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Option value of low carbon technologies policies: how to combine irreversibility effect and learning-by-doing in decisions?

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In this paper we analyze the dilemma of deployment policies of large-size low carbon technologies (LCT) in situations of uncertainty on the future carbon price: on the one hand, these policies open options with the help of learning, and on the other hand, uncertainty usually calls for careful investment policies. These investments must be performed in a context of uncertainty surrounding the carbon price, which itself is related to the uncertainty of future climate policies and scientific knowledge on climate change.

The present approach is in the the tradition of the option value litterature applied to respective irreversibilities of climate change and clean investment. Irreversibility of accumulated emissions are not considered here in order to focus on the specific role of learning-by-doing. Investments in a new technology motivated by the learning-by-doing benefit are quite similar to investments in R&D intended to reduce the cost of an LC. The influence of uncertainty surrounding the carbon price on R&D spending has been previously analyzed by Larson and Frisvold (1996), Baker and Shittu (2006), Schimmelpfenning (1995), which obtained contrasting results. On one hand, Baker and Shittu (2006) focus on interior equilibria and use marginal reasoning to conclude that information acquisition should result in decreased investments. On the other hand, Schimmelpfenning (1995) by considering a binary choice concludes that the presence of uncertainty on the carbon price increases the value of an R&D project. The present analysis creates a bridge between these two approaches by considering global conditions and size of policies.

A simple analytical model of a regulator's sequential choice of LCT plants in the context of uncertainty of the carbon price is developed. There are two periods and two technologies: a LCT and a carbon technology. In the first period, the regulator chooses a particular number of LCT plants. In this period, because the LCT is more costly than the carbon technology, there is an opportunity cost to invest in the LCT; however, due to learning-by-doing, these first-period investments reduce the costs of future LCT plants. The uncertainty of the carbon price translates into an uncertainty regarding the cost of the carbon technology. The influence of learning, i.e. acquiring information in the second period on the development of the LCT in the first period is investigated. Two optimal investments in the LCT capacity are compared. These two investments minimize the aggregate expected costs in two scenarios, with and without learning of the true CO2 price in the second period. In both scenarios, in the first period, the regulator has an a priori uncertainty regarding the carbon price. In the "uninformed" scenario, the regulator has still no information in the second period; in the "informed" scenario, the regulator learns the true carbon price in the second period. The difference between the second ans the first scenario is interpreted as an increase in information.

The analysis showed how the anticipation of information acquisition influences the two decisions: the choice to launch an LCT policy and the choice of its size. It is shown that, if the expected price of CO2 is high, the standard irreversibility effect holds: there should be less investment in LCT plants when information will be available than that in an uninformed scenario. However, if the expected price of CO2 is low and uncertainty is sufficiently high, larger investment in the LCT occurs when information will be available. More precisely, the LCT is not developed in the uninformed scenario, whereas in the informed scenario, a strictly positive quantity of plants is developed. This stresses the distinction of the two decisions: whether or not to launch an LCT policy, and its size. It is established that, with information acquisition, LCT policy should be launched earlier and, if launched, it should be smaller.

An essential feature of the model is the existence of multiple local optima. This multiplicity is related to learning-by-doing and more generally to endogeneous technical change. The initial investment in a technology constitutes a pure loss until the technology becomes competitive. It is only once this competitivity threshold is reached that a marginal investment could increase welfare. A numerical illustration was done to extend the analyzis to a framework with a welfare function and to consider the effect of the learning rate and the distribution of the CO2 price.

Two important lessons could be deduced. A first lesson is related to the non-monotonicity of marginal welfare with respect to the investment in LCT. Governements witnessing the financial costs of the support to renewable energies are contemplating this `non-convexity'': indeed a support policy should be sufficiently important in order to ensure that LCTs are competitive. These policies constitute a bet; whether the cost to subsidize LCTs today is worth will depend on their relative cost to the carbon technology cost tomorrow. The terms of this bet should be acknowledged. A support to LCT opens an option to face high carbon price and the size of this support should integrate the possibility that the carbon price be lower than expected. The second lesson is with respect to LCT policies that are decided by ignoring uncertainty and considering an expected carbon price. It is important to stress that the anticipation of information arrival does not constitute an argument to stop these policies but only to downsize them. The move from a corner optimum with no support to LCT to an interior optimum with a strictly positive support arises when information is anticipated and not the other way around.

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