Environmental Policy in a Federal State

A Regional CGE Analysis of the NEC Directive in Belgium

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5.1. INTRODUCTION

This paper develops and applies a regional computable general equilibrium (CGE) model for environmental and energy policy in a federal state. This regional CGE model differs from the national CGE models by taking into account the interregional mobility of labor, the common product market across the regions and the explicit modeling of two government levels within one nation. We illustrate our regional CGE model with an analysis of the NEC Directive[1] in Belgium. The NEC Directive sets upper limits for each EU member state in 2010 for the total emissions of four pollutants, responsible for acidification, eutrophication and ground-level ozone pollution. These pollutants are sulphur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOC), and ammonia (NH_3).

Whereas the earliest policy-oriented computable general equilibrium (CGE) studies were developed in the 1970s[2], CGE models applied to regional economies are more recent. One possible reason for the scarcity and late start of regional CGE modeling is its complexity and implementation cost. The costs of regional CGE models may outweigh the benefits. First, CGE models are very data intensive, requiring data on industry output, industry technology, consumption and investment expenditures, government expenditures and taxes, trade flows, and factor ownership patterns. These data are much more readily available at national level

1 Officially known as Directive 2001/81/EC of the European Parliament and the Council on National Emission Ceilings for certain pollutants (NECs).

2 For an overview, see Partridge and Rickman (1998).

than at regional level. In addition, further complications arise with the appropriate definition of a region such as the degree of factor specificity/mobility and regional product differentiation (Partridge and Rickman, 1998). The greater openness of the regional economy complicates the regional CGE modeling. Regions trade not only with foreign countries, but also with other regions in the same country. Labor is more likely to be mobile between regions in a country than between countries. Similarly, savings by residents in the region are less likely to influence investment in the region. Interregional commuting creates a divergence between the region of factor employment and region of expenditure of factor income. Finally, there are vertical externalities between regional and federal levels of government, because the tax bases of the various government levels are (partially) shared. Moreover, in most federations, there are important constitutional monetary transfers between the government levels.

Regional CGE models dealing with energy or environmental issues are relatively rare. Conrad and Schröder (1991, 1993) analyze the choice between emission taxes or abatement subsidies for climate change policy in Baden-Wurttemberg, Germany. In a partial equilibrium model the welfare effects of the two policies are identical if a small open economy is assumed. This is not longer the case in a general equilibrium setting. Li and Rose (1995) measure the impact of emission controls in Pennsylvania. They stress that the substitution from energy towards other input and the reallocation of factors across sectors mitigate the costs. However, they note that higher regional mobility of factors may induce higher costs of regional environmental policy. André et al. (2005) analyze an environmental tax reform and the double dividend hypothesis for CO_2-and SO_2-policy in Andalusia, Spain. The double dividend literature[3] argues that substituting environmental taxes for pre-existing distorting taxes may yield not only a cleaner environment but also a more efficient way of raising revenue. André *et al.* (2005) find an employment double dividend if the payroll tax is selected to recycle the excess environmental tax revenues. The opportunities for a strong double dividend are very limited.

While the aforementioned regional CGE models mostly follow the framework of the national CGE models, we capture more specific characteristics of regional modeling. First, in our model,

3 Three types of double dividend are distinguished (Goulder, 1995; Carraro *et al.*, 1996). The weak double dividend states that, using the environmental tax revenues to cut distorting taxes, one can achieve non-environmental cost savings compared to the case where the revenues of the environmental taxes are recycled in a lump-sum fashion. The strong double dividend holds if an environmental tax reform raises welfare through both environmental benefits and higher non-environmental efficiency of the tax system. An employment double dividend is obtained if an environmental tax reform improves the quality of the environment and boosts employment.

each region has its own labor market but interregional commuting limits the wage differential between regions. This approach takes into account the significant interregional commuting in small federations (e.g. Belgium) or metropolitan areas. Second, most national and regional CGE models use the Armington assumption, where goods produced in different regions and countries are assumed to be imperfect substitutes (Armington, 1969). Our model has only one goods market per country, and the goods produced in the regions of one country are perfect substitutes. The Armington assumption, however, is still used for goods imported from other countries. Finally, we explicitly model the fiscal responsibilities of the various government levels. We allocate the tax revenues to the appropriate government level and model the monetary transfer mechanisms between the government levels.

The aim of this paper is developing a regional CGE model which can be used for the analysis of environmental and energy policy in a multi-region and multi-government setting. We start from the multi-national GEM-E3 model[4] and subdivide one country in three regions. This country has two government levels but a common labor and goods market for the regions. The GEM-E3 model is a CGE model for the European and World Economy, modeling the economy, the energy system and the environment. It has been used to evaluate the welfare impacts of various environmental policies[5].

The structure of the paper is as follows. Section 5.2 explains briefly the federal structure of Belgium. Section 5.3 presents the general characteristics of the standard GEM-E3 model, and discusses how the model is extended to take into account a country with several regions. In section 5.4, an illustrative simulation illustrates the main mechanisms at work in the regional model. In section 5.5, we describe the NEC directive and use the regionalized GEM-E3 model to simulate the NEC directive for Belgium. In section 5.6 we conclude and discuss some caveats.

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4 The GEM-E3 model was built under the auspices of the European Commission by a consortium involving principally NTUA, KUL, ZEW and ERASME. For more details on the model, we refer to Capros et al. (1997).

5 See e.g. Capros *et al*. (1999), Jansen and Klaassen (2000), Proost and Van Regemorter (2000, 2004), Mayeres and Van Regemorter (2003), Criqui *et al*. (2003), and Russ *et al*. (2005). The GEM-E3 model has been used for non-environmental analyses as well. Conrad *et al*. (2005) use the GEM-E3 model to analyze the economy-wide effects of a labor market reform in Germany.

5.2. MODELING THE FEDERAL STRUCTURE OF BELGIUM

First, we explain the federal structure of Belgium. Further, we present the data corresponding to the federal structure of Belgium.

5.2.1. Federalism in Belgium

Since the 1970s five reforms of the constitution[6] have transformed Belgium into a federation with increasingly more autonomy for the three regions and three communities. The three regions – Flanders, Wallonia and Brussels-Capital – are responsible for geographically related issues as environment, road infrastructure, and land management, whereas the three communities – Flemish, French, and German – deal with personally related issues as culture and education. The borders of regions and communities do not fully overlap. Both the Flemish and French community are active in Brussels-Capital region. The German community is a part of Wallonia (Figure 5.1).

