

**SOBRE OS EFEITOS
AMBIENTAIS E ECONÓMICOS
DE UM NOVO
IMPOSTO SOBRE O CARBONO**

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1. Introdução

2. O Modelo de Equilíbrio Geral Dinâmico

2. The Dynamic General Equilibrium Model

- We examine the economic and budgetary effects of environmental fiscal reform in the context of a **dynamic general equilibrium model**.
 - This model incorporates fully dynamic optimization behavior, endogenous growth, and a detailed modeling of public sector activities, both tax revenues and consumption and investment spending.
 - The key distinguishing feature of this model in the applied climate policy literature is its focus on endogenous growth and the associated treatment of public sector optimization behavior [see Conrad (1999) and Bergman (2005) for literature surveys].

2. The Dynamic General Equilibrium Model

The model has been used to study the impact of tax reform (Pereira and Rodrigues, 2001), social security reform (Pereira and Rodrigues, 2006) and, more recently, energy and environmental policies (Pereira and Pereira, 2011a, 2011b).

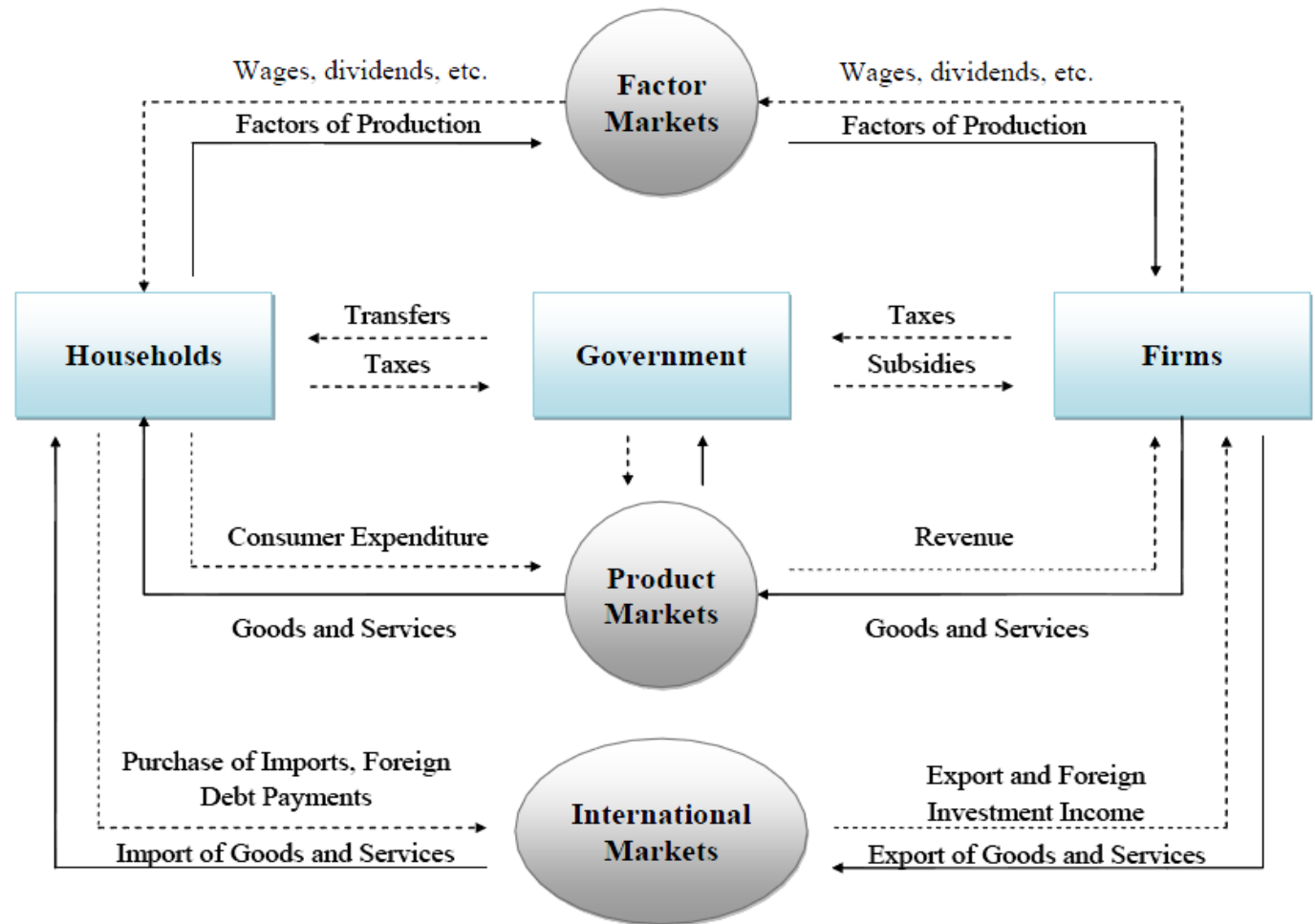
Bring together two important strands of the taxation literature.

- Considers the tax system in great detail.
 - in the tradition of Auerbach and Kotlikoff (1984,1987), Goulder and Thalmann (1993), Goulder and Summers (1989), Kotlikoff (1995, 1996), and Pereira (1994,1999a).
- Insights of the endogenous growth literature
 - in the tradition of Barro (1990), Barro and Sala-i-Martin (1992, 1995), Osang and Pereira (1996), Pecorino (1993), and Romer (1986) among many others.

2. The Dynamic General Equilibrium Model

- We consider a decentralized economy in a **dynamic general-equilibrium framework**.
 - All agents are price-takers and have perfect foresight.
 - There are four sectors in the economy – the production sector, the household sector, the public sector and the foreign sector.
 - The trajectory for the economy is described by the optimal evolution of eight stock and five shadow price variables.

2. The Dynamic General Equilibrium Model



2. The Dynamic General Equilibrium Model

- Data
 - Flow data take the average value between 1998-2013;
 - Stocks defined at 2013 levels.
- Calibration
 - Steady State calibration;
 - Values defined in the literature.

The model solution is that for a system of thirteen nonlinear first order difference equations, together with accounting identities, first-order conditions within each time period and equilibrium conditions.

- The model is implemented in General Algebraic Modeling System (GAMS) and solved with the Minos Solver.

**3. Um imposto sobre as
emissões de dióxido de carbono
em Portugal
- necessário?**

**Table 1:
Fossil Fuel Price Scenario**

	2013	2015	2020	2025	2030
European Commission Forecast (EC)					
Crude Oil	1.00	1.10	1.32	1.36	1.38
Coal	1.00	1.17	1.17	1.25	1.25
Natural Gas	1.00	1.12	1.52	1.43	1.61
Crude Oil/Coal Price Ratio	1.00	0.94	1.13	1.09	1.10
Natural Gas/Coal Price Ratio	1.00	0.96	1.30	1.14	1.29
Crude Oil/Natural Gas Price Ratio	1.00	0.98	0.87	0.95	0.86
Reference Case (REF)					
Crude Oil	1.00	1.02	1.06	1.09	1.11
Coal	1.00	1.07	1.13	1.20	1.20
Natural Gas	1.00	1.02	1.19	1.12	1.26
Crude Oil/Coal Price Ratio	1.00	0.95	0.94	0.91	0.93
Natural Gas/Coal Price Ratio	1.00	0.95	1.05	0.93	1.05
Crude Oil/Natural Gas Price Ratio	1.00	1.00	0.90	0.98	0.89
Future Market Case (MKT)					
Crude Oil	1.00	0.94	0.80	0.82	0.83
Coal	1.00	0.98	1.08	1.16	1.16
Natural Gas	1.00	0.92	0.86	0.81	0.91
Crude Oil/Coal Price Ratio	1.00	0.96	0.74	0.71	0.72
Natural Gas/Coal Price Ratio	1.00	0.94	0.82	0.70	0.78
Crude Oil/Natural Gas Price Ratio	1.00	1.02	0.90	1.01	0.92

