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A Lower VAT Rate on Electricity in Portugal: Towards a Cleaner Environment, Better Economic Performance, and Less Inequality

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Abstract

This article determines the budgetary, economic, distributional and environmental impact of permanently increasing the value-added tax on electricity in Portugal. The analysis is carried out in the context of a new multi-sector and multi-household dynamic general equilibrium model. Simulation results suggest that a permanent increase from 6% to 23% in the statutory VAT on electricity improves the public budget as well as the environment, but both gains have detrimental economic and distributional effects. As the economy in Portugal begins to recover in the aftermath of the Great Financial Crisis, and the public budgetary situation becomes less constraining, pressure is mounting for this VAT increase on electricity to be reversed. This mixed bag of results is an important element for the debate. Reverting to a tax of 6% on electricity is desirable, as it would improve economic performance and have positive distributional effects. The question, then, is how to compensate for the loss of tax revenue and, at the same time, protect the environment. To offset the adverse budgetary and environmental effects of a lower VAT, we propose to increase the tax on petroleum products. This proves to be a dominant strategy from all relevant perspectives – economic, distributional, and environmental.

Keywords: Value-Added Tax on Electricity, Tax on Petroleum Products, Macroeconomic Effects, Distributional Effects, Environmental Effects, Portugal

JEL Classification: C68, E62, H23, Q43, Q48.

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1. Introduction

In late 2011, Portugal increased the statutory Value Added Tax [VAT, hereafter] rate on electricity purchases from 6% to 23%. Designed essentially as a revenue-generating measure, this increase was part of an extensive austerity plan implemented by the Portuguese authorities, in the context of the international bailout, under the auspices of the European Commission, the European Central Bank, and the International Monetary Fund [see IMF (2011)].

This increase in VAT made electricity more expensive, thus affecting the economy. For the first time ever, the price of electricity in Portugal became more expensive than the EU-28 average, and is currently in the top price quartile for both consumers and industries [see Eurostat (2016)]. As to the VAT on electricity proper, there are only five countries that exhibit higher statutory VAT tax rates: Croatia, Denmark, Finland, Hungary, and Sweden [see European Commission (2017a)]. Naturally, despite the expectation of being positive for the environment, this austerity measure was greeted with widespread concern for its potential adverse effects both in terms of economic performance and in terms of inequality. On the economic front, the main concerns have centered on its potentially detrimental effects on economic activity, in general, and on growth, in particular. On the equity front, the regressive distributional effects were a matter of great concern. On the environmental front there was the worry that this measure would lead to a shift away from the use of electricity to alternative sources of energy that are less friendly to the environment.

Six years after this measure was introduced, the country is facing a less gloomy economic outlook, as well as a less stringent situation in what regards its public finances. Indeed, after eight years under close European Commission surveillance, in mid-2017, Portugal successfully abandoned the Excessive Deficit Procedures [see European Commission (2017b)], and regained some policy flexibility in terms of fiscal rules. Nevertheless, there is still no sign that authorities plan to reverse the VAT on electricity. Accordingly, there is a very pertinent policy question of evaluating the effects of this measure on the public purse – by any reckoning the rationale for its introduction – and to attempt to measure the possible detrimental effects on economic performance, inequality, and the environment. Ultimately, our objective in this article is to inform on whether the additional VAT revenues outweigh the potential adverse economic, distributional, or even environmental costs. As such, we open the door to the possibility of reverting the VAT tax on electricity to its original level, either as an isolated policy measure, or in conjunction with other revenue-neutral alternatives, more specifically, an increase in the tax on petroleum products.

The economic, budgetary, distributional, and environmental effects of this increase in the VAT on electricity in Portugal are analyzed in the context of a multi-sector, multi-household dynamic general equilibrium model of the Portuguese economy. From a methodological perspective, this work is based on a newly-developed disaggregated dynamic general equilibrium model that builds upon the aggregate dynamic general equilibrium model of the Portuguese economy, known as DGEP. Previous versions of this model are documented in Pereira and Pereira (2012), and have been used recently to address energy and climate policy issues [see Pereira and Pereira (2014a, 2014b, 2016, 2017a, 2017b) and Pereira et al. (2016)]. An important shortcoming of the previous version of the model was its aggregated nature – as it was based on a representative consumer and a representative producer. The new version of the model, while keeping the wealth of a dynamic framework and the detailed modeling of the public sector, disaggregates the economy into five household income groups and thirteen production sectors. Furthermore, it greatly develops the energy module of the model to accommodate the use of different primary energy sources, different forms of final energy production, namely of electricity from conventional sources and from renewables, and different final uses by households and productions sectors. Emissions of CO_2 are calculated based on the use of primary energy sources – coal, oil, and natural gas – according to fixed technical proportions.

The remainder of this article proceeds as follows. Section 2 provides a brief account of the disaggregated dynamic general equilibrium model. Section 3 presents the budgetary, economic, distributional and environmental effects of the increase in statutory VAT rate on electricity from 6% to 23%. Section 4, does the same for an alternative surtax on petroleum products of the same magnitude. Finally, Section 5 provides a summary, discusses a few policy implications, and then concludes.

2. The Dynamic General Equilibrium Model

What follows is necessarily a very brief and general description of the design and implementation of the new multi-sector, multi-household dynamic general equilibrium model. More detailed information in provided in the Appendix. For full documentation, see Pereira and Pereira (2017c).

2.1. The General Features

The dynamic multi-sector general equilibrium model of the Portuguese economy incorporates fully dynamic optimization behavior, detailed household accounts, detailed industry accounts, a comprehensive modeling of the public sector activities, and an elaborate description of the energy sectors. We consider a decentralized economy in a dynamic general equilibrium framework. There are four types of agents in the economy: households, firms, the public sector and a foreign sector. All agents and the economy in general face financial constraints that frame their economic choices. All agents are price takers and are assumed to have perfect foresight. With money absent, the model is framed in real terms.

Households and firms implement optimal choices, as appropriate, to maximize their objective functions. Households maximize their intertemporal utilities subject to an equation of motion for financial wealth, thereby generating optimal consumption, labor supply, and savings behaviors. We consider five household income groups per quintile. While the general structure of household behavior is the same for all household groups, preferences, income, wealth and taxes are household-specific, as are consumption demands, savings, and labor supply.

Firms maximize the net present value of their cash flow, subject to the equation of motion for their capital stock to yield optimal output, labor demand, and investment demand behaviors. We consider thirteen production sectors covering the whole spectrum of economic activity in the country. These include energy producing sectors, such as electricity and petroleum refining, other European Trading System [ETS hereafter] sectors, such as transportation, textiles, wood pulp and paper, chemicals and pharmaceuticals, rubber, plastic and ceramics, and primary metals, as well as non-ETS sectors such as agriculture, basic manufacturing and construction. While the general structure of production behavior is the same for all sectors, technologies, capital endowments, and taxes are sector-specific, as are output supply, labor demand, energy demand, and investment demand.