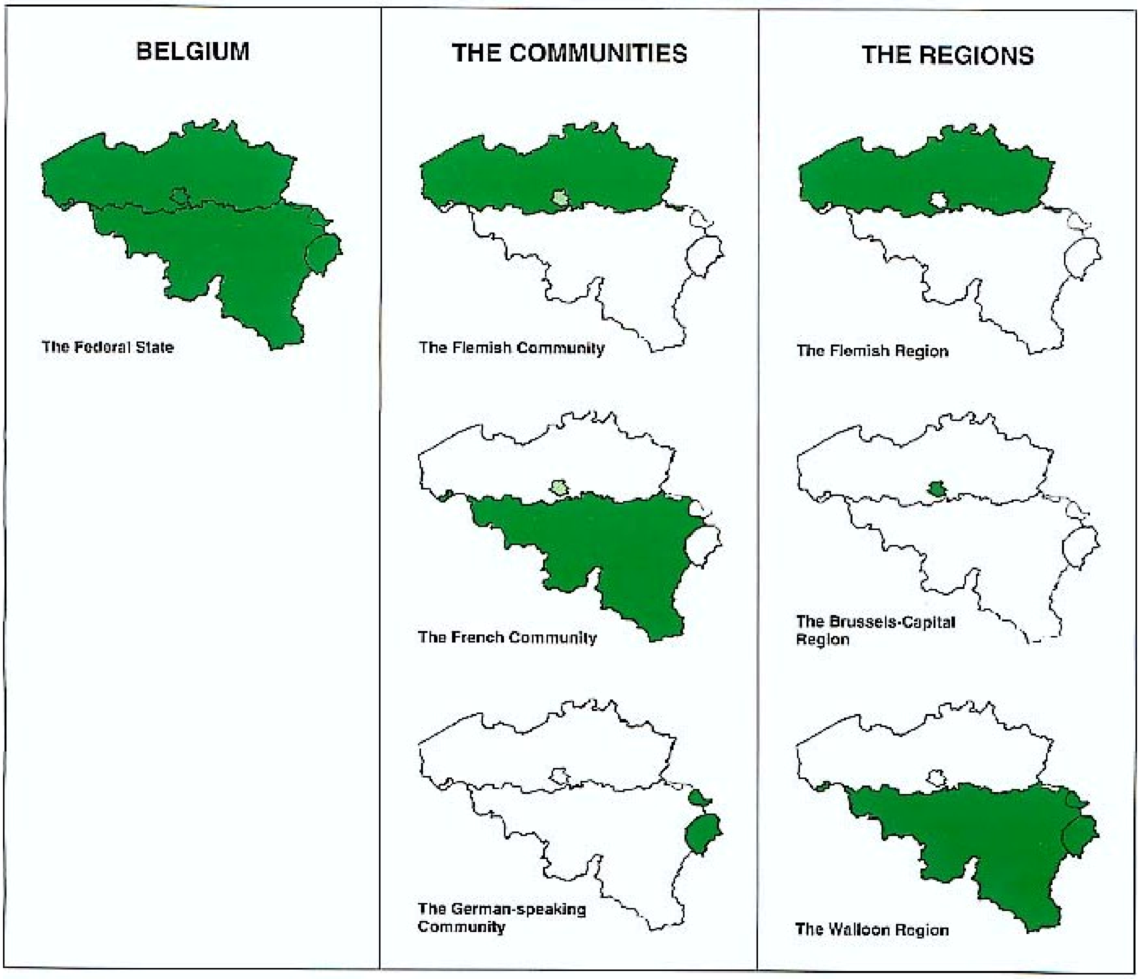
Each constitutional reform resulted in more autonomy for the lower levels. Unfortunately, they also made the relations between the government levels increasingly complex. In our analysis, we lump the communities with the three regions for the sake of simplicity.

(a) Federal Government and Social Security

The federal budget and the social security budget account for 24% and 39% of the total budget of all Belgian governments, respectively. The main tax revenues are corporate taxes, direct income taxes, capital taxes and value-added taxes. Moreover, two environmentally related taxes remain on the federal level: the energy excises, which are the main environmentally related taxes, and environmental consumption taxes on e.g. batteries, razor blades, plastic and carton bottles, etc. The contributions (mainly payroll taxes) and expenditures of the social security remain mostly on the federal level. Some social services are provided by the lower government levels, and are included in the regional budget.

Figure 5.1: The Federal State of Belgium

6 The timing of the various reforms was 1970, 1980, 1988-1989, 1993 and 2001-2003. From 2007 on, new institutional reforms are expected, possibly resulting in more (fiscal) autonomy for the regions.



Source: www.belgium.be

(b) Regions and Communities

The aggregate budget of the regions and communities corresponds to 24% of the Belgian total of government budgets. Today, the fiscal autonomy of the Belgian regions is rather small. The regions are competent for a number of smaller taxes, with the inheritance taxes, property taxes and car taxes being more important. In 1988 the regions became competent for the main environmental issues[7]. However, the regions only set some non-energy environmental taxes (manure, waste disposal, etc).

A large share of their budget is financed through transfers from the federal level. The transfer mechanisms to the lower government levels are complex. The monetary transfer that a region receives is a function of the number of students in the community and the regional origins from

7 The federal level remains responsible for product norms, protection against radiation and transport of waste.

the personal direct income tax revenues. The transfers are absolute amounts and they evolve independently from the collected tax revenues by the federal government.

(c) Municipalities and Provinces

The municipalities and provinces finance their budgets (13% of the Belgian total) mainly with taxes (47%), transfers from other government levels (20%), dividends and revenues from services. The two main taxes, a shared property tax and a shared tax on the direct income of their inhabitants, represent each about 40% of the tax revenues. The other taxes are rather diverse. In our analysis the municipalities and provinces are lumped with the regions and communities.

5.3. THE REGIONAL GEM-E3 MODEL FOR BELGIUM

First we discuss successively the characteristics of standard GEM-E3 model and the regional GEM-E3 model. Then, we give an overview of the data that are used.

5.3.1. The standard GEM-E3 Model: general characteristics

The standard version of the GEM-E3 model is an applied general equilibrium model, simultaneously representing world regions or EU member states, linked through endogenous bilateral trade. There is a high degree of endogeneity between sectors of the economy. GEM-E3 covers the interactions between the economy, the energy system and the environment. There are two versions of GEM-E3, GEM-E3 Europe and GEM-E3 World. They differ in their geographical and sectoral coverage, but the model specification is the same. The European version covers 27 EU countries (all EU countries) and the rest of the world (in a reduced form). This paper starts from the GEM-E3 Europe model and develops a third version, the regional GEM-E3 model. The data are based on the EUROSTAT database (Input-Output tables and National Accounts data). The base year is 1995.

The model has the following general features:

(a) General Characteristics

The GEM-E3 model computes the equilibrium prices of goods, services, labor, capital and tradable emission rights such that all markets are simultaneously cleared under the Walras law.

The competitive market equilibrium under Walras' law also includes more detailed equilibria in energy demand/supply and emission/abatement.

Although the model is global/European, the sectors, structural features of energy/environment and policy-oriented instruments (e.g. taxation) are disaggregated. GEM-E3 evaluates consistently the distributional effects for the various economic sectors and agents across the countries. The economic consequences of environmental or economic policies can be analyzed on a national level, while ensuring that the World/European economy remains in equilibrium.

The model is dynamic, driven by the accumulation of capital and equipment. Technological progress is explicitly represented in the production functions.

(b) Behavior of Agents

The economic agents optimize each their objective and determine separately the supply or demand of capital, energy, environment, labor and other goods. Market derived prices endogenously guarantee a global equilibrium.

The production of the firms is modeled with a nested CES neo-classical production function, using capital, labor, energy and intermediate consumption of goods from other branches. The model allows for alternative market clearing mechanisms, in addition to perfect competition.

The model allows for various degrees of capital mobility (across sectors or national borders). The amount of capital is fixed within each period. The investment decisions of the firms in the current period affect the stock of capital in the next period.

The consumers decide endogenously on their demand of goods and services using a nested Stone Geary utility function[8]. In a first stage, a representative consumer for each region allocates their total expected income between total consumption of goods and services (both durables and non-durables), leisure and savings. In a second stage, the utility function distinguishes between durable (equipment) and consumable goods and services. The rationale behind the distinction between durables and non-durables is the assumption that the households obtain utility from consuming a non-durable good or service and from using a durable good.

8 Stone-Geary utility function is a simple generalization of the Cobb-Douglas utility function, the extension being that consumption is measured relative to subsistence levels of consumption of the goods.

If the economic conditions are favorable, households can supply more labor to the detriment of their leisure time. Labor is immobile across national borders.

The demand of goods by the final consumers, firms (for intermediate consumption and investment) and the public sector constitutes the total domestic demand. This total demand is allocated between domestic goods and imported goods, using the Armington specification. The behavior of the rest of the world is exogenous.

Government behavior is exogenous. The model distinguishes between 9 categories of receipts, including indirect taxes, environmental taxes, direct taxes, value added taxes, production subsidies, social security contributions, import duties, foreign transfers and government firms.

(c) Environmental Module

The environmental module of GEM-E3 concentrates on three air pollution problems: (i) climate change (ii) acidification and eutrophication through deposition of emissions, and (iii) ambient air quality linked to tropospheric ozone concentration.

