fuels, and this increase in spending on non-durable goods will have a positive impact on the economy, as it can stimulate demand for goods and services, leading to increased production and employment opportunities. Additionally, it can also improve households' standard of living, as they are able to afford more goods and services that can enhance their quality of life.

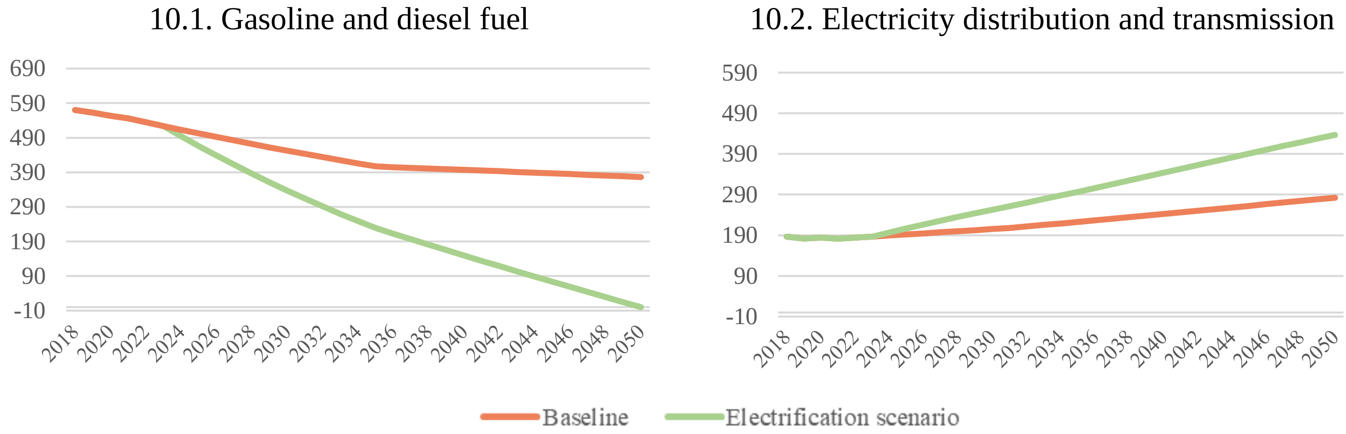
Families can increase their savings by using electric vehicles instead of gasoline or diesel cars. This is mainly since electric vehicles have lower fuel costs than internal combustion vehicles, as electricity is cheaper than gasoline or diesel. Moreover, electric vehicles have a longer lifespan than internal combustion vehicles, which means that households don't need to replace them as often. Additionally, electric vehicles require less maintenance than internal combustion vehicles, as they have fewer moving parts and do not require oil changes, as gasoline or diesel cars would. With the increasing use of renewable energy, particularly solar energy, households can further reduce their energy costs by using solar panels or other renewable energy sources to charge their electric vehicles. In addition, electric vehicles have a lower depreciation rate than internal combustion vehicles, which means that households can get more income back when they sell the vehicle.

Moreover, electric vehicles exhibit higher energy efficiency than internal combustion vehicles, resulting in households being able to travel more miles with the same amount of energy. Furthermore, governments provide incentives and support policies to encourage the adoption of electric vehicles, such as tax credits, vehicle purchase allowances, and tax exemptions. These incentives not only promote the use of electric vehicles but also enable families to retain more disposable income.

4.2. Fiscal impact

In terms of socio-economic impact, a decrease in government consumption has been observed, which is due to the reduction in the government's total revenue. In order to carry out a more comprehensive fiscal analysis, a detailed breakdown of the variables related to public accounts is presented in Figures 10 and 11, which will allow a more precise evaluation of the fiscal impact.

Figure 10. Collection of final product taxes (€k, 2018-2050)



Source: Own elaboration based on data from Eustat (2018).

The transition to a climate-neutral economy implies a reduction in the consumption of fossil fuels, which has been the main source of energy used in transportation for decades and has generated significant tax revenues for the Basque government through fossil fuel taxes. However, reliance on fossil fuel revenues creates a significant barrier to the adoption of cleaner energy sources, exposing local utilities to significant risks in the post-transition period.

