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Environmental climate instruments in Romania: A comparative approach using dynamic CGE modelling

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ABSTRACT

This study simulates a CO_2 permit market in Romania using a dynamic general equilibrium model. The carbon constraint is set at 20.7% below the reference emissions level for sectors eligible according to the European Union Emission Trading Scheme (EU-ETS). Free permit distribution enhances growth despite a severe emissions cap, because environmental regulation stimulates structural changes [Porter, M., 1991. American's green strategy. Scientific American 264, 168]. That is, grandfathering allows sectors additional resources to invest in developing technologies, but it also raises the CO_2 abatement costs because of energy rebound effects from enhanced growth. Results under endogenous growth [Romer, P.M., 1990. Endogenous technological change. Journal of Political Economy 98 (5), 71–102] are very similar to those obtained under an exogenous growth scenario [Ramsey, Y.F., 1928. A mathematical theory of saving. Economic Journal 38, 543–559], as the substitution effects are responsible for the majority of variations; in addition, Romanian research activities are too modest to significantly impact this system. The abatement cost per unit of GDP is higher under endogenous growth, as spillover effects reduce incentives to invest. Technological diffusion continues to have a positive impact on economic growth, which counterbalances the free-riding attitude adopted by some energy-intensive sectors, such as glass and cement.

1. Introduction

The international environmental context has deeply changed with the ratification of the Kyoto Protocol and the implementation of the European Union's Emission Trading Scheme (EU-ETS) in 2005. These agreements have greatly influenced national climate policy in Romania, especially since the country acceded to the European Union in 2007. Some national actions include the ratification of the Kyoto Protocol[1] and the transposition into Romanian legislation of the European Directive that sets the terms of carbon trade (Directive 2003/87EC; EC, 2003).

As in most Eastern European countries, energy consumption in Romania has undergone a significant drop during the transition from a centrally planned economy to a market economy. This decrease is partly due to a decline in economic activity, particularly after the dissolution of Council of Mutual Economic Assistance (CMEA) in 1991, as well as to structural transformations that took place during the transition. Consequently, Romanian GHG emission levels decreased by 50% in 2002 relative to their 1989 levels. Besides industrial and economic transitions, energy supply transformations are also noteworthy, as the commissioning of the first nuclear power reactor in 1996 allowed the country to further reduce GHG emissions. Before the end of the first commitment period of the Kyoto Protocol (2012), it is likely that GHG emissions will be below the benchmark set for Romania, even given scenarios with high economic growth rates (RME, 2005, 2006c). Yet after this period, rapid growth could lead to emissions levels 40% higher than the 2002 levels (RME, 2006b).

Romania has a diverse range of natural resources, such as oil, gas, coal, uranium and other significant renewable energy resources[2] including hydraulic energy, that ensures up to 67.7% of the country's energy independency (2003). The lifetime of these resources is estimated at 240 years for coal, 121 years for lignite and 122 years for uranium, while it is only 14 years for both oil and gas[3] (RME, 2006a). In this context, coal and uranium are the main energy resources for the country's energy balance; as such, two new nuclear plants are scheduled for 2010 and 2015 (RME, 2006b). As coal remains the main energy resource in the long run, the study of the evolution of emissions is essential to ensure

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[1] Romania ratified the UNFCCC in 1994 and the Kyoto Protocol in 2001 with the commitment to reduce greenhouse gas emissions by 8% compared to 1989 levels over the period 2008–2012.

[2] Primary energy resource shares in 2003 are: 34.8% gas, 25.7% oil, 23.4% coal and 5.1% for hydroelectric and nuclear–electric energy. National production is around 5.2 million tonnes per year for oil and 12.9 billion m^3 for gas.

[3] The country's reserves are estimated at 73.7 million tonnes for oil and to 184.9 billion m^3 for gas (RME, 2006a).

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long-term, sustainable economic development. Thus, the main objective of this research project is to estimate the costs of carbon reduction using two growth scenarios of the Romanian economy. Environmental policies are tested within these two scenarios by focusing on quantities and prices. One consists in the implementation of a CO_2 permit market; the other consists in the introduction of a tax on CO_2 emissions.

Note that technological progress can reduce the costs of abatement (Goulder and Schneider, 1999). Most models confirm that the cost reduction is sensitive to the level of technological change, concluding that pollution reduction is accelerated through the spillover effects that technological progress generates. In contrast, other models assign a major role to the abatement functions of interfactorial substitution effects (Nordhaus, 2002).

The recent literature on this topic presents technological progress as the main factor affecting the evolution of and reduction in greenhouse gas emissions because of the scarcity of energy options with low carbon emissions (Tietenberg et al., 1999). Analyses of the tradable permit market have shown that innovation can reduce abatement costs, because environmental research tends to reduce emissions, increase the supply of permits and lower the equilibrium price (Buonanno et al., 2003; Manne and Richels, 2002). Environmental regulation can thus improve research policy, as it creates incentives for the development of new technologies (Porter, 1991). However, some have shown that environmental constraints do not necessarily improve environmental research, because the pace of innovation slows down as energy prices rise and research spending diminishes (Kohler et al., 2006; Popp, 2002).