Table 2:
On the Effects of Fossil Fuel Prices
Central Scenario

	2020	2025	2030	2050
Energy				
Total Energy Demand	-2.17	-3.11	-3.74	-6.96
Demand for Fossil Fuels	-3.43	-4.99	-6.16	-11.20
Crude Oil	-2.20	-3.47	-4.45	-8.75
Coal	-4.60	-9.92	-8.31	-15.34
Natural Gas	-7.30	-6.02	-10.99	-16.94
Investment in Wind Energy	13.46	14.61	16.60	21.51
Wind Energy Infrastructures	4.98	7.54	9.94	16.98
Carbon Dioxide Emissions from Fossil Fuel Combustion	-3.33	-5.15	-6.07	-11.16
Change as a percent of 1990 levels	-3.99	-6.49	-8.03	-17.98
Economy				
Growth Rate of GDP (Percent Change over Previous Period)	0.95	0.95	0.94	0.94
GDP	-0.02	-0.22	-0.45	-1.45
Private Consumption	-0.95	-0.95	-0.96	-0.98
Private Investment	-0.81	-1.14	-1.47	-2.74
Private Capital	-0.20	-0.42	-0.67	-1.81
Imported Energy	4.23	5.47	6.92	11.96
Foreign Debt	-3.64	-6.09	-8.45	-15.89
Labor Markets				
Employment	0.34	0.24	0.12	-0.38
Wages	-0.46	-0.58	-0.71	-1.28
Public Sector				
Public Debt	-2.29	-3.80	-5.24	-9.62
Public Expenditures	-2.10	-2.13	-2.16	-2.25
Public Consumption	-3.22	-3.18	-3.13	-2.92
Public Investment	-0.66	-0.97	-1.29	-2.54
Investment in Human Capital	-0.49	-0.55	-0.60	-0.80
Public Capital	-0.19	-0.42	-0.67	-1.84
Human Capital	-0.03	-0.06	-0.08	-0.20
Tax Revenues	-0.33	-0.47	-0.64	-1.30
Personal Income Tax (IRS)	-0.22	-0.61	-1.04	-2.63
Corporate Income Tax (IRC)	0.16	-0.04	-0.29	-1.42
Value Added Tax (IVA)	-1.02	-1.08	-1.13	-1.34
Social Security Contributions (TSU)	-0.15	-0.39	-0.68	-1.86

**Table 3:
On the Effects of Fossil Fuel Prices
Alternative Scenarios**

	2020	2025	2030	2050
Fossil Fuel Price Scenario: MKT				
Carbon Dioxide Emissions	5.29	4.55	3.63	-1.38
GDP	0.60	0.73	0.70	0.19
Labor Demand	0.27	0.32	0.29	0.02
Foreign Debt	0.36	-0.57	-1.78	-6.52
Public Debt	-0.08	-0.76	-1.56	-4.48
Fossil Fuel Price Scenario: Central				
Carbon Dioxide Emissions	-3.33	-5.15	-6.07	-11.16
GDP	-0.02	-0.22	-0.45	-1.45
Labor Demand	0.34	0.24	0.12	-0.38
Foreign Debt	-3.64	-6.09	-8.45	-15.89
Public Debt	-2.29	-3.80	-5.24	-9.62
Fossil Fuel Price Scenario: EC				
Carbon Dioxide Emissions	-9.36	-11.80	-12.75	-17.93
GDP	-0.58	-1.07	-1.48	-2.93
Labor Demand	0.41	0.17	-0.03	-0.75
Foreign Debt	-7.19	-11.01	-14.39	-24.25
Public Debt	-4.24	-6.50	-8.49	-14.18

Table 4:
On the Effects of Energy Efficiency Improvements
Annual Gain of 2%

	2020	2025	2030	2050
Energy				
Total Energy Demand	-7.65	-9.72	-10.37	-9.94
Demand for Fossil Fuels	-7.95	-9.86	-10.32	-9.49
Crude Oil	-7.98	-9.96	-10.47	-9.75
Coal	-8.00	-9.47	-10.16	-9.05
Natural Gas	-7.77	-9.88	-9.86	-8.88
Investment in Wind Energy	-16.26	-15.18	-14.16	-12.83
Wind Energy Infrastructures	-6.00	-8.92	-10.64	-12.45
Carbon Dioxide Emissions from Fossil Fuel Combustion	-7.96	-9.85	-10.33	-9.50
Change relative to 1990 levels	-9.53	-12.40	-13.67	-15.31
Economy				
Growth Rate of GDP (Percent Change over Previous Period)	1.03	1.00	0.98	0.96
GDP	0.37	0.69	0.91	1.35
Private Consumption	0.96	0.96	0.96	0.97
Private Investment	1.63	1.77	1.82	2.00
Private Capital	0.51	0.85	1.12	1.71
Imported Energy	-8.56	-10.93	-11.75	-11.97
Foreign Debt	3.29	4.82	5.90	8.23
Labor Markets				
Employment	-0.14	0.03	0.14	0.34
Wages	0.75	0.96	1.08	1.26
Public Sector				
Public Debt	1.84	2.69	3.29	4.55
Public Expenditures	1.94	1.92	1.92	1.93
Public Consumption	2.81	2.73	2.69	2.60
Public Investment	1.45	1.61	1.69	1.93
Investment in Human Capital	0.40	0.44	0.47	0.58
Public Capital	0.55	0.91	1.18	1.73
Human Capital	0.03	0.05	0.07	0.15
Tax Revenues	0.55	0.77	0.91	1.17
Personal Income Tax (IRS)	0.46	1.01	1.38	2.05
Corporate Income Tax (IRC)	0.17	0.68	1.02	1.61
Value Added Tax (IVA)	1.14	1.16	1.17	1.20
Social Security Contributions (TSU)	0.64	1.04	1.29	1.75

**Table 5:
On the Effects of Energy Efficiency
Alternative Scenarios**

	2020	2025	2030	2050
Annual Energy Efficiency Improvements: 1.5				
Carbon Dioxide Emissions	-6.14	-7.65	-8.04	-7.38
GDP	0.29	0.54	0.71	1.05
Labor Demand	-0.11	0.02	0.11	0.27
Foreign Debt	2.57	3.77	4.63	6.45
Public Debt	1.44	2.11	2.57	3.56
Annual Energy Efficiency Improvements: 2.0				
Carbon Dioxide Emissions	-7.96	-9.85	-10.33	-9.50
GDP	0.37	0.69	0.91	1.35
Labor Demand	-0.14	0.03	0.14	0.34
Foreign Debt	3.29	4.82	5.90	8.23
Public Debt	1.84	2.69	3.29	4.55
Annual Energy Efficiency Improvements: 2.5				
Carbon Dioxide Emissions	-9.68	-11.90	-12.46	-11.47
GDP	0.45	0.84	1.10	1.62
Labor Demand	-0.17	0.04	0.16	0.41
Foreign Debt	3.95	5.78	7.08	9.87
Public Debt	2.21	3.22	3.94	5.46