The efficiency of the technology and infrastructure used for the production, distribution and consumption of fossil fuels and electricity can influence the magnitude of the decrease or increase in tax revenue. Electricity production from renewable sources can be more efficient and less costly than fossil fuel production, which can reduce production costs and thus electricity prices. In fact, due to the efficiency factor in electricity, the increase in revenue from final product taxes on electricity distribution and transmission is lower than the decrease in the collection of final product taxes on gasoline and diesel fuel (Figure 10). This is a clear direct effect on revenue. However, to complete the analysis, it would be interesting to determine the net effect on the total revenue of the Basque Country.

Table 3. Expenditure variation between baseline and electrification scenario on fiscal variables (%, 2030 and 2050)

	2030	2050
Government Revenue	**-0.20%**	**-0.52%**
Net taxation on products	-0.54%	-1.18%
Net taxes on production	1.25%	2.26%
Taxes on income, wealth, profits	0.02%	-0.03%
Social security contributions	0.02%	0.08%
Other net revenues	-0.10%	-1.43%
Government Expenditure	**-0.20%**	**-0.52%**

Source: Own elaboration based on data from Eustat (2018)

Total government revenue decreases in both 2030 and 2050, as does government expenditure, with the same exact variation due to the deficit rule (Table 3). The deficit rule establishes that a ratio between the balance of public accounts and GDP must be maintained. If the ratio is above the target, government consumption and investment are reduced. Therefore, in the electrification scenario, if the transition to electric vehicles and the phase-out of fossil fuels has a negative impact on government revenues, the government may have to reduce its consumption and investment to comply with the deficit rule. This could affect the variation in government spending on fiscal variables, including a decrease in net product tax collections and a decrease in spending on investment and consumption.

The decrease in net product tax collections is mainly due to the decrease in fossil fuel tax collections, which are expected to decrease as the transition to electric vehicles and the gradual elimination of fossil fuel consumption takes place. On the other hand, the increase in net production tax collections is mainly due to investment in electric vehicle charging infrastructure and electricity production from renewable sources, which are expected to increase as the transition to electric vehicles and the phase-out of fossil fuels takes place.

The increase in tax collections on income, wealth, profits and social security contributions is due to the expectation that the transition to electric vehicles and the phasing out of fossil fuels will have a positive impact on the economy and, therefore, on the income of individuals and businesses. Investment in electric vehicle charging infrastructure and the production of electricity from renewable sources is expected to generate jobs and increase the income of individuals and businesses, which in turn will increase the collection of taxes on income, wealth, profits and social security contributions.

4.3. Sensitivity analysis

After conducting socio-economic and fiscal evaluations, this section performs two sensitivity analysis on various electricity prices. The first assessment compares the outcomes of the baseline with those of the electrification scenario with different electricity prices. The second analysis is focused on the electrification scenario, and the response of different agents to fluctuations in electricity prices is examined.

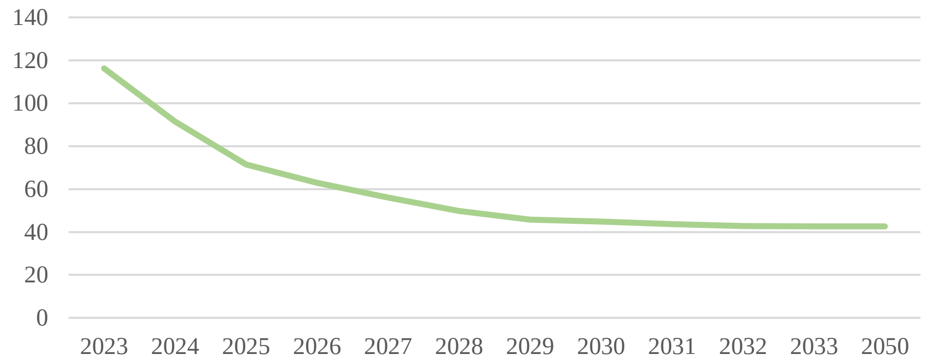
This analysis employs the DERIO model once again, but with three distinct inputs, each with varying prices. Firstly, the Central Price, which represents the future electricity prices in Spain (MEFF, 2023) and correspond to the prices used in previous sections.