The model evaluates the energy-related emissions of CO_2, nitrogen oxides (NO_x), sulphur dioxide (SO_2), volatile organic compounds (VOC) and particulates (PM_{10}). There are three mechanisms of emission reduction explicitly specified in the model: (i) substitution between fuels and between energetic and non-energetic inputs, (ii) emission reduction due to a decline in production and consumption, and (iii) purchasing abatement equipment.

The model is able to compare the welfare effects of various environmental instruments, such as taxes, various forms of pollution permits and command-and-control policy. It is also possible to consider various systems of revenue recycling.

The standard GEM-E3 model take s into account both costs and benefits of environmental policy. It includes an environmental quality function that depends on the emissions and that has an impact on welfare through the utility function. It is assumed that environmental quality provides a separable contribution to the consumers' welfare.

5.3.2. Characteristics of the regional model

We focus on the characteristics of the regional extension of the standard GEM-E3 model. First, the Regional GEM-E3 model allows to opt for separate regional labor markets. The assumption of zero commuting costs implies that wages are identical across the regional labor markets. Second, the goods are traded inter-regionally on a common market. Third, the Regional GEM-E3 has two government levels. Tax revenues may be attributed either to the regional level or the federal level. The model also includes monetary transfers between these government levels.

(a) Common Labor Market

The regional model includes a common labor market across all regions of the federal state. The labor force is perfectly mobile across regional borders. The total labor supply in all regions equals the total labor demand in all regions (5.1). The labor supply of a single region does not necessarily equal the labor demand of that same region. Perfect interregional mobility implies that wages have to be identical across the regions.

$$\sum_{\text{Regions}} \text{Labor Supply} = \sum_{\text{Regions}} \text{Labor Demand} \tag{5.1}$$

Assumption (5.1) is appropriate for small countries, but may be too strong for regional modeling of larger countries. The standard GEM-E3 EU 25 model uses national labor markets. Commuting between EU member states is very small. Similarly, commuting between large US states as California, and its neighboring states is negligible. However, commuting may be significant for the modeling of smaller US states, counties, metropolitan areas or small federations. More than 6% of the total labor force in New Jersey State works in New York County, NY. In Hudson County, NJ, just across the Hudson River, this share reaches 22%. Commuting, however, is not limited to urban regions. About 40% of the labor force in rural counties Pierce and St Croix, Wisconsin commute to the industrial Mississippi basin around St Paul and Minneapolis, Minnesota (Census 2000). In Belgium, about half of the people working in Brussels Capital-Region are commuters from Flanders or Wallonia.

Commuting from one region to another results in additional (short-term) opportunities of the residents to respond to a policy change. If one assumes erroneously that commuting is impossible, then the model will overestimate the effects of policy changes when aggregated across all the regions of the federal state. Similarly, if one assumes erroneously that the labor force can commute freely, then a multi-regional model will underestimate the aggregate effects of changes in economic policies. For individual regions, commuting may alleviate or exacerbate the effects, as outward commuting raises the regional wages and inward commuting reduces the wages (Saveyn, 2006).

(b) Common goods markets

As in the standard model, the Regional GEM-E3 model still uses the Armington assumption for trade with foreign countries. Here, the goods produced in the home country and abroad are not perfect substitutes. Moreover, this model has a common output market shared by all regions of the federal state. Consumers in one region can not distinguish between the regional origins of goods produced in their home country. Implicitly, we assume that the goods produced in the other regions of the same country are perfect substitutes for the goods produced in the home region. Although the assumption of perfect substitutability might not be acceptable for international trade models, the elasticity of substitution between goods produced in different regions of a federation is likely to be high. This makes the assumption of perfect substitutability an acceptable approximation for regional models (Plassmann, 2005).

In the regional GEM-E3 model, we can also choose the degree of mobility for physical capital. It is important to note that full capital mobility/substitutability, combined with free commuting and a common market of goods leads to a corner solution where each sector is completely located in the cheapest region. We believe that full mobility or substitutability between sectors and regions is not realistic in a medium term. Real estate can not cross borders, whereas it is difficult to change service offices into an industrial plant. Limiting some factor mobility improves the realism of the Regional GEM-E3 model.

(c) Multi-level Government

We explicitly model a multi-level government in the Regional GEM-E3. Each region has a regional government with a federal government encompassing all the regions of one country. The model is able to take into account the variation in distribution of competences in regulatory or fiscal policy, and the type and direction of constitutional transfers across various federations.

The budget of each government level may be financed by tax revenues, which are set autonomously by the government level, or by monetary transfers coming from the other government levels. This may lead to two types of vertical interactions between the various government levels. First, a policy change of a government level may not only affect its own tax bases, but the tax bases of the other government levels as well, increasing or reducing their tax revenues (Saveyn and Proost, 2005). Second, as the tax revenues and income levels may change, the constitutional monetary transfers between the government levels may also be affected.

5.3.3. Data

The main constraint for the regional modeling is the lack of regional SAMs. The Social Accounting Matrix provides a complete circular flow of regional income and expenditures between households, industrial sectors and government levels.

In our analysis, we use the SAM for Belgium (1995) and regionalize the Belgian Input-Output table using the regional distribution of the added value of the sectors. The investment, private and public consumption are regionalized using the respective figures in the regional accounts. Export and import are not regionally disaggregated. The tax revenues are allocated to the relevant government level using the shares in Table 5.1.

The direct taxes include the corporate taxes, direct personal taxes, capital taxes and inheritance taxes. The indirect taxes include, among others, the pre-existing environmental taxes.

Table 5.1: Multi-Level Shares of Taxes

	Federal Government	Regional Governments
Direct Taxes	80%	20%
Indirect Taxes	64%	36%
Subsidies	0%	100%
Duties	100%	0%
VAT	100%	0%
Government Firms	50%	50%
Social Security	80%	20%

Further, we use the environmental data (including the abatement costs) of the EU-25 GEM-E3 model. The environmental data for the NEC pollutants are based on the RAINS model[9]. For all regions we use the emission coefficients and abatement cost curves available for Belgium in EU25 GEM-E3. We correct, however, for the more service oriented and less energy-intensive characteristics of the economy in Brussels Capital-Region. The emission/ added-value ratio in

9 The RAINS model was developed at the International Institute for Applied Systems Analysis (IIASA) in Vienna, Austria.

Brussels may be totally different from the ratios in Flanders or Wallonia. Typically, Brussels holds more emission-low headquarters and coordination centers, whereas the other regions have more high-emission production plants (e.g. Ports of Antwerp, Gent and Zeebrugge in Flanders, and the Meuse-Samber axis in Wallonia).

5.4. AN ILLUSTRATIVE SIMULATION

CGE models typically try to simulate the whole economy. They take into account a large number of counter-acting or reinforcing effects. This section disentangles the main effects by starting with a simple model simulation. A single region, Flanders, unilaterally tightens the emissions of one pollutant, SO_2, using grandfathered permits. The other regions of Belgium or foreign countries do not change their policies. First, we explain the effects in Flanders. Second, we discuss the effects which occur in the other regions due to the policy reform in Flanders. The policy is analyzed as a counterfactual scenario and is compared against a business-as-usual scenario.

5.4.1. Intra-Regional Effects

Flanders reduces its SO_2 emissions with 33.75% compared to the business-as-usual scenario (Table 5.3). As SO_2 is a pollutant with important local effects, the environmental quality of Flanders improves. The SO_2 is mainly the result of the use of fossil fuels and a SO_2 policy causes a number of economic effects. Some of them – mostly- affect the SO_2-intensive energy sectors; whereas the sectors with low SO_2 emissions experience only the indirect economic effects.