Table 6:
On the Effects of a Carbon Tax
15 Euros per tCO₂

	2020	2025	2030	2050
Energy				
Total Energy Demand	-6.26	-5.50	-5.32	-4.60
Demand for Fossil Fuels	-8.78	-8.25	-8.19	-7.31
Crude Oil	-5.94	-5.74	-5.65	-5.23
Coal	-26.38	-23.47	-23.88	-20.46
Natural Gas	-1.75	-2.45	-1.98	-1.92
Investment in Wind Energy	16.55	13.50	12.03	10.11
Wind Energy Infrastructures	8.00	10.10	10.90	10.75
Carbon Dioxide Emissions from Fossil Fuel Combustion	-9.76	-9.10	-9.07	-8.06
Change relative to 1990 levels	-11.70	-11.45	-11.99	-12.99
Economy				
Growth Rate of GDP (Percent Change over Previous Period)	0.99	0.97	0.96	0.95
GDP	-0.70	-0.87	-0.98	-1.21
Private Consumption	-0.36	-0.36	-0.35	-0.32
Private Investment	-1.68	-1.62	-1.58	-1.58
Private Capital	-0.67	-0.95	-1.14	-1.46
Imported Energy	-7.17	-7.14	-7.16	-7.23
Foreign Debt	-1.87	-2.74	-3.36	-4.65
Labor Markets				
Employment	-0.27	-0.34	-0.40	-0.50
Wages	-0.71	-0.78	-0.82	-0.86
Public Sector				
Public Debt	-0.86	-1.25	-1.52	-2.03
Public Expenditures	-1.52	-1.50	-1.49	-1.48
Public Consumption	-2.11	-2.07	-2.04	-1.97
Public Investment	-1.52	-1.49	-1.49	-1.55
Investment in Human Capital	-0.34	-0.36	-0.38	-0.46
Public Capital	-0.75	-1.03	-1.20	-1.47
Human Capital	-0.02	-0.04	-0.06	-0.12
Tax Revenues	0.34	0.21	0.13	-0.02
Personal Income Tax (IRS)	-0.74	-1.01	-1.19	-1.52
Corporate Income Tax (IRC)	-0.67	-0.93	-1.11	-1.42
Value Added Tax (IVA)	-0.65	-0.63	-0.62	-0.60
Social Security Contributions (TSU)	-1.00	-1.16	-1.27	-1.49

**Table 7:
On the Effects of a Carbon Tax
Alternative Scenarios**

	2020	2025	2030	2050
CO2 Tax of 5€ per tCO2				
Carbon Dioxide Emissions	-3.91	-3.60	-3.59	-3.13
GDP	-0.24	-0.30	-0.34	-0.42
Labor Demand	-0.10	-0.12	-0.14	-0.18
Foreign Debt	-0.65	-0.95	-1.17	-1.61
Public Debt	-0.30	-0.43	-0.52	-0.69
CO2 Tax of 15€ per tCO2				
Carbon Dioxide Emissions	-9.76	-9.10	-9.07	-8.06
GDP	-0.70	-0.87	-0.98	-1.21
Labor Demand	-0.27	-0.34	-0.40	-0.50
Foreign Debt	-1.87	-2.74	-3.36	-4.65
Public Debt	-0.86	-1.25	-1.52	-2.03
CO2 Tax of 35€ per tCO2				
Carbon Dioxide Emissions	-17.69	-16.70	-16.62	-15.07
GDP	-1.51	-1.89	-2.15	-2.66
Labor Demand	-0.58	-0.73	-0.85	-1.10
Foreign Debt	-4.10	-6.01	-7.38	-10.25
Public Debt	-1.89	-2.76	-3.37	-4.52

Table 8:
**Summary of the Relative Roles of Fossil Fuel Prices,
 Energy Efficiency Improvements and Carbon Taxation**

	2020	2025	2030	2050
Carbon Dioxide Emissions				
Total Effect	-25.23	-30.34	-33.70	-46.28
Fossil Fuel Prices	-3.99	-6.49	-8.03	-17.98
Energy Efficiency	-9.53	-12.40	-13.67	-15.31
Carbon Tax	-11.70	-11.45	-11.99	-12.99
GDP				
Total Effect	-0.35	-0.39	-0.53	-1.31
Fossil Fuel Prices	-0.02	-0.22	-0.45	-1.45
Energy Efficiency	0.37	0.69	0.91	1.35
Carbon Tax	-0.70	-0.87	-0.98	-1.21
Labor Demand				
Total Effect	-0.07	-0.07	-0.14	-0.55
Fossil Fuel Prices	0.34	0.24	0.12	-0.38
Energy Efficiency	-0.14	0.03	0.14	0.34
Carbon Tax	-0.27	-0.34	-0.40	-0.50
Foreign Debt				
Total Effect	-2.23	-4.02	-5.91	-12.31
Fossil Fuel Prices	-3.64	-6.09	-8.45	-15.89
Energy Efficiency	3.29	4.82	5.90	8.23
Carbon Tax	-1.87	-2.74	-3.36	-4.65
Public Debt				
Total Effect	-1.30	-2.37	-3.48	-7.10
Fossil Fuel Prices	-2.29	-3.80	-5.24	-9.62
Energy Efficiency	1.84	2.69	3.29	4.55
Carbon Tax	-0.86	-1.25	-1.52	-2.03

**4. Um imposto sobre as
emissões de dióxido de carbono
em Portugal
- um bem necessário?**

**Table 9:
Effects of an Indexed Carbon Tax
Without Recycling**

	2020	2025	2030	2050
Energy				
Total Energy Demand	-3.26	-5.72	-7.80	-6.86
Demand for Fossil Fuels	-5.04	-8.78	-11.92	-11.32
Crude Oil	-3.10	-6.04	-8.55	-8.44
Coal	-16.67	-25.36	-33.21	-29.84
Natural Gas	-0.67	-2.47	-3.20	-3.52
Investment in Wind Energy	21.18	25.15	24.03	17.50
Wind Energy Infrastructures	6.80	11.61	15.56	18.35
Carbon Dioxide Emissions from Fossil Fuel Combustion	-5.68	-9.70	-13.13	-12.37
Economy				
Growth Rate of GDP (Percent Change over Previous Period)	0.94	0.91	0.92	0.94
GDP	-0.17	-0.54	-0.92	-1.55
Private Consumption	-0.67	-0.67	-0.68	-0.71
Private Investment	-1.49	-1.97	-2.14	-2.35
Private Capital	-0.42	-0.79	-1.16	-1.96
Imported Energy	-3.92	-7.55	-10.66	-11.46
Foreign Debt/GDP	-1.70	-2.78	-3.67	-5.90
Labor Markets				
Employment	0.15	-0.08	-0.31	-0.57
Wages	-0.47	-0.76	-1.03	-1.17
Public Sector				
Public Debt/GDP	0.51	1.07	1.74	3.96
Public Expenditures	-0.23	-0.57	-0.91	-1.48
Public Consumption	-0.23	-0.57	-0.91	-1.48
Public Investment	-0.23	-0.57	-0.91	-1.48
Investment in Human Capital	-0.23	-0.57	-0.91	-1.48
Public Capital	-0.05	-0.17	-0.37	-1.15
Human Capital	-0.01	-0.02	-0.06	-0.29
Tax Revenues	0.19	0.32	0.38	-0.08
Personal Income Tax (IRS)	0.15	-0.29	-0.82	-1.27
Corporate Income Tax (IRC)	0.20	-0.33	-1.01	-1.83
Value Added Tax (IVA)	-0.73	-0.83	-0.88	-0.99
Social Security Contributions (TSU)	-0.33	-0.86	-1.39	-2.01