Secondly, due to self-consumption or the use of renewable energies, a decrease in electricity prices could also be observed. Electricity prices are falling due to the use of renewable energy, this is because renewable energy sources, such as solar and wind, have lower production costs compared to fossil fuels. By using more renewable energy in electricity generation, dependence on fossil fuels is reduced, which in turn reduces production costs and ultimately prices for consumers. Electricity prices can also fall due to household energy self-consumption. When households generate their own electricity through solar panels or other renewable sources, they can reduce their dependence on the grid and therefore lower their electricity costs. By generating their own electricity, households can consume less energy from the grid.

Finally, prices could increase due to endogenous or exogenous effects that impact the electricity market, as has recently been observed, and electricity prices may increase due to factors affecting the market. These factors may include changes in electricity supply and demand, fluctuations in fossil fuel prices, government policies and regulations, among others. In some cases, these factors can lead to an increase in electricity prices, even if renewable energy is being used. In addition, electricity prices could rise as households may decide to charge their electric vehicles at public charging stations, where the cost is higher than charging the electric vehicle at home. This is because charging stations may have higher fees compared to charging the vehicle at home. If households choose to charge their electric vehicles at public or private charging stations, they may have to pay additional fees, which could result in higher electricity costs.

The data used as input for the sensitivity analysis are the forward prices called the Central Price (Figure 11), and as a representation of the rise and fall in electricity prices, 25% of each year's price is added to the Central Price to obtain the High Price, and 25% is subtracted to obtain the Low Price.

Figure 11. Baseline electricity price path (€/MWh, 2023-2050)



Source: MEFF

4.3.1. Price sensitivity in the baseline vs. electrification scenario

Different electricity prices can have a significant impact on the substitution of gasoline and diesel for MWh in household consumption; in this sense, electricity prices can accelerate or delay the effects of the electrification measure. For example, if electricity prices are high, households may be unwilling to make the substitution due to the associated higher costs, which would delay the effects of the electrification measure. In this sense, the first sensitivity analysis will allow us to analyze the impact of different electricity prices on the economy. In this way, it would be possible to predict what would be the optimal electricity price to accelerate the effects of the electrification measure and achieve a faster transition to a low-carbon economy.

Table 4. Expenditure variation between baseline and electrification scenario
(%, 2030 and 2050)

	Low Price		Central Price		High Price	
	2030	2050	2030	2050	2030	2050
Household consumption (C)	0.25%	0.66%	0.22%	0.57%	0.19%	0.47%
Government consumption (G)	-0.28%	-1.04%	-0.26%	-0.88%	-0.25%	-0.70%
Net exports (XN)	1.42%	1.16%	0.72%	0.43%	-2.09%	0.37%
Gross capital formation (I)	0.27%	1.17%	0.13%	0.36%	0.12%	0.33%
GDP supply (Y)	0.06%	0.15%	0.04%	0.13%	0.03%	0.09%

Source: Own elaboration based on data from Eustat (2018)

Table 4 shows the variation in percentage terms between the baseline and the electrification scenario for 2030 and 2050, considering the Low Price, Central Price and High Price scenarios. Transitioning from the baseline to the electrification scenario leads to an increase in household consumption in all price scenarios, with the highest increase in 2050 under the Low Price scenario. This suggests that Low Prices of electricity may lead to a faster household consumption increase when transitioning to electric vehicles due to the increase in disposable income. However, government consumption variation is negative in all price scenarios, with the highest decrease in 2050 under the Low Price scenario, suggesting government may collect less revenue from taxes and fees related to electricity production and consumption. The impact of electrification on net exports is not linear and may depend on a variety of factors, such as the competitiveness of domestic industries, the availability of export markets, and the price of electricity. Indeed, this is the only variable where a change in sign is observed for the High Price scenario. These results also suggest that the impact of electrification on net exports may be more positive at lower prices of electricity, which may make it easier for domestic industries to compete in export markets.

Low prices of electricity may lead to higher investment in energy-related infrastructure and equipment because when electricity prices are low, businesses and investors may be more likely to invest in energy-related infrastructure and equipment, such as renewable energy projects, electric vehicle charging stations, and energy storage systems. This increased investment can even help to accelerate the transition to a low-carbon economy and reduce GHG emissions. Low prices of electricity may also lead to a positive impact on overall economic output because when electricity prices are low, businesses and households may have more disposable income to spend on other goods and services, which can stimulate economic growth. Additionally, low electricity prices can make businesses more competitive by reducing their operating costs, which can lead to increased production and job creation.