Table 5.2: Change in Sectoral Output and Emplyment (in %)

	Pollutant	Brussels	Flanders	Wallonia	Belgium
Sectoral Output	Energy Sectors	0.79	-0.73	0.33	-0.67
	Energy Intensive Sectors	0.33	-0.54	0.39	-0.22
	Goods	0.01	-0.02	0.01	-0.01
	Services	0.00	-0.01	0.00	-0.01
Sectoral Employment	Energy Sectors	0.34	-0.39	0.27	-0.12
	Energy Intensive Sectors	0.55	-0.81	0.60	-0.24
	Goods	0.03	-0.01	0.02	0.00
	Services	0.00	0.00	0.00	0.00

As the region tightens the regulation of SO_2 emissions, the industrial sectors look for ways to reduce their emissions. The sectors can respond to the new regulation in three ways. They can try to reduce emissions by substituting sulfur-rich fuels with sulfur-poor fuels; they can install SO_2 abatement equipment; or they can simply reduce their level of production. Either way, the new regulation increases the production costs, reducing the demand for the output of these industrial sectors in Flanders. Table 5.2 shows that the restriction on SO_2 emissions reduces the output for energy sectors and energy-intensive with 0.73% and 0.54%, respectively. The goods and services sectors with low SO_2 emissions are hardly affected.

The higher production costs also reduce the demand for inputs by the energy and energy-intensive sectors, affecting the regional markets for labor, capital, energy etc. In this way the effects of the environmental policy spread from a single market to the rest of the economy. Table 5.2 shows that the employment drops more in the sectors which are directly affected by the new environmental regulation. The lower demand for labor by the affected sectors reduces the wages (with about 0.03% for Flanders and Belgium). The lower demand for labor not only reduces the wages but also reduces overall labor supply in Flanders. Sectors which are not SO_2-intensive hardly reduce their employment; they may even increase employment thanks to the lower wages. The lower wages and the lower labor supply reduce the disposable income of the inhabitants in Flanders. As the productivity slows down due to the higher production costs, the returns on capital also drop, and there is less appetite for investment.

The environmental policy not only generates environmental benefits by reducing the SO_2 emissions, but also by reducing the emissions of other pollutants associated to energy use. Table 5.3 shows that not only the SO_2 emissions drop (with about -33%) but the environmental policy also reduces the CO_2 and NO_x emissions in Flanders (-2,47% and -1,46%, respectively). The NH_3, PM_{10} and VOC emissions, however, show smaller reductions, as these pollutants are less associated with the use of energy and SO_2.

Table 5.3: Change in Emissions (%)

Pollutant	Brussels	Flanders	Wallonia	Belgium
CO_2	-0.07	-2.47	0.23	-1.47
NH_3	0.00	-0.03	0.00	-0.02
NO_X	-0.10	-1.46	0.23	-0.88
PM_{10}	0.00	-0.77	0.23	-0.43
SO_2	0.00	-33.75	0.44	-22.40
VOC	0	-0.38	0.08	-0.26

Whether the prices of capital or energy change significantly, depends, among others, on the structure of the import and export markets of these goods and the market power of the local production. Typically, regions are small and their unilateral policies do not influence much the prices on international goods markets. As the environmental regulation raises the production costs, especially of the SO_2 polluting sectors, Flanders looses market share on the national and international good markets. Table 5.2 shows that the output of the energy and energy-intensive sectors in Brussels and Wallonia increases. This partly offsets the output loss in Flanders. Overall, the output of Belgium in energy and energy-intensive sectors drops. The Belgian export of energy and energy-intensive goods drops with 0.24% and 0.38%, respectively.

Overall, the environmental regulation causes a decline of the regional economy. Hence, the tax bases of regional and federal taxes also shrink, possibly leading to lower tax revenues for all government levels (Saveyn and Proost, 2005). The environmental policy in Flanders decreases the environmental and energy tax revenues of the Belgian federal government with 0.22%. As environmental taxes correspond to about 2.6% of all tax revenues (federal and regional), the overall effect on public consumption is rather limited. The decline of the Flemish economy reduces the non-environmental tax revenues (regional and federal) collected in Flanders with 0.03%.

These are the effects expected for a command-and-control policy or grandfathered permits policy. Economic literature, however, explains that not only the level of the environmental target, but also the choice of instruments has important efficiency and distributional effects on the economy (e.g. Bovenberg and Goulder, 1996; Goulder *et al.*, 1999). The choice for environmental taxes or subsidies causes a redistribution of income across the SO_2 polluting sectors, the non-polluting sectors, households and the various governments (Saveyn, 2006). Moreover, the use of the tax revenues of pollution taxes also affects the efficiency of the economy. In general, the economic literature recommends lowering pre-existing distorting taxes as labor or capital taxes. Typically, the highest efficiency gains can be obtained when the tax rates with the highest Marginal Cost of Public Funds[10] are lowered. In contrast, if the financing

10 The marginal cost of public funds associated to a tax is defined as the marginal welfare cost of raising revenue by this tax, where the revenue of the tax is spend on public goods that do not affect the consumption of the taxed goods.

of the environmental subsidy needs higher distorting tax rates, the non-environmental efficiency of the economy deteriorates.

5.4.2. Inter-Regional Effects

Although Brussels and Wallonia do not change their environmental policy, they still experience the environmental and economic effects of the policy reform in Flanders. The economies of Brussels and Wallonia react to these effects causing feedback effects to Flanders and the total Belgian economy.

Although, the effects of SO_2 as a pollutant are partially local, the neighboring regions of Flanders reforming region also benefit from the new environmental regulation as less SO_2 is deposited within their borders.

The non-reforming regions do not reform their own policy and, hence, do not exogenously change their production costs. The production costs of Brussels and Wallonia are altered endogenously as the unilateral policy of Flanders changes the price of labor, capital and goods on the common national markets. The lower demand for employment and the lower wages in Flanders cause commuting towards the non-reforming region until wages are equalized across all regions. The environmental policy increases the share of commuters in the total Flemish active population from 6,44% to 6,50%. The arrival of commuters in the non-reforming regions lowers the wages (with about -0.03%, as much as in Flanders), and these lower wages boost the demand for employment. Table 5.2 shows that all sectors in Brussels and Wallonia increase their employment. This increase is higher for energy and energy-intensive sectors as they benefit more from the Flemish loss of market shares. The shares of the regions on the goods markets change. The non-reforming regions expand their market shares of SO_2-intensive goods to the detriment of Flanders. Sectors in the non-reforming regions may also export more as they can benefit from cheaper inputs as labor, capital and energy. Unfortunately, the lack of regional export data does not allow us to analyze whether the small output increase in Brussels and Wallonia is destined for the national or foreign markets. Table 5.3 shows that the emissions of some pollutants, increase slightly due to the higher economic activity. Overall, however, the Belgian emissions drop.

Saveyn (2006) explains that commuting alleviates the wage decrease in the reforming region and causes lower wages in the non-reforming regions. Commuting exports a part of the costs of environmental policy of the reforming region to the employees in the non-reforming regions. Similarly, lower energy and capital prices may boost the demand in the non-reforming regions. However, the small size of the reforming region compared to the international markets limits these effects.

A final effect is through the tax revenues and public services of the various government levels. As their economies change, the regional tax revenues by the regional governments also change. Moreover, as explained in Saveyn and Proost (2005), a regional environmental reform may cause vertical externalities, affecting the public consumption by the federal government. The slightly higher economic activity increases the non-environmental tax revenues (regional and federal) collected in Brussels and Wallonia with 0.03% and 0.06%, respectively. The transfers between the government levels may also be affected.

5.5. POLICY SIMULATIONS

We apply our regional CGE model to the NEC directive in Belgium. Belgium and its regions are subordinate to EU law. First, we describe the NEC directive. Next, we present the results for six alternative scenarios.

5.5.1. NEC Directive

(a) International context of NEC Directive

The NEC Directive deals with the emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOC), and ammonia (NH_3). These pollutants are transported in large quantities across national boundaries. Therefore, the initiative is taken on the EU level. The NEC directive, however, leaves it largely to the member states to decide which emission reduction measures to take in order to comply with the maximum emission caps. The NEC directive is binding as soon as it was approved by the EU Parliament and EU council.