The public sector and the foreign sector, in turn, evolve in a way that is determined by the economic conditions, and their respective financial constraints. All economic agents interact through demand and supply mechanisms in different markets: commodity markets, factor markets, and financial markets.

The general market equilibrium is defined by market clearing in product markets, labor markets, financial markets, and the market for investment goods. The equilibrium of the product market reflects the national income accounting identity and the different expenditure allocations of the output by sector of economic activity. The total amount of a commodity supplied to the economy, be it produced domestically, or imported from abroad, must equal the total end-user demand for the product, including the demand by households, by the public sector, its use as an intermediate demand, and its application as an investment good. The total labor supplied by the different households, adjusted by an unemployment rate that is assumed exogenous and constant, must equal total labor demanded by the different sectors of economic activity. There is only one equilibrium wage rate, although this translates into different household-specific effective wage rates, based on household-specific levels of human capital which obviously differ by quartile of income. Different firms buy shares of the same aggregate labor supply. Implicitly, this means that we do not consider differences in the composition of labor demand among the different sectors of economic activity, in terms of the incorporated human capital levels. Saving by households and the foreign sector must equal the value of domestic investment plus the budget deficit.

The evolution of the economy is described by the optimal and endogenous change in the stock variables – five household-specific financial wealth variables and thirteen sector-specific private capital stock variables, as well as their respective shadow prices/co-state variables. In addition, the evolution of the stocks of public debt and of the foreign debt act as resource constraints in the overall economy. The endogenous and optimal changes in these stock variables – investment, saving, the budget deficit, and current account deficit – provide the endogenous and optimal link between subsequent time periods. Accordingly, the model can be conceptualized as a large set of nonlinear difference equations, where critical flow variables are optimally determined through optimal control rules.

The intertemporal path for the economy is described by the behavioral equations, by the equations of motion of the stock and shadow price variables, and by the market equilibrium conditions. We define the steady-state growth path as an intertemporal equilibrium trajectory in which all the flow and stock variables grow at the same rate while market prices and shadow prices are constant.

2.2. Calibration

The model is calibrated with data for the period 2005-2014 and stock values for 2015. The calibration of the model is ultimately designed to allow the model to replicate as its most fundamental base case, a stylized steady state of the economy, as defined by the trends and information contained in the data set. In the absence of any policy changes, or any other exogenous changes, the model's implementation will just replicate into the future such stylized economic trends. Counterfactual simulations thus allow us to identify marginal effects of any policy or exogenous change, as deviations from the base case.

There are three types of calibration restrictions imposed by the existence of a steady state. First, it determines the value of critical production parameters, such as adjustment costs and depreciation rates, given the initial capital stocks. These stocks, in turn, are determined by assuming that the observed levels of investment of the respective type are such that the ratios of capital to GDP do not change in the steady state. Second, the need for constant public debt and foreign debt to GDP ratios implies that the steady-state budget deficit and the current account deficit are a fraction of the respective stocks of debt equal to the steady-state growth rate. Finally, the exogenous variables, such as public transfers or international transfers, have to grow at the steady-state growth rate.

2.3. Numerical Implementation

The dynamic general equilibrium model is fully described by the behavioral equations and accounting definitions, and thus constitutes a system of nonlinear equations and nonlinear first order difference equations. No objective function is explicitly specified, on account that each of the individual problems (the household, firm and public sector) are set as first order and Hamiltonian conditions.

These are implemented and solved using the GAMS (General Algebraic Modeling System) software and the MINOS nonlinear programming solver.

MINOS uses a reduced gradient algorithm generalized by means of a projected Lagrangian approach to solve mathematical programs with nonlinear constraints. The projected Lagrangian approach employs linear approximations for the nonlinear constraints and adds a Lagrangian and penalty term to the objective to compensate for approximation error. This series of sub-problems is then solved using a quasi-Newton algorithm to select a search direction and step length.

3. The VAT on Electricity: Simulation Results

We now evaluate the effects of a permanent increase in the VAT on electricity. We focus on the budgetary, economic, distributional and environmental impacts. More detailed results at the disaggregated level for the households, the different production sectors, the public purse, the foreign account, and the energy sectors are available from the authors upon request. All results are reported *vis-à-vis* a steady-state trajectory for the economy, reflecting the economy's trend over the last two decades. We focus mostly on the long-term results, i.e., the effects by 2050. See Tables 1 through 8 for more details.

3.1. On the Budgetary Effects on an Increase in the VAT Rate

The budgetary effects of increasing the VAT rate on electricity are reported in Table 1. This change translates – as desired – into a net increase of tax revenues. This is because of an increase of 1.4% in VAT revenues in the long run. This increase more than compensates for small declines in the personal income tax revenues and social security contributions, of -0.409% and -0.108% respectively, associated with a reduction in general economic activity and in employment, induced by the VAT increase [more on this below]. Overall, this increase in tax revenues leads to lower budget deficits over time. Because of the public debt dynamics, consecutively lower budget deficits translate into a lower interest payments which, in turn, reinforces the positive revenue effects of the VAT increase. In the long term, the progressive decline of the public debt/GDP ratio would reach 6.954%.

3.2. On the Macroeconomic Effects on an Increase in the VAT Rate

In terms of its economic impact – see Table 2 for details – increasing the VAT on electricity translates directly into an increase in the CPI of 0.280%. It has a negative effect in overall economic performance. GDP and employment decline in the long term by -0.138% and -0.108%, respectively, a reduction led by a decline in private consumption of -0.207%, and in private investment of -0.237%. The foreign balance, however, improves somewhat in the long term, as the VAT tax rate hike favor exports by 0.036% and decreases imports by -0.121%. In the long term, helped by the interest rate dynamics, the current account balance would improve by 2.122%. Overall, the foreign debt would progressively decline over time to reach in the long term a reduction of -1.343%.

3.3. On the Distributional Welfare Effects on an Increase in the VAT Rate

For the households, the increase in the VAT rate on electricity represents a loss in purchasing power. See Table 3 for details. As mentioned above, the CPI increases by 0.280%. This increase, however, is spread throughout income groups in a rather regressive manner. Prices increase for the lowest income group by 0.468%, while for the highest income group the increase is just 0.187%. On the flip side, employment and after-tax income also decline by -0.108% and -0.278%, respectively, but in this case in a progressive manner. For the lowest-income group, after-tax income declines by -0.103% while the highest income group it declines by -0.329%. Overall, therefore, we observe that all households face a reduction in purchasing power through higher prices and lower after tax income.