4.3.2. Price changes in the electrification scenario

In the second sensitivity analysis to be carried out, only the electrification scenario has been considered and changes in the price of electricity have been added: the Low Price and High Price will be considered again, in comparison with the Central Price. The objective of this analysis is to evaluate how economic agents react to changes in electricity prices in a scenario where the substitution of combustion private cars by electric private cars is a reality.

Table 5. Expenditure variation different prices comparison in electrification scenario (%, 2030 and 2050)

	Central vs LowP	Central vs HighP
Household consumption	19.24%	-29.13%
Government consumption	16.30%	-17.98%
Gross capital formation	19.25%	-21.84%
Net final products taxes	3.73%	-9.19%
GDP supply	19.24%	-29.13%
Refining	-0.75%	1.04%
Employee remuneration / Mixed income	18.89%	-24.14%
Gross operating surplus	11.96%	-18.97%
Social benefits AAPP CAE	-6.90%	-46.24%
Public Administration CAE consumption	13.64%	-18.11%

Source: Own elaboration based on data from Eustat (2018)

Table 5 shows the difference in percentage terms between the Central Price scenario and the Low Price scenario (second column), and the Central Price scenario and the High Price scenario (third column). A positive value indicates that the variable increases in the Low/High scenario with respect to the Central case. Overall, different electricity prices have a significant impact on spending in different economic categories, and low electricity prices seem to stimulate spending, while high prices seem to reduce spending. However, the most relevant insight from Table 5 is that the reaction to changes in electricity prices is greater when the price of electricity is high. This is because when the price of electricity is high, it has a greater impact on the cost of living and the cost of doing business, which in turn affects the behavior of economic agents.

That is, when the price of electricity is high, households may reduce their consumption of electricity and related goods and services, while businesses may reduce their investment in electrification projects. Similarly, the government may reduce its spending on electrification projects when the price of electricity is high.

On the other hand, when the price of electricity is low, the impact on the cost of living and the cost of doing business is lower, which may result in a more moderate reaction to changes in electricity prices. Overall, the reaction to changes in electricity prices is greater when the price of electricity is high because it has a more significant impact on the economy and the behavior of economic agents.

5. Conclusions

In this Master's Thesis a comprehensive analysis of the fiscal implications of energy transition in the transport sector in the Basque Country was conducted. Data on the current context of the region, including the fiscal, energy, and economic context was collected and analyzed, as well as the transport sector. A modeling framework to estimate the socioeconomic and fiscal impacts of the proposed decarbonization policy was used, which involves the gradual elimination of fossil fuels in favor of electrification in the transport sector. The analysis revealed that this policy could have impact in terms of decreasing total government revenue or increasing households' disposable income.

Indeed, the transition to a climate-neutral economy, which involves the gradual elimination the use of fossil fuels, may have a negative impact on the Basque government's total revenue collection. As a result, the Basque government faces a dilemma: on the one hand, the government must take measures to reduce GHG emissions and meet climate targets; on the other hand, the government must also ensure that its public finances are sustainable and meet fiscal targets.

To address this dilemma, the Basque government may need to adapt to a new fiscal framework that considers the impacts of the transition to a climate-neutral economy on its public finances. However, it is also suggested that the transition to a low-carbon economy may have economic benefits, such as increase of disposable income and the creation of new employment opportunities. Nevertheless, the Basque government must set a balance between maintaining adequate tax revenues and promoting decarbonization.

To address the challenges of decarbonization, public policy recommendations could include implementing fiscal policies that incentivize the adoption of clean and sustainable technologies, while compensating for the potential loss of revenue from fossil fuel taxes. However, designing and proposing a public policy plan to address the fiscal and economic challenges of decarbonization is a complex task that requires a deep understanding of the potential impacts of energy transition on the socioeconomic aspect. Therefore, further research is needed to identify the most effective policy measures to ensure a fair distribution of the benefits and costs of energy transition. Further research is also needed to explore the potential trade-offs between fiscal autonomy and the need for coordinated action. Placing the fiscal process of energy transition in the Foral Deputations within the international research currents of fiscal federalism is an important step towards understanding the potential implications of energy transition on the fiscal autonomy and sustainability of subnational governments.