Although the effects are felt across borders, the considered pollutants have a more geographically localized impact than, say, CO_2. In the latter case, it does not matter for the climate where in the world the CO_2 is emitted. The NEC pollutants have a range of 100s of kilometers, but their effect is not global. This “local” impact of the NEC pollutants limits the scope for the efficiency gains of market-based instruments. The market is not global, and the differences in costs of reduction opportunities may be restricted. Nevertheless, the US and Canada have experimented with local trading schemes for NO_x, SO_2 and VOC (e.g. Burtraw, 1995; Ellerman *et al.*,1997; Ellerman, 2003ab; Kosobud *et al*., 2004). Recently, EU Member States, as the Netherlands and the UK, have launched local trading schemes meeting the NEC requirements.

Parallel to the development of the EU NEC Directive, most European countries (EU and non-EU), Russia, the United States and Canada agreed in 1999 on the Gothenburg protocol under the Convention on Long-Range Transboundary Air Pollution of UNECE[11]. The emission ceilings in the UNECE protocol are equal or less ambitious than those of the NEC directive. The protocol needs to be ratified by all signatories, before coming into force.

(b) Climate Change and NEC Directive

The NEC Directive and UNECE Protocol are not the only environmental policies involving air pollution. The EU is strongly committed to the Kyoto Protocol. The time frame of both policies overlaps. Although the NEC pollutants have a more local effect compared to the global greenhouse gases (GHG), there are important synergies between climate and NEC policies. Both the GHG and the NEC pollutants are strongly (but not exclusively) linked with energy consumption. The reduction of GHG may bring ancillary benefits in the form of lower levels of NEC pollutants. Similarly, the NEC directive may also reduce the GHG. These ancillary benefits reduce the costs of the environmental policies (Rübbelke, 2002).

Proost and Van Regemorter (2003), using the partial equilibrium MARKAL/TIMES model, find that climate policy alone reduces the NEC pollutants by about 10-20% in Belgium. They find also lower GHG for a policy focused on the NEC pollutants. The more local effects of NEC pollutants means that the benefits of the NEC policy are more local than the benefits of CO_2 reduction, which can be felt world wide. In addition, the benefits of climate policy may only be felt by the future generations, whereas the benefits of the NEC directive can be felt immediately. All this may explain a stronger support of the policy makers for policies on NEC pollutants compared to climate policies (e.g. the Clean Air Act vs. Kyoto Protocol in US).

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(c) The NEC Directive and the Environment

The four NEC pollutants are responsible for acidification, eutrophication and ground-level ozone pollution. Acidification is the process whereby air pollution – mainly NH_3, SO_2 and NO_x – is converted into acid substances. This 'acid rain' damages forests and lakes, soils and ancient historical monuments. Moreover, the acidification releases heavy metals into groundwater. SO_2 and NO_x are mainly emitted by burning fossil fuels. The most important sectors for SO_2 and NO_x emissions in Belgium are power stations, oil refineries, chemical plants as well as ferro and non-ferro industry. Most NH_3 emissions are generated by livestock production. The latter has more short-range effects compared to SO_2 and NO_x.

Acidification is a cross-border issue, requiring coordinated initiatives across countries and sectors. In Flanders, 57% of the acid deposition comes from neighboring countries, whereas Flanders itself is a net exporter of acidifying components. The 1990s saw the SO_2 emissions drop substantially in the EU, thanks to a combination of European Directives forcing the installation of desulphurization systems and the move away from coal as a fossil fuel, and major economic restructuring in the new German Lander. Nevertheless, acidification is still a major environmental problem in Europe, but the NO_x and NH_3 deposits have become relatively more important.

The NO_x and NH_3 emissions also contribute to the eutrophication of the environment. Eutrophication is the enrichment of land or water ecosystems with chemical nutrients, and is considered a form of pollution because it promotes plant growth, favoring certain species over others and forcing a change in species composition and a loss in biodiversity.

Ozone (O_3) has the same chemical structure whether it occurs miles above the earth surface or at ground level and can be "good" or "bad," depending on its location in the atmosphere. "Good" ozone occurs naturally in the stratosphere and forms a layer that protects life on earth from the sun's harmful rays. In the earth's lower atmosphere, ground-level ozone is considered "bad". Ozone is not emitted directly into the air, but is created at ground level by a chemical reaction between oxides of nitrogen (NO_x) and volatile organic compounds (VOC) in the presence of sunlight. Transport and industrial emissions, gasoline vapors, and chemical solvents as well as natural sources emit NO_x and VOC that contribute to form ozone. Sunlight and hot weather cause ground-level ozone to form in harmful concentrations in the air. As a result, it is known as a summertime air pollutant. Many urban areas tend to have high levels of "bad" ozone, but also rural areas are subject to increased ozone levels because wind carries ozone and pollutants away from their original sources.

(d) NEC Directive in Belgium

The emission ceilings in the NEC Directive are the result of political bargaining on the EU-level. Table 5.4 represents the emission ceilings in the NEC Directive (NEC) and those in the original proposal of the European Commission (NEC+). The emissions in the NEC Directive are less stringent than those in the original Commission proposal.

Table 5.4: Belgian Emission Ceilings in NEC and NEC+ (kt/year)

	NH_3	NO_x	SO_2	VOC
Belgium (NEC)	74	176	99	139
Belgium (NEC+)	57	127	76	102

Belgium is a net exporter for most emissions to its neighboring countries. Therefore, the effort required from Belgium is among the highest in the EU (Table 5.4). This is due to the central location of Belgium, and the fact that the country and its neighbors are very densely populated. Within Belgium, inter-regional burden sharing agreements split the federal emission levels into emission levels for the three regions (Table 5.5). Each region is responsible for its own emission ceilings. The emission ceiling for transport remains at the federal level. The Belgian emission ceilings are the sum of the emission ceilings of the three regions and the emission ceiling for transport.

Table 5.5: Regional Emission Ceilings for 2010 (kt/year)

	Flanders	Wallonia	Brussels	Transport	Belgium
NH_3	45	28.7			73.7
NO_x	58.3	46	3	68	175.3
SO_2	65.8	29	1.4	2	98.2
VOC	70.9	28	4	35.6	138.5

5.5.2. Scenario Description

We compare six scenarios to a reference scenario. The reference scenario is the business as usual scenario with no climate policy, nor NEC policy. Scenario (i) and scenario (ii) analyze the climate policy and NEC policy separately. Scenarios (iii) to (vi) combine both environmental policies. However, they differ in the choice of environmental instrument and the responsible government level. Scenarios (iii) and (iv) are analyses on the federal level, whereas scenarios (v) and (vi) analyze regional environmental policy. Scenarios (iii) and (v) use grandfathered environmental permits, whereas scenarios (iv) and (vi) use environmental taxes. The scenarios using environmental taxes are budget neutral compared to the reference scenario. The governments redistribute the excess environmental tax revenues to their residents through an additional transfer of social benefits. This tax recycling scheme is more similar to a lump-sum transfer as it does not reduce existing distorting taxes. Hence, this way of tax-recycling foregoes efficiency gains as discussed in de Mooij and Bovenberg (1998). The environmental policies may be cheaper if the excess environmental tax revenues would be used to reduce distorting taxes. Auctioning the permits instead of grandfathering would also improve the efficiency of the economy.

(-) Reference Scenario

Business as usual: No climate policy, nor NEC policy. The following counterfactual scenarios are compared against this reference scenario.

(i) Scenario 1: National Climate Policy - No NEC policy

Here, Belgium complies with its commitments for climate policy using national permits. In 2010 its CO_2-emissions are 7,5% lower than in 1990 (or 30% lower compared to 2000). There are no NEC initiatives.