**Table 10:
Effects of an Indexed Carbon Tax
Recycling Mechanisms**

	Carbon Dioxide Emissions		Employment		GDP		Foreign Debt /GDP		Public Debt /GDP	
	2030	2050	2030	2050	2030	2050	2030	2050	2030	2050
No Additional Energy Efficiency Gains										
Lump Sum	-13.13	-12.37	-0.31	-0.57	-0.92	-1.55	-3.67	-5.90	1.74	3.96
Value Added	-12.97	-12.36	0.08	-0.25	-0.71	-1.53	-5.47	-8.47	1.18	-0.47
Personal Income Tax	-12.62	-11.56	0.54	0.46	-0.25	-0.44	-0.53	-1.38	0.55	2.10
Social Security Contributions	-12.77	-11.82	0.29	0.12	-0.45	-0.79	-1.90	-3.70	-0.51	-3.01
Investment Tax Credit	-12.60	-10.41	-0.37	0.18	-0.22	1.13	3.48	8.27	0.45	2.11
Additional Energy Efficiency Gain of 0.25%										
Value Added	-14.07	-13.38	0.07	-0.24	-0.64	-1.40	-4.99	-7.78	0.91	-1.07
Personal Income Tax	-13.73	-12.60	0.52	0.46	-0.18	-0.32	-0.14	-0.83	0.30	1.47
Social Security Contributions	-13.87	-12.85	0.27	0.13	-0.38	-0.67	-1.49	-3.11	-0.75	-3.56
Investment Tax Credit	-13.71	-11.48	-0.38	0.19	-0.15	1.23	3.81	8.65	0.19	1.50
Additional Energy Efficiency Gain of 0.5%										
Value Added	-15.13	-14.35	0.06	-0.23	-0.57	-1.27	-4.53	-7.12	0.65	-1.65
Personal Income Tax	-14.80	-13.60	0.50	0.46	-0.12	-0.21	0.23	-0.31	0.05	0.87
Social Security Contributions	-14.94	-13.84	0.26	0.14	-0.31	-0.55	-1.10	-2.55	-0.99	-4.09
Investment Tax Credit	-14.78	-12.51	-0.38	0.19	-0.08	1.32	4.13	9.02	-0.05	0.91
Additional Energy Efficiency Gain of 1.0%										
Value Added	-17.13	-16.19	0.04	-0.21	-0.43	-1.03	-3.68	-5.90	0.16	-2.73
Personal Income Tax	-16.82	-15.48	0.47	0.46	0.00	0.00	0.92	0.67	-0.41	-0.26
Social Security Contributions	-16.95	-15.71	0.23	0.15	-0.18	-0.33	-0.37	-1.50	-1.43	-5.09
Investment Tax Credit	-16.79	-14.46	-0.38	0.20	0.04	1.49	4.72	9.70	-0.51	-0.21

Table 11:
Effects of an Indexed Carbon Tax
Mixed Recycling Mechanisms

CFI Share	TSU Share	IRS Share	Carbon Dioxide Emissions		Employment		GDP		Foreign Debt /GDP		Public Debt /GDP	
			2030	2050	2030	2050	2030	2050	2030	2050	2030	2050
No Additional Energy Efficiency Gains												
0.50	0.00	0.50	-12.61	-10.97	0.08	0.32	-0.23	0.37	1.56	3.62	0.48	2.07
0.50	0.50	0.00	-12.68	-11.10	-0.05	0.16	-0.33	0.19	0.88	2.48	-0.05	-0.47
0.50	0.25	0.25	-12.64	-11.04	0.02	0.24	-0.28	0.28	1.22	3.05	0.22	0.80
Additional Energy Efficiency Gain of 0.25%												
0.50	0.00	0.50	-13.72	-12.03	0.07	0.33	-0.16	0.47	1.92	4.09	0.23	1.45
0.50	0.50	0.00	-13.79	-12.15	-0.06	0.16	-0.26	0.29	1.25	2.96	-0.30	-1.05
0.50	0.25	0.25	-13.75	-12.09	0.01	0.24	-0.21	0.38	1.58	3.53	-0.03	0.20
Additional Energy Efficiency Gain of 0.5%												
0.50	0.00	0.50	-14.79	-13.04	0.06	0.33	-0.10	0.57	2.26	4.52	-0.02	0.85
0.50	0.50	0.00	-14.86	-13.17	-0.06	0.17	-0.20	0.40	1.60	3.42	-0.53	-1.61
0.50	0.25	0.25	-14.82	-13.10	0.00	0.25	-0.15	0.49	1.93	3.97	-0.28	-0.38
Additional Energy Efficiency Gain of 1.0%												
0.50	0.00	0.50	-16.80	-14.96	0.04	0.33	0.02	0.76	2.89	5.34	-0.48	-0.27
0.50	0.50	0.00	-16.87	-15.08	-0.08	0.18	-0.07	0.59	2.25	4.28	-0.98	-2.67
0.50	0.25	0.25	-16.84	-15.02	-0.02	0.26	-0.02	0.68	2.57	4.81	-0.73	-1.47

**Table 12:
Effects of an Indexed Carbon Tax
Partial Revenue Recycling**

	Carbon Dioxide Emissions		Employment		GDP		Foreign Debt /GDP		Public Debt /GDP	
	2030	2050	2030	2050	2030	2050	2030	2050	2030	2050
50% CFI - 50% IRS										
25%	-17.12	-15.87	-0.17	-0.27	-0.41	-0.56	-1.46	-3.00	-2.70	-11.05
50%	-17.01	-15.56	-0.10	-0.07	-0.27	-0.12	0.01	-0.16	-1.96	-7.45
75%	-16.91	-15.26	-0.03	0.13	-0.12	0.32	1.47	2.62	-1.22	-3.85
100%	-16.80	-14.96	0.04	0.33	0.02	0.76	2.89	5.34	-0.48	-0.27
50% CFI - 50% TSU										
25%	-17.13	-15.90	-0.20	-0.31	-0.44	-0.60	-1.62	-3.27	-2.83	-11.65
50%	-17.05	-15.62	-0.16	-0.15	-0.32	-0.20	-0.31	-0.71	-2.22	-8.65
75%	-16.96	-15.35	-0.12	0.01	-0.19	0.20	0.98	1.81	-1.60	-5.66
100%	-16.87	-15.08	-0.08	0.18	-0.07	0.59	2.25	4.28	-0.98	-2.67
50% CFI - 25% TSU - 25% IRS										
25%	-17.13	-15.88	-0.19	-0.29	-0.42	-0.58	-1.54	-3.14	-2.77	-11.35
50%	-17.03	-15.59	-0.13	-0.11	-0.29	-0.16	-0.15	-0.43	-2.09	-8.05
75%	-16.93	-15.30	-0.08	0.07	-0.16	0.26	1.22	2.22	-1.41	-4.76
100%	-16.84	-15.02	-0.02	0.26	-0.02	0.68	2.57	4.81	-0.73	-1.47