It is true that the electrification of private cars is only one of many measures needed to achieve the decarbonization of the economy. The transition to a carbon-neutral economy will require the implementation of a wide range of measures, including the electrification of other modes of transport and greater use of renewable energy. It is therefore important to continue to research and considering other decarbonization policies and measures.

This Master Thesis, despite having limitations of the approach, provides a valuable contribution to the literature on the socioeconomic and, especially, fiscal implications of energy transition in the transport sector in the Basque Country. The fact that the Basque Country could be a pioneering region in implementing fiscal measures towards a zero-emissions scenario would make it a reference not only at the state level but also at the European level. The added value of this Master's Thesis has been having familiarized with a complex model of real energy policy and having obtained conclusions that could have an impact on the Basque agenda and active policy.

The research topic presented in this Master's Thesis is of great interest and relevance for further research, in which the authors will deepen the aspects identified and explore new perspectives and approaches. This work lays the foundation for future research and contributes to the advancement of knowledge in the field of decarbonization and the transition to a climate-neutral economy in the Basque Country.

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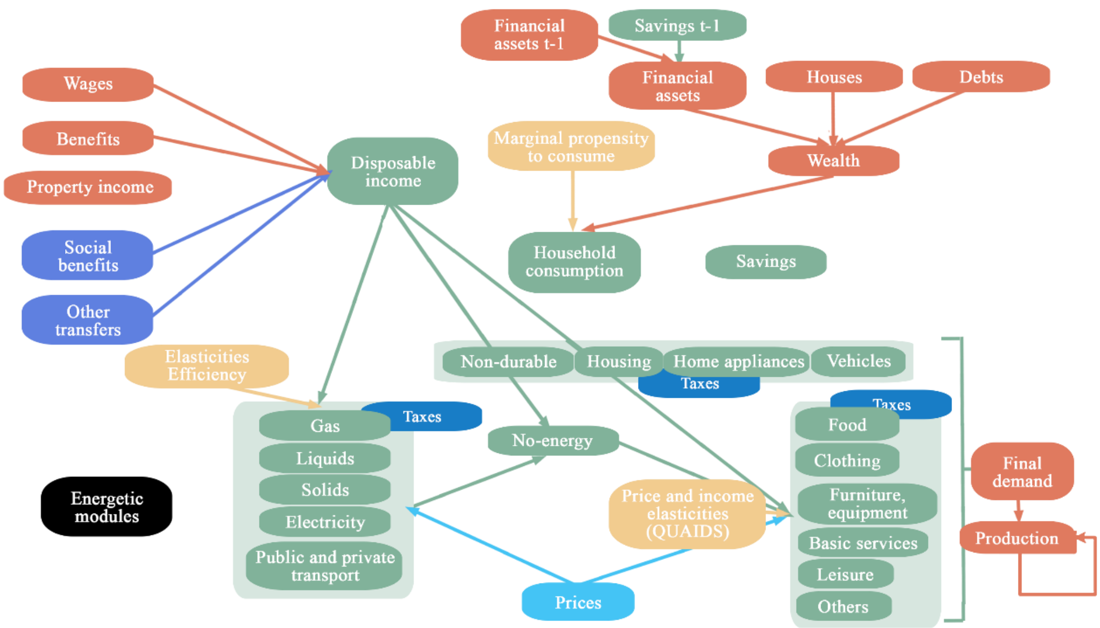
7. Appendix

In this section, a detailed description of the modules that make up the DERIO model is provided.

The Household module

In the Household module (see Figure A.1), the demand equations by expenditure category are structured in three levels in which demand is determined for a total of 24 expenditure categories. The first level calculates, for each of the nearly 2,000 types of households representative of the Basque population, the expenditure on durable goods (housing, vehicles and household appliances) and the total expenditure on non-durable goods as a function of disposable income, taking into account liquidity constraints and environmental attitudes.