(ii) Scenario 2: National NEC policy – No Climate Policy

Belgium introduces a NEC policy on the federal level with national permits. There is no Climate Policy.

(iii) Scenario 3: National Climate and NEC Policies using National Permits

Belgium uses national permits for its climate and NEC policies.

(iv) Scenario 4: National Climate and NEC Policies using National Environmental Taxes

Belgium uses national environmental taxes for its climate and NEC policies. The federal government gets the environmental tax revenues.

(v) Scenario 5: Regional Climate and NEC Policies using Regional Permits

The regional governments are responsible for the environmental policy within their borders. They use regional permits for their climate and NEC policies.

(vi) Scenario 6: Regional Climate and NEC Policies using Regional Environmental Taxes

The regional governments are responsible for the environmental policy within their borders. They use regional environmental taxes for their climate and NEC policies. The regional governments receive the regional environmental tax revenues.

5.5.3. Results

For the six scenarios, we discuss the effects on the environment, sectoral output, employment, commuting and tax revenues and transfers of the various government levels. All relative changes (in %) are w.r.t. the reference scenario.

Table 5.6: Change in Emissions (%)

Pollutant	Scenario	Brussels	Flanders	Wallonia	Belgium
CO_2	(i) National Climate - No NEC	-20.68	-30.09	-33.89	-30.37
CO_2	(ii) National NEC - No Climate	-9.23	-18.98	-21.05	-18.72
CO_2	(iii) – (vi) National/Regional Climate and NEC	-17.96	-30.55	-33.73	-30.37
NH_3	(i) National Climate - No NEC	-1.10	-1.10	-1.10	-1.10
NH_3	(ii) National NEC - No Climate	-28.38	-28.36	-28.36	-28.37
NH_3	(iii) – (vi) National/Regional Climate and NEC	-28.38	-28.36	-28.36	-28.37
NO_X	(i) National Climate - No NEC	-16.34	-18.60	-19.89	-18.81
NO_X	(ii) National NEC - No Climate	-23.48	-30.81	-31.50	-30.47
NO_X	(iii) – (vi) National/Regional Climate and NEC	-28.63	-32.57	-33.12	-32.44
SO_2	(i) National Climate - No NEC	-21.19	-19.52	-24.57	-21.11
SO_2	(ii) National NEC - No Climate	-20.60	-34.10	-34.98	-34.03
SO_2	(iii) – (vi) National/Regional Climate and NEC	-22.37	-34.10	-35.45	-34.22
VOC	(i) National Climate - No NEC	-3.58	-4.45	-5.98	-4.68
VOC	(ii) National NEC - No Climate	-34.30	-36.39	-29.45	-34.86
VOC	(iii) – (vi) National/Regional Climate and NEC	-34.98	-37.01	-30.45	-35.56
PM_{10}	(i) National Climate - No NEC	-5.69	-7.32	-7.29	-7.25
PM_{10}	(ii) National NEC - No Climate	-13.38	-8.70	-7.62	-8.56
PM_{10}	(iii) – (vi) National/Regional Climate and NEC	-14.96	-11.32	-10.34	-11.16

(a) Environment

Table 5.6 represents the effects of the six scenarios on the emissions for Belgium and its three regions. Scenarios (iii)-(vi) have identical regional and national targets for climate and NEC.

They only differ in the choice of environmental instruments and the responsible government level. Hence, their emission reductions are similar[12].

Although scenario (i) does not impose explicitly any constraints on the NEC pollutants. We still observe important reductions for SO_2 (-21%) and NO_x (-19%). This is consistent with the results of Proost and Van Regemorter (2003). However, NH_3 and VOC show smaller but still significant reductions (-1% and -5%, respectively). We conclude that the reduction of NEC pollutants is an important ancillary benefit of climate policy.

Similarly, scenario (ii) does not include an explicit climate policy, the CO_2 emissions in Belgium reduce with almost 19% solely due to a national NEC policy. We conclude that lower CO_2 emissions are an important ancillary benefit of NEC policy.

Although none of the scenarios impose specific restrictions on PM_{10} emissions, we observe significant reductions for PM_{10} in all scenarios. The climate policy of scenario (i) leads to a reduction of more than 7%. The NEC policy of scenario (ii) reduces the PM_{10} emissions with almost 9%. Combining both environmental policy in scenarios (iii)-(vi) leads to 11% less PM_{10} emissions. We conclude that the reduction of PM_{10} emissions is an important ancillary benefit of both the climate and NEC policies.

Table 5.7 gives an overview of the marginal abatement costs[13] (euro/ton) for the various pollutants for the six scenarios. The very high abatement cost for VOC (at least 80000 euro/ton) can be explained by the fact that abatement technology for VOC is not available in the model. Hence, the abatement cost is likely to be overestimated. Moreover, the concentrations of VOC emissions are low and a ton VOC is linked with a very high level of economic activity. The ancillary benefits between the NEC policy and climate policy are well reflected in the marginal abatement costs. The marginal cost of CO_2 reduction is much higher in climate policy scenario (i) than in scenarios (iii)-(vi) where both environmental policies are combined. The intuition is that when there is only a constraint on CO_2, the emissions are abated with the lowest abatement costs for CO_2. However, when there are constraints on CO_2 and NEC pollutants, the abatement costs are a function of the combined CO_2 and NEC constraints. Those emissions will

12 The small differences in NEC pollutants between scenario (ii) and scenarios (iii)-(vi) are due to the specific modeling of the transport sector and its reaction to the changes of economic activity.

13 The marginal abatement cost of a pollutant with restrictions on multiple joint pollutants, equals the abatement cost of the concerned pollutant, keeping the pollutant levels of the other joint pollutants constant.

be cut with the lowest abatement costs for the combined CO_2 and NEC constraints. Hence, the emissions abated with the combined CO_2 and NEC constraints are not fully identical to the emissions abated with the CO_2 constraint alone. This leaves some "cheap" CO_2 emissions unabated, reducing the marginal abatement cost of CO_2 in scenarios (iii)-(vi) compared to scenario (i). Similarly, the marginal costs for SO_2 and NO_x are higher with only the NEC policy in scenario (ii) than in scenarios (iii) to (vi).

Table 5.7: Marginal Abatement Costs (Euro/Ton)

Pollutant	Scenario	Brussels	Flanders	Wallonia
CO_2	(i) National Climate - No NEC - Permit	27.05	27.05	27.05
CO_2	(ii) National NEC - No Climate - Permit	0	0	0
CO_2	(iii) National Climate and NEC - Permit	13.73	13.73	13.73
CO_2	(iv) National Climate and NEC - Tax	13.61	13.61	13.61
CO_2	(v) Regional Climate and NEC - Permit	13.75	13.73	13.75
CO_2	(vi) Regional Climate and NEC - Tax	14.18	13.55	13.54
NH_3	(i) National Climate - No NEC - Permit	0	0	0
NH_3	(ii) National NEC - No Climate - Permit	5796.10	5796.10	5796.10
NH_3	(iii) National Climate and NEC - Permit	5672.54	5672.54	5672.54
NH_3	(iv) National Climate and NEC - Tax	5462.63	5462.63	5462.63
NH_3	(v) Regional Climate and NEC - Permit	5916.58	5673.43	5673.42
NH_3	(vi) Regional Climate and NEC - Tax	5680.39	5458.58	5455.86
NO_X	(i) National Climate - No NEC - Permit	0	0	0
NO_X	(ii) National NEC - No Climate - Permit	247.44	247.44	247.44
NO_X	(iii) National Climate and NEC - Permit	121.79	121.79	121.79
NO_X	(iv) National Climate and NEC - Tax	116.92	116.92	116.92
NO_X	(v) Regional Climate and NEC - Permit	121.07	121.87	121.97
NO_X	(vi) Regional Climate and NEC - Tax	130.40	117.42	115.34
SO_2	(i) National Climate - No NEC - Permit	0	0	0
SO_2	(ii) National NEC - No Climate - Permit	319.33	319.33	319.33
SO_2	(iii) National Climate and NEC - Permit	176.66	176.66	176.66
SO_2	(iv) National Climate and NEC - Tax	160.49	160.49	160.49
SO_2	(v) Regional Climate and NEC - Permit	45.01	176.83	176.54
SO_2	(vi) Regional Climate and NEC - Tax	166.16	162.79	156.65
VOC	(i) National Climate - No NEC - Permit	0	0	0
VOC	(ii) National NEC - No Climate - Permit	91393.95	91393.95	91393.95
VOC	(iii) National Climate and NEC - Permit	82402.37	82402.37	82402.37
VOC	(iv) National Climate and NEC - Tax	79855.35	79855.35	79855.35
VOC	(v) Regional Climate and NEC - Permit	82516.43	82405.84	82362.19
VOC	(vi) Regional Climate and NEC - Tax	79828.02	79668.13	80175.26