Table 13:
Effects of a Constant Carbon Tax of 5 Euros per tCO₂

CFI Share	TSU Share	IRS Share	Carbon Dioxide Emissions		Employment		GDP		Foreign Debt /GDP		Public Debt /GDP	
			2030	2050	2030	2050	2030	2050	2030	2050	2030	2050
No Additional Energy Efficiency Gains												
0.50	0.00	0.50	-2.75	-2.28	0.04	0.06	0.06	0.11	0.50	0.70	0.21	0.57
0.50	0.50	0.00	-2.77	-2.31	0.02	0.03	0.04	0.08	0.42	0.52	-0.04	-0.09
0.50	0.25	0.25	-2.76	-2.29	0.03	0.05	0.05	0.09	0.46	0.61	0.09	0.24
Additional Energy Efficiency Gain of 0.25%												
0.50	0.00	0.50	-4.01	-3.46	0.03	0.07	0.12	0.22	0.88	1.21	-0.03	-0.03
0.50	0.50	0.00	-4.03	-3.48	0.01	0.04	0.10	0.19	0.79	1.04	-0.29	-0.68
0.50	0.25	0.25	-4.02	-3.47	0.02	0.05	0.11	0.20	0.83	1.13	-0.16	-0.35
Additional Energy Efficiency Gain of 0.5%												
0.50	0.00	0.50	-5.23	-4.59	0.02	0.07	0.18	0.32	1.23	1.70	-0.27	-0.60
0.50	0.50	0.00	-5.24	-4.61	0.00	0.05	0.16	0.29	1.15	1.53	-0.53	-1.24
0.50	0.25	0.25	-5.23	-4.60	0.01	0.06	0.17	0.31	1.19	1.61	-0.40	-0.92
Additional Energy Efficiency Gain of 1.0%												
0.50	0.00	0.50	-7.52	-6.73	0.01	0.09	0.30	0.52	1.89	2.61	-0.73	-1.68
0.50	0.50	0.00	-7.53	-6.75	-0.02	0.06	0.28	0.49	1.81	2.44	-0.98	-2.31
0.50	0.25	0.25	-7.52	-6.74	0.00	0.07	0.29	0.50	1.85	2.52	-0.85	-2.00

Table 14:
Effects of a Constant Carbon Tax of 35 Euros per tCO₂

CFI Share	TSU Share	IRS Share	Carbon Dioxide Emissions		Employment		GDP		Foreign Debt /GDP		Public Debt /GDP	
			2030	2050	2030	2050	2030	2050	2030	2050	2030	2050
No Additional Energy Efficiency Gains												
0.50	0.00	0.50	-12.02	-10.28	0.23	0.32	0.27	0.52	2.60	3.66	1.30	3.38
0.50	0.50	0.00	-12.11	-10.41	0.11	0.17	0.15	0.34	2.14	2.70	-0.07	-0.13
0.50	0.25	0.25	-12.07	-10.34	0.17	0.25	0.21	0.43	2.37	3.18	0.61	1.62
Additional Energy Efficiency Gain of 0.25%												
0.50	0.00	0.50	-13.15	-11.34	0.21	0.32	0.33	0.62	2.94	4.11	1.04	2.75
0.50	0.50	0.00	-13.23	-11.47	0.10	0.18	0.21	0.45	2.49	3.18	-0.31	-0.72
0.50	0.25	0.25	-13.19	-11.41	0.16	0.25	0.27	0.54	2.72	3.65	0.36	1.02
Additional Energy Efficiency Gain of 0.5%												
0.50	0.00	0.50	-14.23	-12.37	0.20	0.33	0.39	0.72	3.27	4.55	0.79	2.14
0.50	0.50	0.00	-14.31	-12.49	0.09	0.18	0.28	0.55	2.83	3.63	-0.55	-1.28
0.50	0.25	0.25	-14.27	-12.43	0.15	0.26	0.33	0.64	3.05	4.09	0.12	0.43
Additional Energy Efficiency Gain of 1.0%												
0.50	0.00	0.50	-16.27	-14.31	0.18	0.33	0.50	0.91	3.88	5.36	0.32	1.00
0.50	0.50	0.00	-16.35	-14.42	0.07	0.19	0.39	0.74	3.45	4.48	-1.00	-2.34
0.50	0.25	0.25	-16.31	-14.36	0.13	0.26	0.45	0.82	3.66	4.92	-0.34	-0.67

5. Sobre os efeitos ambientais, económicos e orçamentais da Reforma da Fiscalidade Verde

**Table 15:
Environmental Fiscal Reform - Different Recycling
(Lower Bound)**

	Carbon Dioxide Emissions		Employment		GDP		Public Debt /GDP	
	2030	2050	2030	2050	2030	2050	2030	2050
	No Additional Energy Efficiency Gains							
Lump Sum	-5.46	-5.02	-0.15	-0.23	-0.34	-0.54	0.78	1.83
Value Added	-5.38	-5.02	0.03	-0.09	-0.25	-0.53	0.37	-0.28
Personal Income Tax	-5.20	-4.64	0.22	0.21	-0.03	-0.05	0.27	1.03
Social Security Contributions	-5.28	-4.76	0.11	0.07	-0.12	-0.21	-0.35	-1.36
Investment Tax Credit	-5.11	-4.06	-0.14	0.10	0.08	0.67	0.21	1.11
Additional Energy Efficiency Gain of 0.25%								
Value Added	-6.60	-6.15	0.02	-0.08	-0.18	-0.41	0.11	-0.87
Personal Income Tax	-6.43	-5.78	0.21	0.21	0.03	0.06	0.02	0.43
Social Security Contributions	-6.50	-5.90	0.10	0.07	-0.06	-0.10	-0.59	-1.93
Investment Tax Credit	-6.33	-5.21	-0.15	0.11	0.14	0.77	-0.03	0.52
Additional Energy Efficiency Gain of 0.5%								
Value Added	-7.77	-7.23	0.01	-0.07	-0.12	-0.30	-0.13	-1.44
Personal Income Tax	-7.60	-6.87	0.20	0.22	0.09	0.17	-0.22	-0.15
Social Security Contributions	-7.67	-6.99	0.09	0.08	0.01	0.01	-0.83	-2.49
Investment Tax Credit	-7.51	-6.33	-0.15	0.11	0.21	0.87	-0.27	-0.06
Additional Energy Efficiency Gain of 1.0%								
Value Added	-9.99	-9.29	-0.01	-0.05	0.00	-0.08	-0.60	-2.52
Personal Income Tax	-9.82	-8.95	0.17	0.23	0.21	0.37	-0.68	-1.24
Social Security Contributions	-9.89	-9.06	0.07	0.09	0.12	0.22	-1.27	-3.53
Investment Tax Credit	-9.74	-8.43	-0.17	0.13	0.32	1.06	-0.72	-1.14

**Table 16:
Environmental Fiscal Reform - Mixed Recycling
(Lower Bound)**

ITC Share	TSU Share	PIT Share	Carbon Dioxide Emissions		Employment		GDP		Public Debt /GDP	
			2030	2050	2030	2050	2030	2050	2030	2050
No Additional Energy Efficiency Gains										
0.50	0.00	0.50	-5.16	-4.35	0.04	0.16	0.02	0.31	0.24	1.07
0.50	0.50	0.00	-5.19	-4.41	-0.01	0.08	-0.02	0.23	-0.07	-0.13
0.50	0.25	0.25	-5.17	-4.38	0.01	0.12	0.00	0.27	0.08	0.47
Additional Energy Efficiency Gain of 0.25%										
0.50	0.00	0.50	-6.38	-5.49	0.03	0.16	0.09	0.42	-0.01	0.47
0.50	0.50	0.00	-6.42	-5.55	-0.02	0.09	0.04	0.34	-0.32	-0.71
0.50	0.25	0.25	-6.40	-5.52	0.00	0.13	0.07	0.38	-0.16	-0.12
Additional Energy Efficiency Gain of 0.5%										
0.50	0.00	0.50	-7.56	-6.60	0.02	0.17	0.15	0.52	-0.25	-0.11
0.50	0.50	0.00	-7.59	-6.66	-0.03	0.10	0.11	0.45	-0.55	-1.28
0.50	0.25	0.25	-7.57	-6.63	-0.01	0.13	0.13	0.48	-0.40	-0.69
Additional Energy Efficiency Gain of 1.0%										
0.50	0.00	0.50	-9.78	-8.68	0.00	0.18	0.27	0.72	-0.70	-1.20
0.50	0.50	0.00	-9.81	-8.74	-0.05	0.11	0.22	0.64	-1.00	-2.34
0.50	0.25	0.25	-9.80	-8.71	-0.02	0.14	0.25	0.68	-0.85	-1.77