The associated welfare loss is measured by the equivalent variation or the amount of compensation as percentage of income that the household would require, to be able to reach its original level of utility, given the new price conditions. In all cases, we observe a welfare loss. See Table 4 for details. This welfare loss, however, is clearly regressive with the compensation required by the lowest-income group about four times the compensation required by the highest income group – a long-term compensation of 0.454% for the lowest income group, and 0.093% for the highest income group. This is due to the fact that electricity spending is a declining share of income and therefore the effects for lower income groups are amplified.

3.4. On the Energy and Environmental Effects on an Increase in the VAT Rate

The increase of the VAT rate has a clear impact on the energy markets in general, and on the electricity markets in particular. See Tables 5 and 6 for details. The tax increase translates into a -1.034% reduction in final energy demand, which reflects declines for all income groups, as well as for firms, in particular the energy intensive users in the ETS. Electricity demand declines across the board in a more pronounced way, which translates into a reduction of -2.4% in the electricity share in final energy demand.

Finally, the effects of increasing electricity VAT on CO_2 emissions are favorable, albeit small. See Table 7 for details. We estimate a long-term reduction in emissions of -0.048%. For households, we observe an increase in emissions, as consumer substitute away from electricity to other more polluting fuels. In fact, we observe an increase in residential consumption of 2.623%, while in transportation the change is rather marginal – an increase of 0.007%. From a distributional perspective, the increase in emissions is progressive, the flip side of the coin of the regressive distributional welfare effects. In turn, emissions from production activities decline by -0.408%. This goes with a sharp decline of -0.917% in the sectors covered by the ETS and an increase of 0.055% for non-ETS sectors.

Clearly, although at the aggregate level this is a favorable outcome from a strictly environmental perspective, it is clouded by the fact that households replace electricity with other more polluting fuels, which results in larger overall emissions, a rather undesirable development. It is also clouded by the fact that the reduction at the production level is directly linked to weaker economic activity that is induced by the VAT hike and, as such, is not necessarily a desirable way of reducing emissions.

4. An Environmentally-Friendly Alternative: Simulation Results

4.1. Reverting the Increase of the VAT on Electricity and the Need for Alternatives

Increasing the VAT on electricity from 6% to 23% achieved the goal of raising public revenues. The cost in terms of economic performance – in terms of output, employment, and prices – however, is also clear. The environmental benefits are also present, but are marginal and more questionable, given how they are achieved.

Both from an economic perspective and similarly from an environmental standpoint, this leads us to question the desirability of reverting this VAT increase now that the budgetary constraints in Portugal are much less dramatic. The immediate concern is that even though the budgetary situation has improved, renouncing tax revenues is always a difficult decision. In spite of a few undesirable side effects, the VAT increase on electricity is effective in raising tax revenues – i.e., it is successful in achieving what is was designed to do.

A possible solution that may address these concerns and, therefore, have the same benefits as the VAT hike, but fewer costs, is to impose an equivalent surtax on oil products [ISP, hereafter]. We now consider the effects of this surtax with a magnitude to match on an annual basis the lost tax revenues from reverting VAT on electricity back from 23% to 6%.

4.2. On the Budgetary Effects of the ISP Surcharge

The budgetary effects of the ISP surcharge are reported in Table 8. From a budgetary perspective, the ISP alternative leads to a long-term decline in the public debt of -4.917%, slightly less than the VAT case. This is despite a smaller decline in the tax revenues directly related to economic performance such as the personal income tax, corporate income tax, and social security contributions. Indeed, this slighter reduction is idiosyncratic, as it is due to the exogenous evolution of public consumption and transfers, which are indexed to GDP, and therefore grow at a faster pace under the ISP scenario, as well as the interest rate dynamics which are also exogenous for any given level of public debt. Overall, the budgetary effects of the ISP surcharge are positive, although smaller than the effects of the corresponding VAT.

4.3. On the Macroeconomic Effects of the ISP Surcharge

The macroeconomic effects of the ISP surcharge are reported in Table 9. GDP declines by -0.098%, and employment by –0.086%, in both cases less than the VAT counterpart (-0.138% and -0.108%, respectively). The CPI increases by a little more, 0.303% (versus 0.280%). The effects on private consumption are comparable, but the effects on private investment are much less adverse -0.093% (versus -0.237% in the VAT case). Finally, the effects on exports are now adverse, -0.121%, which leads to a slightly smaller reduction in foreign debt of -1.060% (versus -1.434% in the VAT case). Overall, the macroeconomic effects of the ISP surcharge on GDP, employment, and investment are less detrimental than the effects of the corresponding VAT change, despite a slightly smaller improvement in the foreign account and a slighter increase in the CPI.

4.4. On the Distributional Welfare Effects of the ISP Surcharge

The ISP surcharge represents for the households a loss in purchasing power. See Table 10 for details. The CPI increases by 0.303% (versus 0.280% in the VAT case). This increase, unlike the VAT case, is spread throughout income groups in a slightly progressive manner. In turn, the effects on employment and after-tax income are also more subdued: -0.082% and – 0.161% (as opposed to -0.108% and -0.278% in the VAT case), but still in a progressive manner. Overall, therefore, we observe that, as in the VAT case, all households face a reduction in purchasing power through higher prices and lower after-tax income, but now the changes are clearly smaller and not regressive, in terms of both income and prices.

The distributional effects of the ISP surcharge are reported in Table 11. These results are strikingly different from the corresponding VAT results. We observe here that the adverse welfare effects are close to proportional and, therefore, do not display the sharp regressive pattern of the VAT case. Accordingly, the adverse welfare effects for the lowest-income group is just -0.275% and the highest income group is -0.264% (versus -0.454% and -0.093%, respectively in the VAT case). Overall, the ISP alternative is clearly preferred from a distributional perspective.

4.5. On the Environmental Effects of the ISP Surcharge

The ISP surcharge naturally affects the energy and electricity markets. See Tables 12 and 13 for details. The surcharge translates into a -0.663% reduction in final energy demand (versus -1.034% in the VAT case), which is reflected across the economy albeit to different degrees. Electricity demand declines but only marginally, which translates into an increase of 0.587% in the electricity share in final energy demand (as opposed to a reduction of -2.4% in the VAT case).

The environmental effects of the ISP surcharge are reported in Table 14. These results are also strikingly different. First, the ISP surcharge would lead to a decline in emissions of -2.518% (compared to just -0.048% for the VAT case). In this case, emissions from households would be reduced by -0.148%, including from a -3.29% reduction from residential activities and of -0.890% from transportation activities (versus increases of 0.65%, 2.62%, and 0.01% in the VAT case, respectively).

The decrease of emissions from production activities, however, is less pronounced, -0.05% (as opposed to -0.480%), again led by lower emissions in the ETS sectors. Overall, at the aggregate level and from the perspective of environmental incentives towards electrification, the ISP alternative is superior.