The difference in marginal abatement costs between scenarios (ii) and (iii) to (vi) are much less significant for NH_3 and VOC, reflecting the lower ancillary benefits between these pollutants and climate policy (Table 5.7). The marginal cost of CO_2 reduction is zero in scenario (ii) as there is no constraint on CO_2 emissions. Similarly, the marginal costs for the NEC pollutants are zero in scenario (i). The reduction in marginal abatement costs if the climate policy and NEC policy are simultaneously combined shows that the costs of these policies are lower when both policies are simultaneously analyzed and implemented (scenarios (iii)-(vi)), than when both policies are separately analyzed and implemented (i.e. scenario (i) + (ii)).

In the national scenarios (iii) and (iv) the abatement costs are identical across the regions. For the regional scenarios (v) and (vi), the abatement costs are not equalized. From a perspective of Belgium, the national scenarios are more efficient. The differences in regional marginal abatement costs are due to the different sector compositions.

(b) Output

Table 5.8 summarizes the change in output for 4 aggregate sectors and six scenarios. Obviously, the energy and energy-intensive sectors are more affected by both environmental policies. The interactions and ancillary benefits between climate policy and NEC policy are also clearly reflected in Table 5.8. The climate policy of scenario (i) reduces the output of the energy sectors with 5% in Belgium. The NEC directive of scenario (ii) reduces the energy output with almost 16%. The combination of both policies in scenarios (iii)-(vi), however, reduces the energy output with almost 17%. In other words, adding the climate policy to the NEC directive reduces the energy output with only 1% more. Similar observations can be made for the energy-intensive sectors, the goods and services. In all four sectors, the output is reduced more with the NEC directive than with the climate policy, reflecting the fact that the NEC directive is relatively more expensive compared to climate policy for 2010.

As its economic activity generates less pollution, Brussels has a comparative advantage to the other regions and attracts more activity when the environmental policy becomes stricter. Although one can expect a shift from industrial output to administrative output, the higher output for the energy sectors in Brussels are not very realistic. Our model may improve by dropping the “perfect substitution assumption” for Brussels and consider the “administrative output” of Brussels as a complement for the “industrial output” of the other regions. In scenario (i), the output of the energy-intensive sectors in Brussels also increases as it benefits from the relatively cheaper energy.

Table 5.8: Change of Sectoral Output in Regions (%)

Pollutant	Scenario	Brussels	Flanders	Wallonia	Belgium
Energy Sectors	(i) National Climate - No NEC - Permit	-2.49	-5.65	-7.04	-5.35
	(ii) National NEC - No Climate - Permit	25.35	-24.74	-17.55	-15.52
	(iii) National Climate and NEC - Permit	23.25	-25.41	-19.48	-16.62
	(iv) National Climate and NEC - Tax	22.83	-25.31	-19.42	-16.61
	(v) Regional Climate and NEC - Permit	23.23	-25.41	-19.46	-16.62
	(vi) Regional Climate and NEC - Tax	22.74	-25.25	-19.60	-16.61
Energy Intensive Sectors	(i) National Climate - No NEC - Permit	3.73	-3.03	-4.50	-3.12
	(ii) National NEC - No Climate - Permit	-5.97	-8.67	-5.48	-7.59
	(iii) National Climate and NEC - Permit	-3.41	-9.43	-7.34	-8.50
	(iv) National Climate and NEC - Tax	-4.58	-10.55	-8.54	-9.65
	(v) Regional Climate and NEC - Permit	-3.44	-9.42	-7.32	-8.50
	(vi) Regional Climate and NEC - Tax	-4.63	-10.54	-8.61	-9.67
Goods	(i) National Climate - No NEC - Permit	-0.62	-0.67	-0.70	-0.67
	(ii) National NEC - No Climate - Permit	-4.39	-4.42	-3.16	-4.18
	(iii) National Climate and NEC - Permit	-4.37	-4.43	-3.29	-4.21
	(iv) National Climate and NEC - Tax	-5.08	-5.14	-3.88	-4.89
	(v) Regional Climate and NEC - Permit	-4.39	-4.43	-3.29	-4.20
	(vi) Regional Climate and NEC - Tax	-5.14	-5.14	-3.94	-4.91
Services	(i) National Climate - No NEC - Permit	-0.52	-0.63	-0.48	-0.57
	(ii) National NEC - No Climate - Permit	-0.46	-0.40	-0.39	-0.41
	(iii) National Climate and NEC - Permit	-0.66	-0.68	-0.58	-0.65
	(iv) National Climate and NEC - Tax	-0.60	-0.69	-0.48	-0.62
	(v) Regional Climate and NEC - Permit	-0.67	-0.67	-0.58	-0.65
	(vi) Regional Climate and NEC - Tax	-0.64	-0.69	-0.48	-0.63

(c) Employment and inter-jurisdictional commuting

Table 5.9 represents the effects of the environmental policies on the sectoral and regional employment. The effects of Table 5.9 correlate strongly with the effects observed for the output in Table 5.8. The energy and energy-intensive sectors are more severely affected, whereas the employment in the service sector hardly shows any decline. However, the changes in employment are relatively smaller than the changes in output, as the positive substitution effect due to the price increase of the goods, alleviates the negative output effect. Similarly as for the output, the employment of the energy sectors also increases in Brussels. Again, the employment decreases much more for the NEC policy than for the climate policy. The employment decrease for both policies combined is hardly higher than for the NEC policy alone.

Interestingly, the employment decreases more for both tax scenarios (iv) and (vi) than for the other scenarios. This higher decline in employment may be due to the fact that people are less inclined to work as the wages are lower with environmental taxes and the residents receive higher social benefits through the tax recycling. People have fewer incentives to work.

Table 5.9: Change of Sectoral Employment in Regions (%)

Pollutant	Scenario	Brussels	Flanders	Wallonia	Belgium
Energy Sectors	(i) National Climate - No NEC - Permit	-0.84	-4.90	-5.71	-4.36
	(ii) National NEC - No Climate - Permit	7.62	-16.33	-16.52	-12.14
	(iii) National Climate and NEC - Permit	6.96	-17.22	-18.04	-13.14
	(iv) National Climate and NEC - Tax	5.98	-17.70	-18.45	-13.68
	(v) Regional Climate and NEC - Permit	6.95	-17.22	-18.02	-13.13
	(vi) Regional Climate and NEC - Tax	5.92	-17.69	-18.56	-13.71
Energy Intensive Sectors	(i) National Climate - No NEC - Permit	4.75	-1.52	-2.48	-1.52
	(ii) National NEC - No Climate - Permit	-1.11	-4.43	-1.46	-3.20
	(iii) National Climate and NEC - Permit	1.39	-4.84	-2.65	-3.73
	(iv) National Climate and NEC - Tax	-0.74	-6.86	-4.74	-5.78
	(v) Regional Climate and NEC - Permit	1.37	-4.83	-2.63	-3.72
	(vi) Regional Climate and NEC - Tax	-0.82	-6.89	-4.81	-5.83
Goods	(i) National Climate - No NEC - Permit	-0.20	-0.19	-0.14	-0.18
	(ii) National NEC - No Climate - Permit	-2.51	-2.91	-2.23	-2.73
	(iii) National Climate and NEC - Permit	-2.45	-2.84	-2.19	-2.67
	(iv) National Climate and NEC - Tax	-3.61	-4.04	-3.23	-3.83
	(v) Regional Climate and NEC - Permit	-2.47	-2.83	-2.19	-2.66
	(vi) Regional Climate and NEC - Tax	-3.69	-4.06	-3.29	-3.86
Services	(i) National Climate - No NEC - Permit	-0.14	-0.17	-0.07	-0.14
	(ii) National NEC - No Climate - Permit	-0.23	-0.16	-0.14	-0.17
	(iii) National Climate and NEC - Permit	-0.25	-0.21	-0.13	-0.20
	(iv) National Climate and NEC - Tax	-0.35	-0.38	-0.17	-0.32
	(v) Regional Climate and NEC - Permit	-0.26	-0.21	-0.13	-0.20
	(vi) Regional Climate and NEC - Tax	-0.39	-0.40	-0.18	-0.34