**Table 17:
Environmental Fiscal Reform - Partial Recycling
(Lower Bound)**

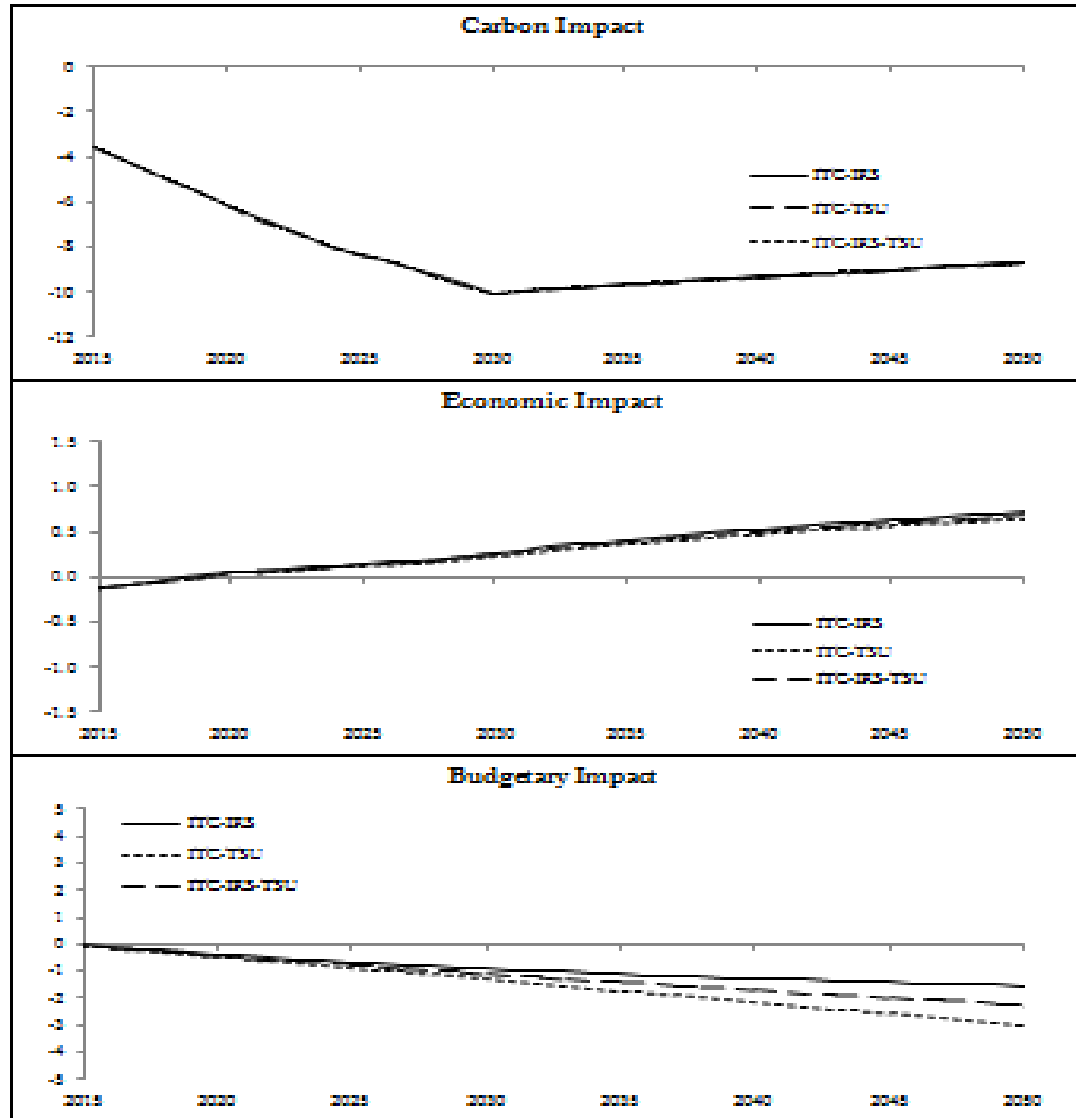
	Carbon Dioxide Emissions		Employment		GDP		Public Debt / GDP	
	2030	2050	2030	2050	2030	2050	2030	2050
50% ITC, 50% IRS								
25%	-9.96	-9.13	-0.10	-0.09	0.03	0.13	-2.02	-6.34
50%	-9.90	-8.98	-0.06	0.00	0.11	0.32	-1.58	-4.63
75%	-9.84	-8.83	-0.03	0.09	0.19	0.52	-1.14	-2.91
100%	-9.78	-8.68	0.00	0.18	0.27	0.72	-0.70	-1.20
50% ITC, 50% TSU								
25%	-9.97	-9.14	-0.11	-0.10	0.02	0.11	-2.09	-6.63
50%	-9.92	-9.01	-0.09	-0.03	0.09	0.29	-1.73	-5.20
75%	-9.87	-8.87	-0.07	0.04	0.16	0.46	-1.37	-3.77
100%	-9.81	-8.74	-0.05	0.11	0.22	0.64	-1.00	-2.34
50% ITC, 25% TSU, 25% IRS								
25%	-9.97	-9.14	-0.11	-0.09	0.03	0.12	-2.06	-6.49
50%	-9.91	-8.99	-0.08	-0.01	0.10	0.30	-1.65	-4.91
75%	-9.85	-8.85	-0.05	0.06	0.17	0.49	-1.25	-3.34
100%	-9.80	-8.71	-0.02	0.14	0.25	0.68	-0.85	-1.77

**Table 18:
Carbon Tax Revenue
(Lower Bound)**

	2015	2020	2025	2030	2035	2040	2045	2050
50% ITC, 50% IRS	110.2	152.6	283.7	419.1	453.3	471.7	490.6	510.2
50% ITC, 50% TSU	110.2	152.6	283.6	418.9	453.0	471.4	490.3	509.8
50% ITC, 25% TSU, 25% IRS	110.2	152.6	283.6	419.0	453.2	471.5	490.5	510.0

Figure 1

Environmental, Economic, and Budgetary (Lower Bound)