5. Conclusions and Further Research

This article focused on the budgetary, economic, distributional and environmental effects of a permanent increase of the value-added tax on electricity spending in Portugal. The analysis was conducted in the context of a new multi-sector and multi-household dynamic general equilibrium model of the Portuguese economy. Simulation results suggest that a permanent increase in the statutory VAT rate on electricity from 6% to 23% has positive budgetary and (marginally) positive environmental effects, but both come at the cost of detrimental economic and distributional side effects.

As economic performance in Portugal improves and the public finances are beginning to shape up, it is inevitable that pressure will mount for this increase in the VAT rate on electricity to be reversed, sooner rather than later. This mixed bag of results provides an important element in this debate. We find that reverting to a VAT rate of 6% on electricity would not only improve economic performance but would also have positive distributional effects, and only marginally affect emissions. From this perspective, such a reversion would be desirable. The question is then whether or not the public budget can somehow compensate for the loss of revenues in a way that would not eliminate the positive economic and distributional effects of such reversion.

A possible alternative considered here is to replace the higher VAT on electricity with a surcharge on the tax on petroleum products of an equivalent magnitude. We find that this alternative leads to substantially smaller adverse effects at the macroeconomic level – GDP, employment, and investment all fare better, and the distributional welfare effects become proportional and are thus no longer regressive. Furthermore, such a reversion would lead to favorable environmental effects that are substantially larger. In a nutshell, if the budgetary situation is not deemed sound enough to just revert the VAT tax rate on electricity to 6%, then clearly replacing this increase it with an equivalent ISP surcharge would have favorable economic, distributional and environmental effects, while still keeping significant budgetary advantages. Increasing the ISP in exchange for lower VAT on electricity is therefore a dominant strategy from all relevant perspectives – economic, distributional, and environmental.

As a final note, although this research is an application to the Portuguese case and is more directly relevant for policy making in this context, its pertinence is far from parochial. Indeed, there are more and more countries adopting VAT systems, which raises the question about what the optimal tax rate on electricity spending ought to be. Furthermore, even in the EU-28 confines, there are seven countries with reduced electricity rates: France, Greece, Ireland, Italy, Luxembourg, Malta, United Kingdom [see European Commission (2017a)]. To be noted, France, Greece and the United Kingdom are three of the four countries still under Excessive Deficit Procedures and, therefore, under high pressure for increasing tax revenues. On the flip side, the issue is also relevant for the remaining EU-28 countries where electricity purchases are taxed at the standard VAT rates, but which may in the future want to consider an abatement for environmental reasons. Finally, in the aftermath of Brexit, there are voices in the UK favoring the elimination – or at least a further reduction – of their already reduced VAT rate on electricity, which is currently set at the minimum mandatory rate of 5% imposed by the European Union.

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Table 1 – Budgetary Effects of the Increase in the VAT on Electricity

(% change relative to the status quo)

	2020	2030	2040	2050
Public Debt	-0.686	-2.256	-4.283	-6.954
Public Expenditures	-0.123	-0.244	-0.410	-0.619
Public Consumption	-0.127	-0.085	-0.069	-0.054
Total Tax Revenue	0.391	0.377	0.392	0.371
VAT and related	1.276	1.284	1.399	1.409
Personal Income Tax	-0.156	-0.221	-0.310	-0.409
Social Contributions	-0.077	-0.090	-0.103	-0.108
Corporate Income Tax	-0.118	-0.108	-0.141	-0.153

Table 2 – Economic Effects of the Increase in the VAT on Electricity

(% change relative to the status quo)

	2020	2030	2040	2050
GDP	-0.058	-0.099	-0.120	-0.138
Private Consumption	-0.151	-0.168	-0.198	-0.207
Investment	-0.262	-0.263	-0.250	-0.237
Employment	-0.077	-0.090	-0.103	-0.108
Foreign Debt	-0.268	-0.766	-1.168	-1.434
Trade Balance	-1.240	-0.933	-0.727	-0.570
Exports	0.174	0.113	0.072	0.036
Imports	-0.108	-0.108	-0.119	-0.121
CPI	0.206	0.232	0.268	0.280

Table 3 – Distributional Effects of the Increase in the VAT on Electricity

(% change relative to the status quo)

	2020	2030	2040	2050
Labor Supply	-0.077	-0.090	-0.103	-0.108
First Quintile (lowest)	-0.044	-0.049	-0.054	-0.055
Second Quintile	-0.060	-0.070	-0.078	-0.082
Third Quintile	-0.076	-0.090	-0.102	-0.108
Fourth Quintile	-0.080	-0.094	-0.108	-0.115
Fifth Quintile (highest)	-0.086	-0.100	-0.115	-0.122
After-tax Income	-0.136	-0.167	-0.219	-0.278
First Quintile (lowest)	-0.050	-0.060	-0.079	-0.101
Second Quintile	-0.104	-0.126	-0.167	-0.213
Third Quintile	-0.140	-0.171	-0.225	-0.286
Fourth Quintile	-0.149	-0.183	-0.240	-0.304
Fifth Quintile (highest)	-0.155	-0.192	-0.251	-0.320
CPI	0.206	0.232	0.268	0.280
First Quintile (lowest)	0.369	0.400	0.453	0.468
Second Quintile	0.286	0.316	0.359	0.374
Third Quintile	0.239	0.267	0.306	0.320
Fourth Quintile	0.188	0.214	0.249	0.262
Fifth Quintile (highest)	0.123	0.147	0.176	0.187

Table 4 – Equivalent Variation Effects of the Increase in the VAT on Electricity

(% change relative to the status quo)

	2020	2030	2040	2050
First Quintile (lowest)	-0.359	-0.388	-0.440	-0.454
Second Quintile	-0.254	-0.277	-0.316	-0.330
Third Quintile	-0.186	-0.205	-0.238	-0.249
Fourth Quintile	-0.127	-0.143	-0.171	-0.180
Fifth Quintile (highest)	-0.050	-0.064	-0.085	-0.093

Table 5 – The Effects of the Increase in the VAT on Electricity on Final Energy Demand

(% change relative to the status quo)

	2020	2030	2040	2050
Final Energy Demand	-0.702	-0.883	-0.943	-1.034
Energy Demand by Households	-1.969	-2.146	-2.098	-2.210
First Quintile (lowest)	-2.528	-2.732	-2.694	-2.815
Second Quintile	-2.112	-2.299	-2.232	-2.352
Third Quintile	-1.983	-2.163	-2.099	-2.217
Fourth Quintile	-1.870	-2.045	-1.996	-2.109
Fifth Quintile (highest)	-1.682	-1.840	-1.821	-1.923
Energy Demand by Production Sectors	-0.625	-0.805	-0.946	-1.015
ETS	-1.082	-1.275	-1.453	-1.524
Non-ETS	0.204	0.077	0.007	-0.028

