SUSTAINABLE GROWTH WITH RENEWABLE AND FOSSIL FUELS ENERGY SOURCES

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Overview

How to control climate change and to spur clean energy are among the most important challenges facing the world today. So far, a large strand of literature on climate change states that we need several economic policy instruments to correct for existing types of market failures, for instance, an environmental tax on the carbon emissions and a research subsidy for research and development (R&D) in the renewable energy sector. We believe that a more fruitful approach to tackle climate change should take into account that investors in renewable energy react positively to a stock of commitment and reputation of the policy makers on the long run. To this end, the novelty of this paper is constituted by modeling a stock of public capital which captures intensity of government long term commitment to support new technology developments. We consider a Schumpeterian model of endogenous growth to take into account that production emit pollutants. The final good is produced employing labour and energy services from renewable energy and fossil fuels that are imperfect substitutes. The quantity of energy from fossil fuels is a function of investment and the amount of resources extracted. In our framework, the price of the non-renewable energy follows the generalized version of the Hotelling rule. Concerning the renewable energy policy intervention, we consider the effective value of an innovation paid to the inventor as an incentive for doing research in renewable energy in order to lower production costs and make it competitive in the energy market. For doing so, we construct two variants since we take into account two different channels for government intervention. In the first variant, the production function depends on investment and existing specific knowledge, together with a stock of public capital which represents the cumulated government support to new technology. In the second variant, the quantity of renewable energy depends on the stock of knowledge and investment, which in turn depends on policy intervention. There is the perspective of a non-linear jump, that is, there is a critical R&D threshold beyond which renewable energy gains in importance with respect to the fossil fuels input. We first present the decentralized economy and study the behaviour of agents in each sector: the final good sector, the energy services, the consumers and the government. We characterize both the decentralized equilibrium and the first-best optimum solutions. Next, we show how the optimum can be implemented by an appropriate flow of public capital, comparing the relative effectiveness of current monetary subsidies and government reputation and commitments, in order to enable policy strategies.

Methods

The bulk of literature on environmental regulation policies (Acemoglu et al., 2009; Grimaud and Rouge, 2008; Nordhaus, 2008; Quiggin and Horowitz, 2003) focuses on the need of a carbon tax and a research subsidy to implement the optimal environmental policy. The model we propose get underway from the one proposed by Grimaud et al. (2010) in which they basically show that two instruments - an R&D subsidy and a carbon tax - are necessary to correct for the two market failures, i.e. R&D spillovers and pollution. We break with tradition in relation to the short-run policies based on monetary subsidies the price of renewables. We believe that a fruitful approach to tackle climate change should take into account that investors in renewable energy react positively to a stock of commitment and reputation of the policy makers on the long run. We model an economy that is made up of four production sectors: the final output, the energy services, the fossil-fuel sector and the renewable one. The combustion of fossil fuels generates carbon dioxide (CO_2) that damage the natural environments and then society. Furthermore, the producer of fossil fuels have a negative cost from polluting emissions, unless the government intervenes with market instruments like taxes. In our model, the carbon and capture storage (CCS) technology that allows for significant CO_2 emission reductions is included in the fossil-fuel sector. The productive capacity of fossil fuels is finite. According to the condition derived by Hotelling (1931), we describe the dynamic of the fossil fuels' price that is expected to grow over time. We assume that there is research only in the renewable energy sector, because fossil fuels are exhaustible and polluting. There are two market failures: pollution and research spillovers. The former is corrected through a tax on the quantity of pollution from fossil fuels. Research spillovers are related to the benefits from new green technologies shared between firms: innovation is a non-rival good and it implies the inability to exclude and to receive the social price of innovation.

We construct two variants since we take into account two different production functions. In the first variant, the quantity of renewable energy depends on investment and the stock of knowledge. The second variant evaluates an "alternative" production function where a stock of public capital enter the production function as an input, with investment and the existing specific knowledge. We work on the effective value of an innovation paid to the inventor as an incentive for doing research in renewable energy in order to lower production costs and make it competitive in the energy market. The effective value of the patent for innovation in the two variants proposed changes according to the production function of renewable energy.

Results

In the first variant, we consider that renewable energy production function is made up of three inputs: investment in renewables I, stock of existing knowledge H and public capital G. The production function writes $ER_t=ER(I,G,H)$ with ER increasing and concave in each argument. G is the cumulated government effort to support in the long run renewable energy and includes both the actual value of policy commitment in monetary resource and the shadow value of the regulatory legislation, which creates a favorable administrative framework for investment decisions. In the second variant, we discard the assumption about the existence of stock of public capital considered in the renewable energy production functions, so that this latter is no more using three inputs as before, but only two: investment in R&D activities I, and the stock of knowledge H so that $ER_t=ER(I,H)$. By computing the effective value of innovation in both variants, that are respectively $a^1_{ER,t} = \mu_{ER}\left(\frac{ER_G}{ER_I} + \frac{H_H}{H_{I^H}}\right)$ in the first variant and $a^2_{ER,t} = \mu_{ER}\left[\frac{ER_{H^{ER}}}{ER_{I^{ER}}}(1-\sigma)\right] + \left(\frac{H^{ER}_{H^{ER}}}{H^{ER}_{I^{ER}}}\right)$ in the second variart, we get a better effect of the capital stock G with respect of the direct subsidy σ, when the productivity effect of the public stock $G(ER_G)$ is relatively stronger than the productivity effect of knowledge stock (ER_H), the higher is the subsidy share. Moreover, by doing the derivative of the effective value of an innovation in the two equations above we get respectively $\frac{\partial a^1_{ER}}{\partial G} = \mu_{ER}\frac{ER_{GG}}{ER_I}$ and $\frac{\partial a^2_{ER}}{\partial \sigma} = -\mu_{ER}\frac{ER_H}{ER_I}$; we note that an increase in public subsidy reduces the effective value of innovation, because firms will rather adopt existing technology if there is a subsidy.

Conclusions

Our analysis is relevant in the current debate on the optimal climate change policy to implement the use of renewable energy instead of fossil fuels. The main policy instruments used by countries are generally classified as price-oriented or quantity-oriented. Some of them are claimed to be more market conform than others, while other schemes are claimed to be more efficient in promoting the development of renewable energy. Currently, there is no general agreement on the effectiveness of each scheme and we are still far from enjoying the environmental benefits coming from the use of renewable energy. We have shown that a more fruitful approach to tackle climate change should take into account that investors in renewable energy react positively to a stock of commitment and reputation of the policy makers on the long run. For this purpose, we model a stock of public capital which captures intensity of government long term commitment to support new technology developments. We focus on the effective value of innovation paid to inventors of new green technologies as an incentive for doing research in renewable energy that make it competitive in the energy market. Such value varies according to the renewables production function, and given the same burden in actual monetary terms for the Government, the main result of the paper is that policy is more effective when the flow of public capital enters the production function as a public stock compared to the monetary subsidies to energy prices.

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