**Table 19:
Environmental Fiscal Reform - Different Recycling
(Upper Bound)**

	Carbon Dioxide Emissions		Employment		GDP		Public Debt /GDP	
	2030	2050	2030	2050	2030	2050	2030	2050
No Additional Energy Efficiency Gains								
Lump Sum	-9.94	-9.26	-0.26	-0.43	-0.67	-1.09	1.43	3.28
Value Added	-9.81	-9.26	0.05	-0.17	-0.51	-1.08	0.76	-0.47
Personal Income Tax	-9.51	-8.60	0.41	0.37	-0.12	-0.21	0.49	1.82
Social Security Contributions	-9.64	-8.81	0.21	0.11	-0.28	-0.49	-0.55	-2.45
Investment Tax Credit	-9.39	-7.62	-0.26	0.16	0.04	1.08	0.40	1.93
Additional Energy Efficiency Gain of 0.25%								
Value Added	-10.97	-10.32	0.04	-0.16	-0.44	-0.95	0.49	-1.07
Personal Income Tax	-10.67	-9.68	0.39	0.37	-0.06	-0.10	0.24	1.20
Social Security Contributions	-10.79	-9.89	0.20	0.12	-0.22	-0.38	-0.80	-3.01
Investment Tax Credit	-10.55	-8.73	-0.27	0.17	0.10	1.17	0.15	1.32
Additional Energy Efficiency Gain of 0.5%								
Value Added	-12.07	-11.34	0.03	-0.15	-0.37	-0.83	0.24	-1.64
Personal Income Tax	-11.78	-10.72	0.38	0.37	0.01	0.01	0.00	0.61
Social Security Contributions	-11.90	-10.92	0.19	0.12	-0.15	-0.26	-1.03	-3.55
Investment Tax Credit	-11.66	-9.80	-0.27	0.18	0.17	1.27	-0.09	0.74
Additional Energy Efficiency Gain of 1.0%								
Value Added	-14.16	-13.27	0.01	-0.13	-0.25	-0.60	-0.24	-2.72
Personal Income Tax	-13.89	-12.69	0.35	0.38	0.12	0.22	-0.46	-0.50
Social Security Contributions	-14.00	-12.88	0.17	0.13	-0.03	-0.05	-1.47	-4.57
Investment Tax Credit	-13.77	-11.81	-0.28	0.19	0.29	1.44	-0.54	-0.36

Table 20:
Environmental Fiscal Reform - Mixed Recycling
(Upper Bound)

			Carbon Dioxide Emissions		Employment		GDP		Public Debt /GDP	
ITC Share	TSU Share	PIT Share	2030	2050	2030	2050	2030	2050	2030	2050
No Additional Energy Efficiency Gains										
0.50	0.00	0.50	-9.45	-8.10	0.07	0.27	-0.04	0.44	0.44	1.85
0.50	0.50	0.00	-9.51	-8.21	-0.03	0.14	-0.12	0.30	-0.09	-0.27
0.50	0.25	0.25	-9.48	-8.16	0.02	0.20	-0.08	0.37	0.18	0.79
Additional Energy Efficiency Gain of 0.25%										
0.50	0.00	0.50	-10.61	-9.20	0.06	0.27	0.02	0.55	0.19	1.24
0.50	0.50	0.00	-10.67	-9.30	-0.04	0.15	-0.06	0.41	-0.33	-0.86
0.50	0.25	0.25	-10.64	-9.25	0.01	0.21	-0.02	0.48	-0.07	0.19
Additional Energy Efficiency Gain of 0.5%										
0.50	0.00	0.50	-11.72	-10.25	0.05	0.28	0.09	0.65	-0.06	0.66
0.50	0.50	0.00	-11.78	-10.35	-0.04	0.15	0.01	0.51	-0.57	-1.42
0.50	0.25	0.25	-11.75	-10.30	0.01	0.21	0.05	0.58	-0.31	-0.38
Additional Energy Efficiency Gain of 1.0%										
0.50	0.00	0.50	-13.83	-12.24	0.04	0.28	0.21	0.84	-0.51	-0.45
0.50	0.50	0.00	-13.88	-12.34	-0.06	0.16	0.13	0.71	-1.02	-2.47
0.50	0.25	0.25	-13.86	-12.29	-0.01	0.22	0.17	0.77	-0.76	-1.46

**Table 21:
Environmental Fiscal Reform - Partial Recycling
(Upper Bound)**

	Carbon Dioxide Emissions		Employment		GDP		Public Debt / GDP	
	2030	2050	2030	2050	2030	2050	2030	2050
50% ITC, 50% IRS								
25%	-14.13	-13.00	-0.15	-0.19	-0.20	-0.22	-2.73	-9.57
50%	-14.03	-12.75	-0.09	-0.03	-0.06	0.13	-1.99	-6.52
75%	-13.93	-12.49	-0.03	0.13	0.07	0.49	-1.25	-3.48
100%	-13.83	-12.24	0.04	0.28	0.21	0.84	-0.51	-0.45
50% ITC, 50% TSU								
25%	-14.13	-13.00	-0.15	-0.19	-0.20	-0.22	-2.73	-9.57
50%	-14.03	-12.75	-0.09	-0.03	-0.06	0.13	-1.99	-6.52
75%	-13.93	-12.49	-0.03	0.13	0.07	0.49	-1.25	-3.48
100%	-13.83	-12.24	0.04	0.28	0.21	0.84	-0.51	-0.45
50% ITC, 25% TSU, 25% IRS								
25%	-14.13	-13.00	-0.15	-0.19	-0.20	-0.22	-2.73	-9.57
50%	-14.03	-12.75	-0.09	-0.03	-0.06	0.13	-1.99	-6.52
75%	-13.93	-12.49	-0.03	0.13	0.07	0.49	-1.25	-3.48
100%	-13.83	-12.24	0.04	0.28	0.21	0.84	-0.51	-0.45

**Table 22:
Carbon Tax Revenue
(Upper Bound)**

	2015	2020	2025	2030	2035	2040	2045	2050
50% ITC, 50% IRS	227.0	312.1	571.8	834.7	902.8	941.0	980.3	1,020.8
50% ITC, 50% TSU	227.0	312.1	571.5	834.1	902.0	940.0	979.1	1,019.4
50% ITC, 25% TSU, 25% IRS	227.0	312.1	571.6	834.4	902.4	940.5	979.7	1,020.1

Figure 2:
Environmental, Economic, and Budgetary Impacts
(Upper Bound)