Table 6 – The Effects of the Increase in the VAT on Electricity on the Electricity Market

(% change relative to the status quo)

	2020	2030	2040	2050
Electricity Production	-1.451	-1.735	-1.904	-1.984
Percent Renewable (%)	0.373	-0.144	0.081	-0.015
Net Imports	-3.405	-2.823	-2.519	-2.408
Electricity Demand by Households	-5.500	-5.751	-5.847	-5.927
First Quintile (lowest)	-5.499	-5.752	-5.860	-5.941
Second Quintile	-5.880	-6.151	-6.258	-6.345
Third Quintile	-5.777	-6.042	-6.143	-6.228
Fourth Quintile	-5.514	-5.766	-5.860	-5.940
Fifth Quintile (highest)	-4.981	-5.203	-5.288	-5.358
Electricity Demand by Production Sectors	-0.789	-1.090	-1.295	-1.384
ETS	-1.563	-1.797	-1.943	-2.011
Non-ETS	0.840	0.426	0.252	0.146
% Electricity in Final Energy Demand	-1.750	-2.024	-2.327	-2.400

Table 7 – Environmental Effects of the Increase in the VAT on Electricity

(% change relative to the status quo)

	2020	2030	2040	2050
Total CO_2 Emissions	-0.068	-0.042	-0.060	-0.048
Households	0.629	0.633	0.653	0.650
Residential	2.537	2.596	2.625	2.623
Transportation	0.029	0.022	0.012	0.007
Households	0.629	0.633	0.653	0.650
First Quintile (lowest)	0.755	0.758	0.776	0.772
Second Quintile	0.812	0.818	0.840	0.837
Third Quintile	0.761	0.769	0.794	0.791
Fourth Quintile	0.631	0.637	0.660	0.658
Fifth Quintile (highest)	0.389	0.391	0.405	0.403
Production Sectors	-0.300	-0.270	-0.420	-0.408
ETS	-0.511	-0.458	-0.942	-0.917
Non-ETS	0.070	0.060	0.059	0.055

Table 8 – Budgetary Effects of an Equivalent Increase in Taxes on Petroleum Products {ISP}

(% change relative to the status quo)

	2020	2030	2040	2050
Public Debt	-0.465	-1.556	-2.995	-4.917
Public Expenditures	-0.056	-0.149	-0.270	-0.424
Public Consumption	-0.029	-0.019	-0.016	-0.012
Total Tax Revenue	0.302	0.292	0.308	0.294
VAT and related	0.956	0.957	1.042	1.048
Personal Income Tax	-0.082	-0.127	-0.188	-0.260
Social Contributions	-0.065	-0.072	-0.082	-0.086
Corporate Income Tax	-0.080	-0.073	-0.080	-0.081

Table 9 – Economic Effects of an Equivalent Increase in Taxes on Petroleum Products {ISP}

(% change relative to the status quo)

	2020	2030	2040	2050
GDP	-0.062	-0.077	-0.091	-0.098
Private Consumption	-0.212	-0.222	-0.248	-0.253
Investment	-0.097	-0.100	-0.096	-0.093
Employment	-0.065	-0.072	-0.082	-0.086
Foreign Debt	-0.172	-0.515	-0.826	-1.060
Trade Balance	-0.818	-0.637	-0.520	-0.413
Exports	-0.029	-0.059	-0.083	-0.100
Imports	-0.187	-0.181	-0.187	-0.181
CPI	0.251	0.265	0.295	0.303

Table 10 – Distributional Effects of an Equivalent Increase in Taxes on Petroleum Products {ISP}

(% change relative to the status quo)

	2020	2030	2040	2050
Labor Supply	-0.065	-0.072	-0.082	-0.086
First Quintile (lowest)	-0.034	-0.035	-0.038	-0.038
Second Quintile	-0.051	-0.055	-0.061	-0.063
Third Quintile	-0.064	-0.071	-0.080	-0.084
Fourth Quintile	-0.067	-0.075	-0.086	-0.091
Fifth Quintile (highest)	-0.074	-0.083	-0.094	-0.099
After-tax Income	-0.070	-0.091	-0.123	-0.161
First Quintile (lowest)	-0.023	-0.030	-0.042	-0.056
Second Quintile	-0.051	-0.067	-0.092	-0.122
Third Quintile	-0.071	-0.092	-0.126	-0.165
Fourth Quintile	-0.078	-0.101	-0.136	-0.178
Fifth Quintile (highest)	-0.081	-0.105	-0.143	-0.187
CPI	0.251	0.265	0.295	0.303
First Quintile (lowest)	0.240	0.253	0.281	0.288
Second Quintile	0.252	0.266	0.297	0.303
Third Quintile	0.254	0.268	0.299	0.306
Fourth Quintile	0.256	0.270	0.301	0.308
Fifth Quintile (highest)	0.249	0.263	0.293	0.300

Table 11 – Equivalent Variation Effects of an Equivalent Increase in Taxes on Petroleum Products {ISP}

(% change relative to the status quo)

	2020	**2030**	**2040**	**2050**
First Quintile (lowest)	-0.229	-0.241	-0.269	-0.275
Second Quintile	-0.226	-0.237	-0.265	-0.271
Third Quintile	-0.215	-0.225	-0.251	-0.257
Fourth Quintile	-0.214	-0.223	-0.249	-0.254
Fifth Quintile (highest)	-0.200	-0.208	-0.233	-0.238

Table 12 –Effects of an Equivalent Increase in Taxes on Petroleum Products [ISP] on Final Energy Demand

(% change relative to the status quo)

	2020	2030	2040	2050
Final Energy Demand	-0.609	-0.604	-0.674	-0.663
Energy Demand by Households	-1.319	-1.267	-1.360	-1.307
First Quintile (lowest)	-1.092	-1.049	-1.129	-1.083
Second Quintile	-1.098	-1.054	-1.130	-1.083
Third Quintile	-1.185	-1.136	-1.217	-1.167
Fourth Quintile	-1.333	-1.279	-1.371	-1.316
Fifth Quintile (highest)	-1.666	-1.604	-1.719	-1.657
Energy Demand by Production Sectors	-0.076	-0.087	-0.102	-0.108
ETS	-0.109	-0.115	-0.132	-0.134
Non-ETS	-0.018	-0.035	-0.046	-0.057

Table 13 –Effects of an Equivalent Increase in Taxes on Petroleum Products [ISP] on the Electricity Market

(% change relative to the status quo)