The impact of technological progress on the economy depends on the level of technological diffusion. Spillover effects are considered to be a growth factor, even if they generally reduce incentives to innovate. From a climate policy perspective, the diffusion of innovations leads to a higher permit price, because diffusion creates and stimulates so-called "free-riding" behaviour. This leads to a lower supply of tradable permits, thus increasing the equilibrium price. The macro-level impact is the opposite; spillover effects lower total abatement costs due to the positive effects they induce on growth (Buonanno et al., 2003).

Theoretical models show that spillover effects positively affect growth, but in practice, growth is dependent on past innovations as well as on capital stock. This latter concept defines progress as an inertial evolution that is difficult to change (Ha-Duong et al., 2004). That is, even if cheaper and more effective technologies are available, old technologies linger on because of their sunk costs. This blocked entry of new technologies is conventionally called a "lock-in effect" (Weyant and Olavson, 1999). Yet, despite this inertial aspect to growth, abatement measures can encourage the substitution of fossil-based technologies with cleaner technologies as well as can help reduce the price of technological progress by highlighting that learning and innovation are cost-saving activities.

Thus, debates aimed at developing an optimal abatement trajectory involve two opposing perspectives on action, namely, immediate action ("act now") versus initiatives undertaken in the future ("wait and see"). Abatement costs appear lower in the future due to increased technical progress, which seem to justify fewer abatement efforts in the short-term (Manne and Richels, 2002; Wigley et al., 1996). However, efforts to reduce emissions are increasingly beneficial the longer they have been enacted (Goulder, 2004), while the adoption of environmental measures can encourage the adoption of cleaner technologies. This increases the speed of technology diffusion and accelerates abatement in the long-term (Goulder and Schneider, 1999).

This research further explores the effect of technological change on climate policies and abatement cost in Romania using a general equilibrium framework. Through intertemporal dynamics, the model exogenously simulates active population growth (Ramsey, 1928) and endogenously introduces the technological progress originating in fundamental research (Romer, 1990). To explicitly describe the permit market, the model adopts appropriate disaggregation criteria and builds a multi-sector structure, as discussed in Section 2. Two distribution rules are tested, including allowances that are freely distributed among sectors, as mostly provided within the European Trading Scheme (ETS) until 2012, as well as allowances that are auctioned to participants, as per the European Commission's goal to gradually increase auctioning until 2020 (EC, 2008). Tax and permit analysis drive the two modelling growth motors so that auctions act as a carbon tax when permits are sold at the same price, as described in Section 3. Final remarks on the findings as well as policy recommendations are presented in the final section.

2. Theoretical specifications of the model and data

The neoclassical growth model is often attributed to Ramsey (1928), Cass (1965) and Koopmans (1965); in fact, it is a reduced form of a saving-investment model with a single infinitely-lived representative agent. Another analytical understanding of growth was developed by Solow (1956) with a focus on the productivity of production factors. In both the Ramsey and Solow models, the long-run growth rate depends on exogenous technological progress and population growth rates. The neoclassical model was developed further by Romer (1986,1990), Lucas (1988), Aghion and Howitt (1992), Grossman and Helpman (1991) and Barro and Sala-i-Martín (1995). These new growth theory models explained growth endogenously using three mechanisms: capital accumulation externalities, human capital accumulation and the existence of a stock of knowledge. This literature assumes that technological progress is a production process and that there is a common stock of knowledge possessed by society. Human capital acts on economic growth first by participating in production process and second by increasing productivity through the research, innovation and diffusion of new technologies. Knowledge stock, moreover, is a public good that generates spillover effects derived from capital accumulation; it compensates for decreases in the marginal productivity of capital and allows the economy to grow at positive rates in the long-run.

Applications of this new growth theory to environmental issues began in the 1990s with Nordhaus (1999), Goulder and Schneider (1999), Goulder and Mathai (2000) and Buonanno et al. (2003). These studies endogenously analyse firm reactions to an increase in energy prices that resulted in improving energy efficiency through research and development investment (R&D). These applications to energy and the environment are based on a relationship among R&D supply, human capital, growth rates and environmental regulations; they focus on the effects of public policies on technical changes that depend on the market structure, investments and the actions and anticipations of individuals. For instance, the implementation of a carbon tax increases energy prices and stimulates the demand for innovation; innovations in cleaner technology are then encouraged, depending on the profitability of the corresponding patents. Among these models, top-down approaches are the most explicitly cited as well as the least abstract methods for modelling technological progress (Weyant and Olavson, 1999). General equilibrium models in particular can more precisely take into account socio-economic contexts as well as growth feedback, both of which are important, because technological change usually influences economic and social progress.