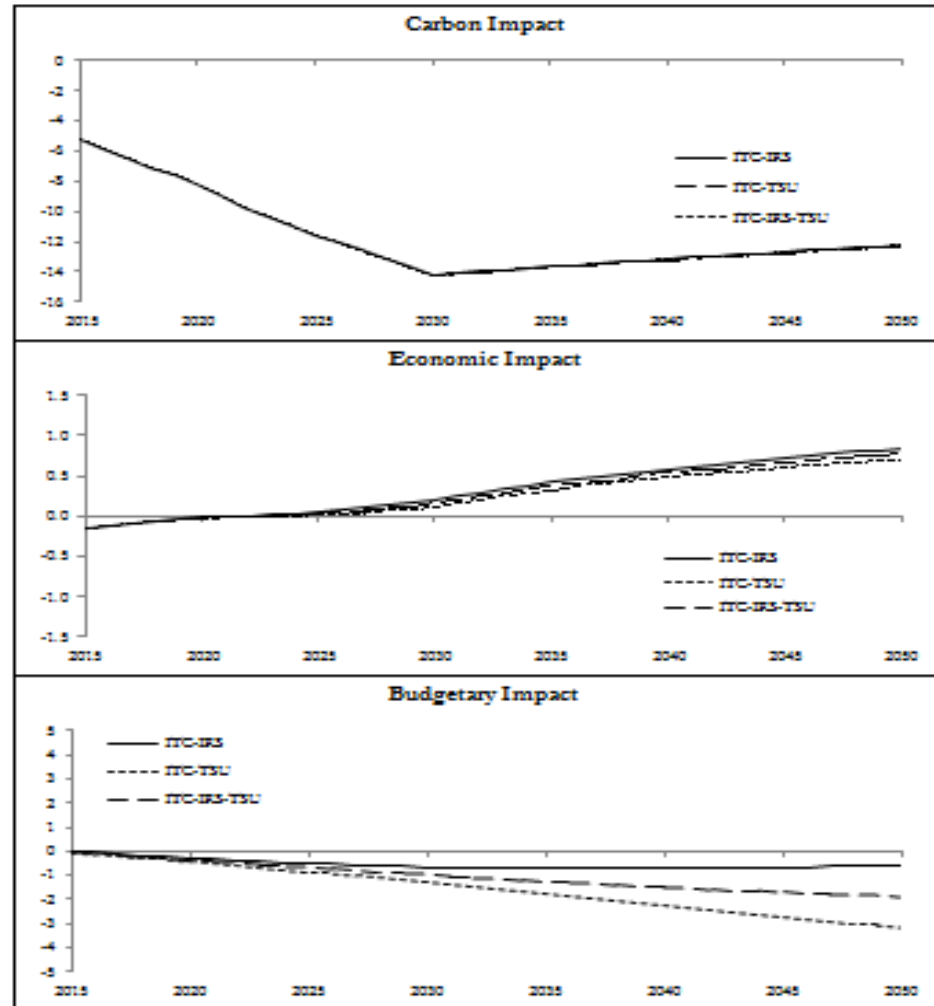


Figure 3:
Environmental, Economic, and Budgetary Impacts
(Lower versus Upper Bounds)

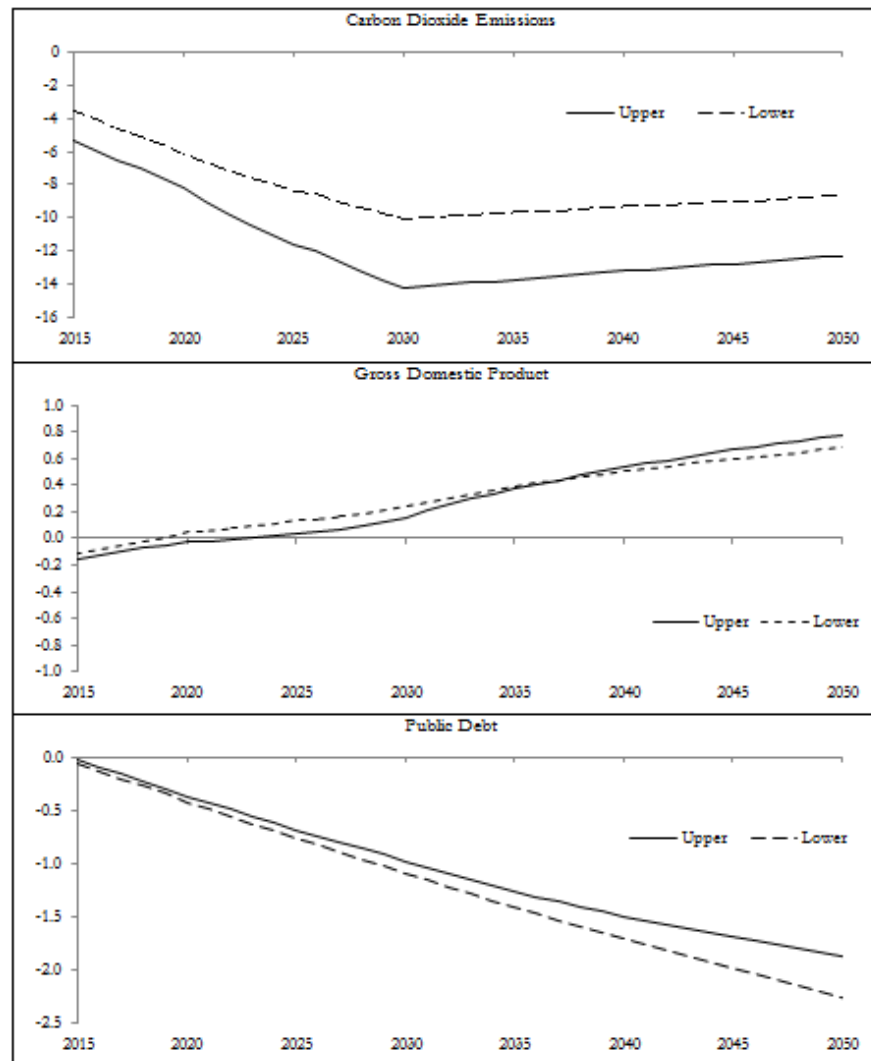
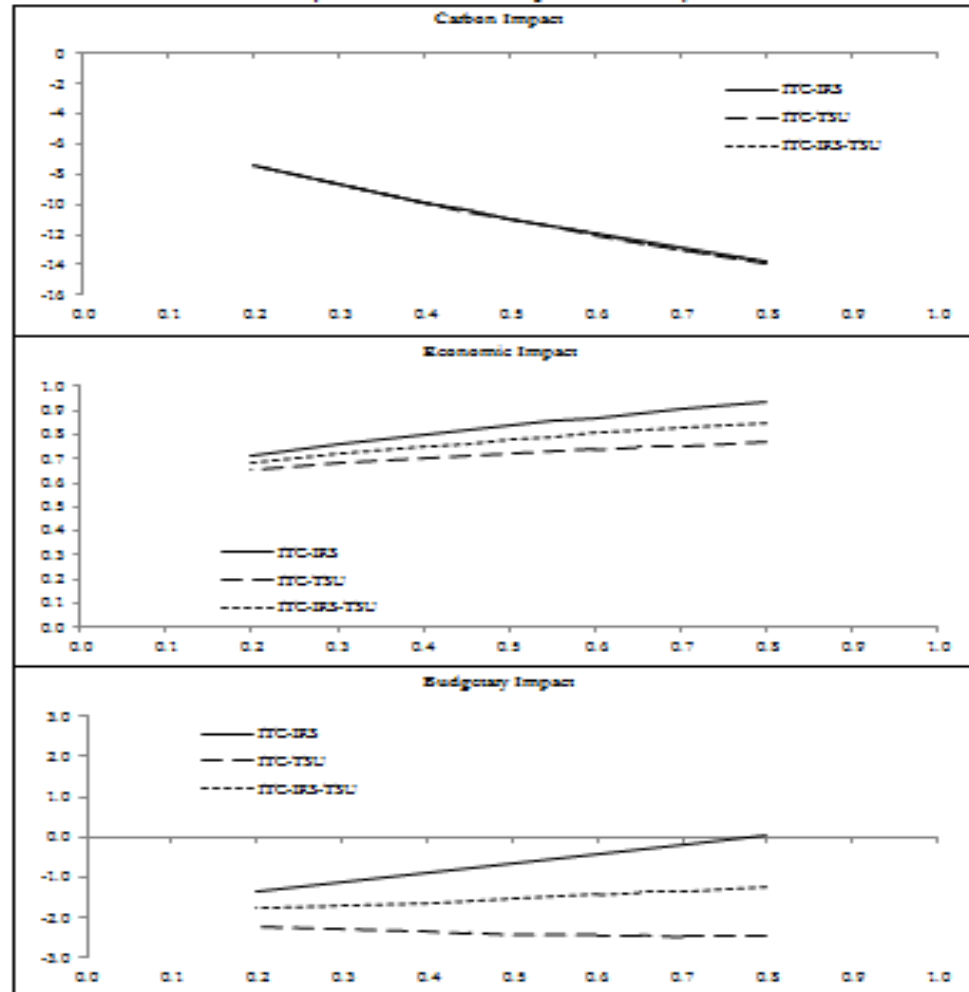


Figure 4:
Environmental, Economic, and Budgetary Impacts
for Different Levels of ISP Exemptions



6. Reflexões Finais