About 43% of the people working in Brussels come from the other regions. In Flanders about 6,5% of the active people work in Brussels, whereas for Wallonia this figure is 16%. These figures are relatively stable for the various environmental policies and scenarios because all regions have to comply with lower emission levels.

(d) *Government*

In Saveyn and Proost (2005), we explained that environmental policy on the regional level may have important consequences for the budget of the federal level. More particularly, Saveyn and Proost (2005) emphasizes that the size and sign of the vertical externality depends on the size of the energy tax reform, the choice of the tax-recycling scenarios, the initial local and federal tax rates, and the size of the federation. However, a full comparison between the results of this paper and the results of Saveyn and Proost (2005) is not possible, as the analyses in both papers differ a lot. First, in Saveyn and Proost (2005) the output prices and the prices for capital and energy are kept constant, thanks to the assumption of small-open-economy. In this paper the prices increase due to the environmental policy. Second, Saveyn and Proost (2005) only use three input taxes (i.e. on labor, capital and energy). The government budgets in this paper are more complex as the model distinguishes between 9 different categories of receipts (see 5.3.1). Moreover, in Saveyn and Proost (2005) it depends, among others, on the tax recycling scenario (i.e. choice between the input taxes for labor or capital) whether a positive or a negative vertical scenario can be found. In this paper, the tax recycling scheme is more similar to a lump-sum transfer to the households as it does not reduce existing distorting (input) taxes.

Table 5.10 summarizes the evolution in nominal terms of the government budgets for the various scenarios. For most scenarios we see a very small increase in the nominal tax revenues for the federal government. For scenario (iv), however, the increase is more significant as the federal budget benefits from the environmental tax revenues. Overall, we can conclude that the effect of the lower economic activity and the lower pollution levels is offset by the higher prices.

As both policies explicitly focus on lower emissions (and, hence, smaller tax bases for environmental taxes), the revenues of the pre-existing federal environmental taxes are about 8% lower due to climate and NEC initiatives.

Table 5.10: Change in Nominal Tax Revenues (in %)

Pollutant	Scenario	Brussels	Flanders	Wallonia	Belgium
Federal Government	(i) National Climate - No NEC - Permit	0.24	0.21	0.24	0.22
	(ii) National NEC - No Climate - Permit	-0.58	0.28	1.08	0.35
	(iii) National Climate and NEC - Permit	-0.40	0.33	1.13	0.42
	(iv) National Climate and NEC - Tax	8.19	16.52	12.97	14.32
	(v) Regional Climate and NEC - Permit	-0.57	0.44	1.02	0.43
	(vi) Regional Climate and NEC - Tax	0.32	0.11	0.21	0.17
Regional Government	(i) National Climate - No NEC - Permit	6.07	4.71	4.60	4.87
	(ii) National NEC - No Climate - Permit	-1.80	-0.07	-1.41	-0.67
	(iii) National Climate and NEC - Permit	-1.47	0.27	-0.95	-0.29
	(iv) National Climate and NEC - Tax	5.56	2.92	4.88	3.81
	(v) Regional Climate and NEC - Permit	-1.42	0.21	-0.91	-0.31
	(vi) Regional Climate and NEC - Tax	101.26	222.54	149.74	186.34

We observe that in scenario (vi) the environmental tax revenues has an important impact on the budget of the regional governments. This is due to the limited fiscal autonomy of the regional governments and the relatively small amount collected from regional taxes (the constitutional transfers between the government levels are not included yet). A small change in revenues may have a important effects. For the other scenarios, the effects on the regional government budget are more complex and a function of the price changes, and the effect on the various revenue categories.

Although the total size of constitutional transfer is identical for all scenarios, these scenarios may differ in the distribution of this transfer across the regions. We find, however, that the differences in distribution across the regions are very small, as both the climate policy and the NEC directive affect the personal direct income tax revenues of all regions (see 5.2.1). A unilateral policy of one region may lead to more significant effects on the intergovernmental transfers.

In each scenario, the governments balance their budget by consuming less or more.

5.6. CONCLUSIONS

In this paper a Regional General Equilibrium Model for Belgium is presented. We start from the EU 25 GEM E3 model and introduce regional characteristics as inter-regional commuting, a national product market and intergovernmental transfers.

We illustrate the use of this model with an analysis of the climate policy and NEC directive in Belgium subdivided in three regions. The simulations show that this model is suitable for analyzing the effect of environmental and energy policies on the regional emissions and the regional marginal abatement costs, the regional output of the sectors, the regional employment, interregional commuting, and the budgets and transfers of the governments.

Overall, our results show that there are important ancillary benefits between the NEC policy and climate policy. These ancillary benefits work in both directions and also on pollutants, which are not explicitly included in either policy. We conclude that combining both environmental policies generates environmental benefits. Moreover, the reduction in marginal abatement costs if the climate policy and NEC policy are simultaneously combined shows that the costs of these policies are lower when both policies are simultaneously analyzed and implemented, than when both policies are separately analyzed and implemented.

The output of the energy and energy-intensive sectors is most affected by the climate policy. The output seems to be reduced more with the NEC directive than with the climate policy, reflecting the fact that the NEC directive is relatively more expensive compared to climate policy for 2010. The employment follows the same sectoral evolution as the output, although alleviated. The various environmental scenarios do not change the inter-regional commuting significantly. We find modest vertical externalities. Finally, we find that the effect of the environmental policies on the constitutional transfers between the government levels is very limited if all regions introduce a similar environmental policy.

The use of this model highly depends on the availability of regional SAM data, regional data on emissions, and data on the intergovernmental relations. In the current analysis, the available data were very poor, and our analysis was often based on strong assumptions. This data deficiency limits the scope for a thorough regional analysis, as the conclusions may be the results of artifacts (e.g. the higher output in Brussels for energy sectors). If more data are available this regional general equilibrium model may become a powerful tool to measure the regional effects of federal or regional environmental and energy policy. The model also allows for unilateral regional policies or for regions not choosing the same environmental targets or instruments.

Besides the data limitations, other improvements to the model can be made. The current analysis is done as if only Belgium has to comply with the climate and NEC policies. In reality, all EU Member States have to take initiatives for climate and NEC pollutants. Hence, the current analysis can be considered as the upper bound of the economic effects.

Although the (regional) GEM-E3 model is initially built for the analysis of environmental policies, it can also contribute to other socio-economic policy questions. Conrad *et al.* (2005) use the GEM-E3 model to study a reform of labor time in Germany. Using a similar CGE model, Boeters *et al.* (2005) analyze the relation between unemployment and the fiscal regime. Similarly, Boeters *et al.* (2006a) studies a VAT reform in Germany. Finally, Boeters *et al.* (2006b) compares a number of social reforms for Germany.

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