	2020	2030	2040	2050
Electricity Production	-0.041	-0.049	-0.058	-0.062
Percent Renewable (%)	0.035	0.025	0.038	0.032
Net Imports	-0.098	-0.079	-0.071	-0.065
Electricity Demand by Households	-0.037	-0.045	-0.057	-0.062
First Quintile (lowest)	-0.064	-0.074	-0.090	-0.096
Second Quintile	-0.036	-0.044	-0.057	-0.063
Third Quintile	-0.026	-0.032	-0.044	-0.050
Fourth Quintile	-0.031	-0.038	-0.050	-0.054
Fifth Quintile (highest)	-0.037	-0.043	-0.055	-0.059
Electricity Demand by Production Sectors	-0.052	-0.061	-0.071	-0.076
ETS	-0.725	-0.693	-0.730	-0.719
Non-ETS	-0.087	-0.086	-0.096	-0.099
% Electricity in Final Energy Demand	0.569	0.554	0.604	0.587

Table 14 – Environmental Effects of an Equivalent Increase in Taxes on Petroleum Products {ISP}

(% change relative to the status quo)

	2020	2030	2040	2050
Total CO_2 Emissions	-2.447	-2.419	-2.552	-2.518
Households	-0.131	-0.133	-0.146	-0.148
Residential	-3.175	-3.131	-3.334	-3.290
Transportation	-0.620	-0.626	-0.883	-0.890
Households	-2.447	-2.419	-2.552	-2.518
First Quintile (lowest)	-2.437	-2.415	-2.539	-2.507
Second Quintile	-2.092	-2.070	-2.173	-2.142
Third Quintile	-2.199	-2.173	-2.286	-2.253
Fourth Quintile	-2.403	-2.375	-2.506	-2.471
Fifth Quintile (highest)	-2.856	-2.819	-2.990	-2.951
Production Sectors	-0.013	-0.022	-0.041	-0.050
ETS	-0.123	-0.125	-0.266	-0.271
Non-ETS	0.180	0.160	0.164	0.152

APPENDIX
DGEP Model Description and Implementation

1. Model Description

Household Behavior

We consider five household income groups per quintile. While the general structure of household behavior is the same for all household groups, preferences, income, wealth and taxes are all household-specific, as are consumption demands, savings, and labor supply.

Household h chooses consumption and leisure streams that maximize intertemporal utility, subject to the consolidated budget constraint. The objective function is lifetime expected utility, subjectively discounted at the rate of β. Preferences, are additively separable in consumption and leisure, and take on the CES form, where σ is the constant elasticity of substitution.

C_h denotes the total consumption by household *h*, including both expenditure on goods and services. P_h is a household-specific price index which reflects consumption levels of individual goods and services as well as their prices. The household-specific price index reflects the individual basket of goods and services that each household selects. The amount of time the household spends in leisure and recreational activities is denoted by ℓ_h.

The budget constraint reflects the fact that consumption is subject to a value-added tax rate of $\tau_{VAT,C}$ and states that the households' expenditure stream discounted at the after-tax market real interest rate, $1 + (1 - \tau_r)r_{t+v}$, cannot exceed total wealth at t, $TW_{h,t}$. For the household h, total wealth, $TW_{h,t}$, is composed of human wealth, $HW_{h,t}$, and net financial wealth, $A_{h,t}$.

The household's wage income is determined by its endogenous decision of how much labor to supply, $LS_t = \bar{L} - \ell_t$, out of a total time endowment of $\bar{L}$, and by the stock of knowledge or human capital, HK_t. Labor earnings are discounted at a higher rate reflecting the probability of survival.

The effective wage rate, wHK_h, accomodates differences in income levels for the same number of work hours, by accounting for differences in worker productivity reflected in differences in the level of human capital each household has accumulated. The level of human capital for each household reflects differences in education and experience among the various household groups. In this version of the model the household-specific HK is fixed or exogenously given.

A household's labor income is augmented by international transfers, R_t, and public transfers, TR_t as well as capital income - interest payments received on public debt, PD_t, net of payments made on foreign debt, and profits distributed by corporations, NCF_t, where s_{ht} is the share of household *h* of the aggregate market portfolio.

On the spending side, taxes are paid and consumption expenditures are made. Income, net of spending, adds to net financial wealth in the form of savings. To allocate aggregate consumption to specific commodities, goods and services, consumers maximize utility from consumption subject to their budget constraint:

$$\max_{\mathbf{QH_h}} \left[\ U^h(\mathbf{QH_h}) \ \mid \ PC_h QC_h \ \geq \ (\mathbf{1} + \boldsymbol{\tau}_{\mathbf{vat}})(\mathbf{PQ} + \boldsymbol{\tau}_{\mathbf{unit}}) \times \mathbf{QH_h} \right]$$

where $\boldsymbol{PQ}$ and $\boldsymbol{QH_h}$ denote a vector of price ($/unit) and quantity (physical units) of a good consumed over the course of a year, respectively. $PC_{ht}QC_{ht}$ represents total expenditure on goods and services by the household h at time t. Expenditure on goods and services is subject to product and service-specific value-added tax rates, $\tau_{\text{vat,c}}$, and other unit taxes, $\tau_{\text{unit,c}}$, including the tax on petroleum and energy products (ISP). At optimality, the marginal rate of substitution is equal to the market opportunity cost. The exchange rate for the individual household required to maintain a given level of utility is exactly equal to the rate at which the household can exchange these goods in the marketplace.

This general framework is applied at two different levels. First, it is applied to determine the optimal allocation of total consumption spending among the three main category of goods: transportation services, residential energy, other goods and services. Second, it is applied to determine the optimal allocation within more specific categories within each one of these three main groups.

Producer Behavior

We consider thirteen production sectors. While the general structure of production behavior is the same for all sectors, technologies, capital endowments, and taxes are sector-specific as are output supply, labor demand, energy demand, and investment demand.

Firms maximize the present value of the firm which serves as a source of financial wealth for households. The firm maximizes the present value Hamiltonian which reflects the firm's net cash flow and is subject to the equation of motion for private capital, and renewable energy capital, specified for hydroelectric, wind and solar power infrastructures.

The firms' net cash flow, NCF, represents the after-tax position when revenues from sales are netted of wage payments spending in energy and materials and investment spending. The after-tax net revenues reflect the presence of a private investment tax credit at an effective rate of τ_{ITC}, taxes on corporate profits at a rate of τ_{CIT}, and Social Security contributions paid by the firms on gross salaries, $w_t L_t^d$, at an effective rate of τ_{FSSC}.

The corporate income tax base is calculated as revenues net of total labor costs, $(1 + \tau_{FSSC}) w_t L_t^d$, as well as spending in energy and materials and is net of fiscal depreciation allowances over past and present capital investments, αI_t.

Output is produced using capital, labor, energy and material inputs. The production technology describes the level of output possible for the use of inputs to production employed by the firm. The production technology is assumed to be continuous and twice differentiable and thus, by the appropriate choices for the elasticity of substitution in production yields a smooth, continuous approximation to the discrete choice of processes, activities and equipment made at the plant level.