Figure A.1. Conceptual scheme of the Households module



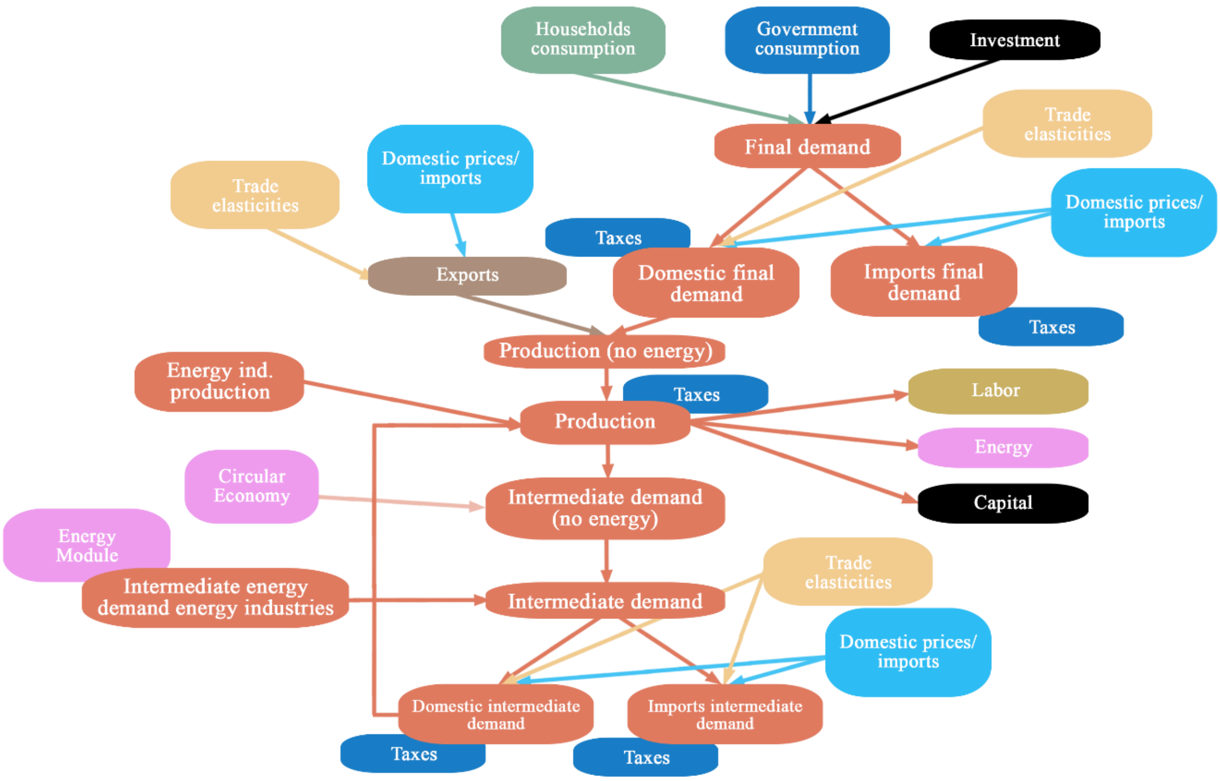
Source: Own elaboration based on BIDERATU

At the second level, total non-durable goods are divided into energy-related expenditures (transportation, fuel, heating, electricity) and other non-durable goods; the equations related to energy use depend on different variables such as prices, efficiency or environmental concerns and are linked to the bottom-up energy modules. The third level divides the other non-durable goods into 6 consumption categories following a Quadratic Almost Ideal Demand System (QAIDS) specification. The resulting expenditure vector in the COICOP (Classification of individual consumption by purpose) classification at acquisition prices is transformed into a vector of final consumption by product (126 products, following Eustat's Classification of Products by Activity (CPA)) at basic prices using a bridging matrix and valuation matrices.

The Production module

The Production module (see Figure A.2) comprises a series of equations that describe the behavior of the 104 sectors included in the Origin and Destination Accounts of Eustat's Input-Output framework. Originally, these accounts represent 88 sectors, which have been disaggregated to 104. Specifically, the demand for factors of production (capital, labor, energy and other intermediates), investment functions and prices of the 126 types of goods and services produced by these 104 sectors are detailed.

Figure A.2. Conceptual scheme of the Production module



Source: Own elaboration based on BIDERATU

The demand for non-energy intermediate inputs is modeled in three steps. First, the total demand for intermediates in each productive sector is estimated. Second, this demand is disaggregated using the production structures of the Input-Output framework's Origin Table. Finally, intermediate demand is divided into products produced in the Basque Country and imported products (from the rest of Spain and the rest of the world). Capital formation is also endogenous and is derived from the demand for capital by sector, applying the product/sector capital formation matrix.

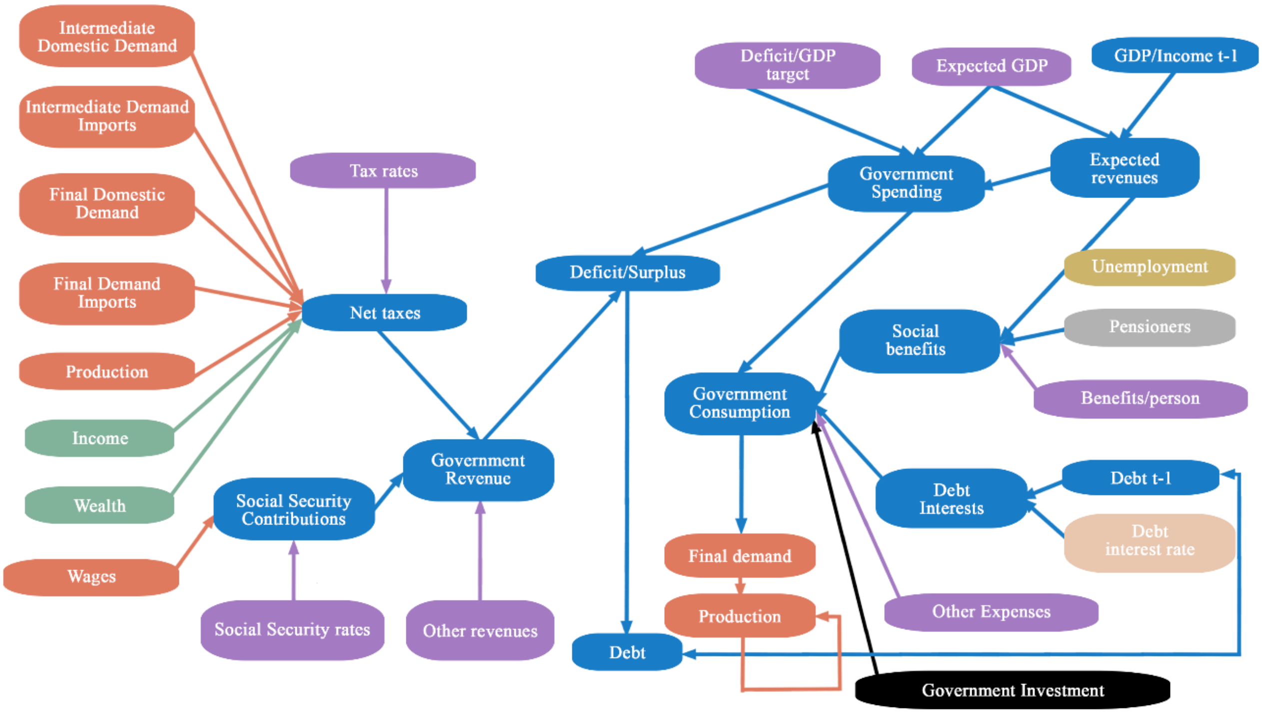
The labor market is specified through wage curves, where wage increases by industry depend on productivity, the consumer price index and the distance to full employment.

The Public Sector module

The Public Sector module (see Figure A.3) constitutes the closing element of the macroeconomic model. This closure consists of the endogenization of parts of public expenditure and investment to meet the deficit targets set by economic policy. This module integrates several endogenous revenue components: taxes on income (with variable rates depending on the income of each household), on wealth, on capital, on products and production, and social security contributions. Interest payments on public debt are also endogenous and depend on the path of public debt. Public consumption and investment are endogenous, in accordance with the closure rule. All these components of the government accounts are linked to other parts of the economic model through a series of equations that describe the relationships between the different agents in the economy.

The model is closed by endogeneizing parts of public spending and investment to comply with the medium-term stability program for public finances. This model closure mechanism is part of the public sector module. This module integrates several endogenous revenue components: taxes on income (with variable rates depending on the income of each household), on wealth, on capital, on products and production, and social security contributions. Interest payments on public debt are also endogenous and depend on the path of public debt. Public consumption and investment are endogenous because of the model closure described above.

Figure A.3. Conceptual scheme of the Production module



Source: Own elaboration based on BIDERATU