Capital, labor and energy inputs are separable into two broader categories, value added and energy inputs. Value added includes capital and labor inputs to production. A Constant Elasticity of Substitution technology is used to describe the level of value added produced from capital and labor inputs. Energy inputs consist of coal, natural gas, crude oil, refined oil products and electricity. These are aggregated according to a constant elasticity of substitution technology. The conditional demand for these inputs is defined from efforts by the firm to minimize the costs of producing the composite quantity required at the higher levels for the nested production structure.

Material inputs are goods and services produced by other industries needed in production. These material inputs are used in fixed proportions to the level of output. The firm cannot substitute among materials in production. The firm may, however, through its organization of assembly and manufacturing operations, substitute between material inputs and capital, labor and energy in production according to a constant elasticity of substitution production technology.

Private capital accumulation is characterized by the equation of motion for capital where physical capital depreciates at a rate δ_K. Gross investment, I_t, is dynamic in nature with its optimal trajectory induced by the presence of adjustment costs. These costs are modeled as internal to the firm - a loss in capital accumulation due to learning and installation costs - and are meant to reflect rigidities in the accumulation of capital towards its optimal level. Adjustment costs are assumed to be non-negative, monotonically increasing, and strictly convex. In particular, we assume adjustment costs to be quadratic in investment per unit of installed capital.

Optimal production behavior consists in choosing the levels of output supply, labor demand, aggregate energy demand, aggregate demand for intermediate materials, and demand for investment that maximize the present value of the firms' net cash flows, subject to the equation of motion for private capital accumulation.

Finally, with regard to the financial link of the firm with the rest of the economy, we assume that at the end of each operating period the net cash flow netted of investment spending is transferred to the consumers as return on their ownership of the firms.

Investment Supply and Demand

The output of various industries is used in the production of capital goods used by firms. Construction, equipment manufacturing, primary metals and other goods and services are used in the production of plant and equipment for firms. These industry determine the supply of investment goods. The supply of the investment good is a CES composite of the different types of investment goods available in the economy. Demand for individual component of the investment good is determined by the minimization of the cost of producing the desired amount of the investment good in the economy at time t. In turn, the demand for investment by firms is determined by the firms' maximization problem described above.

Financing for investment is available from savings by private households and foreign transfers reflected in the current accounts deficit and is affected by public deficits whereby reductions in tax revenues or unfinanced increases in expenditures increase the public deficit and crowd out private investment.

The Foreign Sector

The current account deficit reflects the balance of payments with the foreign sector and incorporates both the trade balance and financial flows from abroad. Because of the nature of the currency markets where the economy finds itself, we assume that the foreign exchange rate is exogenous and fixed. This means that in the absence of import and export duties, the import and export prices for the same commodity would be the same.

Net imports are financed through foreign transfers and foreign borrowing. Foreign transfers grow at an exogenous rate. The domestic economy is assumed to be a small, open economy. This means that it can obtain the desired level of foreign financing at a rate which is determined in the international financial markets. This is the prevailing rate for all domestic agents.

Domestic production and imports are absorbed by domestic expenditure and exports. Domestic demand is satisfied by domestic production and imports from abroad following an Armington specification. Goods produced domestically are supplied to both the national (domestic) market and exported internationally and follow a Constant Elasticity of Transformation (CET) specification

The Public Sector

The equation of motion for public debt reflects the fact that the excess of government expenditures over tax revenues, i.e., the public deficit, has to be financed by increases in public debt. Given the nature of our approach, the evolution of public debt is determined by the endogenous evolution of the tax revenues or more specifically by the endogenous evolution of the different tax bases. Specifically, no behavioral changes on the expenditure side are considered.

Tax revenues include personal income taxes, corporate income taxes, value added taxes as well as other product-specific taxes, social security taxes levied on firms and workers, as well as duties levied on imports and/or exports. All of these taxes are levied on endogenously defined tax bases. Residual taxes are modeled as lump sum, obtained by calibration and are assumed to grow at an exogenous rate.

On the expenditure side, the public sector engages in public consumption and public investment activities. In addition, the public sector transfers funds to households - in the form of pensions, unemployment subsidies, and social transfers also at an exogenous growth rate. Because these expenditures consistent primarily of expenditures on compensation of public sector employees and on social transfers, these expenditures are assumed to grow at an exogenous rate g. Finally, the public sector pays interest on outstanding debt

The allocation of public consumption spending among the different goods and services in the economy is responsive to relative prices and is obtained through the solution to the public sector's cost minimization problem of achieving the desired aggregate consumption level. While aggregate consumption in volume is determined exogenously, public consumption expenditure is affected by endogenous changes in prices determined by the model supply and demand considerations.

2. Data

General Data Sources

Data are from Statistics Portugal (www.ine.pt). The data are based on the Portuguese National Accounts (ESA 2010, base 2011). These data include A – main aggregates for the Portuguese economy, including 1) Gross Domestic Product and its components, 2) Income, Saving and Net Lending/ Borrowing, 3) External Balances, 4) Employment and 5) Goods and Services account. These further include B – Institutional Sectors including, the Government, Households and the Rest of the World (the Foreign Sector). We further consider specific tables by industries including Gross Value Added – Compensation of Employees, Gross Operating Surplus and Taxes/Subsidies on Production, as well as Production and Intermediate Consumption by the A38 classification of economic activity described below. We further use detailed supply and use tables to construct the social accounting matrix for Portugal.

Data for household expenditure are taken from two surveys. The first is the Inquérito ao Consumo de Energia no Sector Doméstico, a one-time survey conducted in 2010. The second is the Inquérito às Despesas das Famílias, a survey conducted every five years. The model largely employs data from the 2010/2011 survey in allocating income to household by income group and describing the expenditure patterns for each household type.

The Energy Sector

Portugal imports fossil fuels and has a large potential for renewable energy resources, namely wind, solar and hydropower. Renewable energy resources accounted for 25.9% of domestic primary energy consumption in Portugal in 2014, primarily used in the production of electricity. Petroleum and petroleum products accounted for 43.4% of primary energy consumption in Portugal in 2014. Natural gas (16.7% and coal (12.8%) are important sources of energy as well.

Transportation demand for energy amounted to 36.3% of the total final demand for energy in 2014, followed closely by industry (31.2%). Diesel is the dominant fuel in transportation in Portugal (4.072 Mtep in 2014), followed by gasoline (1.136). Residential demand for energy amounted to 16.8% of the total and demand in services accounted for 12.8%. The remaining 2.8% constitutes final energy demand in agriculture. With respect to electricity, services (36.7%) and industry (34.5%) are much more important as is residential demand for electricity (26.4% of the total). Agriculture (1.8%) and transportation (0.7%) do not use electricity extensively.

Renewable energies have made substantial advances in Portugal since 2005. In 2005, thermal electricity general amounted to 85% of the total and renewable energies, including hydroelectric, wind, geothermal and solar power, amounted to 15% of electricity generation. By 2014, electricity generation grew to account for 56.4% of electricity generated in continental Portugal lead by a substantial increase in wind energy generation which accounted for 23.4% of electricity production in 2014, a year with very favorable hydrological conditions which allowed for electricity from hydroelectric facilities to account for 31.9% of total electricity produced. The increased reliance on domestic, renewable energy sources has contributed towards a reduction in emissions factor for the electric power industry from 462 tCO_2 per Gwh in 2005 to 217 tCO_2 per Gwh in 2014.

In 2008 and 2009 the final demand for electricity in Portugal fell 1.2% and 0.9%, respectively. During the crisis that followed, electricity demand fell 8.8%, from 48.9 Twh in 2010 to 44.6 Twh in 2014, falling 3.0% in 2011 and 4.1% in 2012, respectively. This reduction in emissions is likely attributable to low levels of economic output and consumer confidence during the crisis (Eurostat, 2017)

Energy products in Portugal are subject to value added taxation and product specific taxes. Since January 1, 2011 the value added tax (IVA) rate on energy products is 23% (Lei nº51-A/2011, de 30 de Setembro), up from 19% in 2005. Energy products are subject to a specific tax on petroleum products (ISP) and to carbon taxation. Industrial use of natural gas is exempt from carbon taxation. The carbon tax rate for 2017 is based on an average price in the EU-ETS of 6.85 Euro/tCO_2 (Portaria nº 10/2017, de 09/01).

The Portuguese Economy

The Portuguese economy was dramatically affected by the sovereign debt crisis experienced in many parts of Europe since 2011. The late 1990s was a period of substantial growth in Portugal during which time the Portuguese economy grew at an average annual rate of 4.2%. During the early 2000s, the Portuguese economy began to stagnate and grew at an average annual rate of 1.5% between 2000 and 2004. Since 2005, growth in Portugal has been very weak. The real annual rate of growth of economic activity between 2005 and 2014 was -0.2%. In fact, since the financial crisis Portugal lost 6.8% of its national income between 2010 and 2013. Growth has picked up over that the last few years with the real growth rate of estimated for 2015 at 1.6%.

Gross domestic product consists of private consumption (66.44%), public consumption (19.94%), investment (19.66%) and net exports (-8.21), the difference between exports (28.75%) and imports (36.96%). From the income side, employment made up 46.23% of GDP between 2005 and 2014 while gross operating surplus for firms amounted to 41.44% of GDP. These figures imply that labor income made up 52.73% of income and capital income accounted for 47.27% of income.

The largest sectors of economic activity, in terms of employment levels between 2005 and 2014, were Wholesale and retail trade (15.6%), construction (9.3%), agriculture (7.5%), the public sector, accommodation and food services (5.8%), and manufacturing of textiles, wearing apparel and leather products (4.9%).The principal exports in Portugal are automobiles and transportation equipment with exports from the manufacturing of transport equipment accounting for 3.2% of GDP followed by the manufacturing of textiles, wearing apparel and leather products which exported products valued at 3.1% of GDP between 2005 and 2014. Other energy intensive manufacturing industries, including basic metals and fabricated metal products (2.3%), non-metallic mineral products (2.0%) and wood and paper products (1.8%), have also been very important tradable sectors in the Portuguese economy. (Source: Statistics Portugal)

Household Income and Expenditure

Households consume energy to satisfy demand for transportation services and for residential use. Residential energy consumption accounted for 3.91% of household expenditure while energy demand for personal transportation accounted for 4.55% of household expenditure. Diesel fuel is the dominant source of fuel for automobile transportation in Portugal, accounting for 56.9% of energy consumption in transportation. Residential energy demand includes the use of electricity for heating (11.1% of expenditure) and cooling (0.7%) the residence, heating water (27.4%), energy consumption in the kitchen (39.7%), associated with electrical appliances (15.0%) and lighting (6.1%). Residential demand for energy is dominated by electricity consumption which accounts for 42.5% of consumption and 62.5% of expenditure on energy across households. Butane, propane and liquefied petroleum gases (LPG) are also an important source of energy in residences accounting for 18.0% of consumption and 24.3% of expenditure. These are particularly important sources of energy for hot water furnaces and for use in cooking in the kitchen. Natural gas use in residences has increased in recent years but remains relatively modest accounting for 9.3% of consumption and 6.1% of expenditures. Coal is used in small amounts in households and almost exclusively for cooking.

Patterns of energy consumption across household groups at different income levels tend to suggest that energy services are normal goods, whose consumption increases with income, and that these are necessary goods, that they tend, generally to make up a larger share of a household's budget at lower levels of income than at higher levels of income. This pattern of consumption is particularly apparent for electricity demand. Expenditure on electricity amounted to 4.04% (3.91%) of expenditure for households in the lowest income quintile in 2010, 3.49% (3.11%) for those in the second quintile, 3.07% (2.69%) for those in the third quintile, 2.63% (2.26%) for those in the fourth quintile and 2.25% (1.70%) for those in the highest income quintile. Natural gas consumption tends to follow a similar pattern of expenditures, though expenditures in the lowest income quintile are slightly lower (0.42% of income) than those in the second (0.56%) and third (0.45%) of income. Expenditure on natural gas for households in the highest two income quintile is somewhat lower, at 0.29% and 0.10% of income, respectively.

Much of Portugal, and the larger cities of Lisbon and Porto, in particular, is equipped with a well-developed public transportation system which includes buses, trains, boats and light rail networks. The availability of this public transportation network coupled with high gasoline and diesel prices, lower salaries, and the relatively compact city structures have contributed towards making cars something of a luxury, though expenditure shares vary little across income groups. Diesel and gasoline consumption together account for 4.32% of expenditure among low income households, 4.49% among households in the second income quintile, 4.55% among those in the third income quintile, 4.63% among those in the fourth income quintile and 4.57% among those in the highest income quintile.

The Public Sector

Since 2005, public debt has exploded from 67.4% of GDP to 130.6% of GDP in 2014. Public deficits in Portugal reached 6.8% of GDP in 2009 and 8.2% of GDP in 2010.

The tax burden in Portugal amounted to 34.5% of GDP in 2015. In recent years, the increase in taxation in the context of austerity measures to address high levels of public indebtedness have focused on increases in the corporate income tax, the value added tax and social security contributions. The tax burden in Portugal was below the EU28 average of 39.0% in 2015. Taxes on income, including personal income taxes (9.27%) and social security contributions (7.98% of GDP from employers and 3.74% from workers) are the largest source of revenue for the Portuguese government. Value added and excise taxes are the second largest source of income for the Portuguese government. Revenues from the value added tax amounted to 8.0% of GDP between 2005 and 2014 and product specific excise taxes, including taxes on energy products amounted to 4.37% of GDP.