Journal of Economic Dynamics & Control 73 (2016) 354–372

Contents lists available at ScienceDirect

Journal of Economic Dynamics & Control

journal homepage: www.elsevier.com/locate/jedc

A contingent claims analysis of optimal investment subsidy

Norvald Instefjord *, Vivekanand Nawosah, Pei Yang

Essex Business School, University of Essex, Wivenhoe Park, Colchester CO4 3SQ, UK

ARTICLE INFO

Article history:
Received 26 January 2016
Received in revised form
19 August 2016
Accepted 10 October 2016
Available online 24 October 2016

JEL classification:
D92
E62
G31
H21

Keywords:
First-mover advantages
Free riding
Investment subsidy
Preemption risk
Subsidy tax

ABSTRACT

This paper uses contingent claims analysis to answer two questions: (i) why are some subsidy markets apparently slow in attracting an optimal subsidy when others are not, and (ii) what can be done about it? The lack of activity in the green investment subsidy markets has been a concern as it appears optimal that countries should offer such support from a welfare point of view but progress has nonetheless been stalling, which motivates this paper. We show that free riding (which is likely to affect the green subsidy market) cools down the subsidy market with harmful welfare effects, and preemption (which is likely to affect the more active FDI subsidy market) overheats the subsidy market with similarly harmful effects. The theory dictates a taxation scheme that offsets these effects to restore the welfare to its maximum point.

1. Introduction

Contingent claims analysis has been one of the success stories in financial economics, and this paper uses this technology to answer questions related to policy on promoting green technology. Investment subsidy can correct the problem that firms fail to recognise the positive externality of their investments, but the subsidy market itself may fail. Two questions related to this problem are addressed. First, we ask what factors explain the activity in the subsidy markets, and second, what role can policy play to enhance the welfare from these markets. The contingent claims framework has the advantage that expressions for the option value of deferring subsidy decisions can be obtained, which can be used to evaluate the effects of policy in this area.

The need for policy is particularly pressing in the area of preventing climate change. The welfare benefits of combatting climate change are well documented but the positive externality associated with green investments has so far failed to attract the kind of investment subsidy we see in other areas such as foreign direct investment (FDI).[1] The policy on climate change has largely been a failure, and although hopes are that the recent 2015 Paris agreements can signify a turnaround,

* Corresponding author.
E-mail addresses: ninstef@essex.ac.uk (N. Instefjord), vnawo@essex.ac.uk (V. Nawosah), pyang@essex.ac.uk (P. Yang).

[1] Thomas (2007) estimates that within the European Union in 2005 €8.4bn were distributed in regional aid, a figure that probably underestimates the actual number, and he cites estimates of between $40 and $50bn for the US for 2002. An estimate by the World Trade Organization is a total of $250bn in 2003 by 21 developed countries. Dutz and Sharma (2012) survey the green investment subsidy market and find that subsidy is largely non-existent globally, and essentially confined to developed economies such as the US and the European Union.

http://dx.doi.org/10.1016/j.jedc.2016.10.004
0165-1889/

concerns still linger about commitment and enforcement mechanisms. An understanding of how the investment subsidy market works and how policy affects this market is, therefore, of interest.

The optimal timing of investment subsidy is a key theme in this paper. A dollar spent too soon or too late in an industry cannot compete with a dollar spent at the optimal time.[2] Timing and welfare are however not necessarily related. Just as a farmer may get the highest yield from the latest harvest, the highest welfare may come from investment subsidy markets with low activity levels. The fact that the green investment subsidy market has been slow to attract activity is, therefore, not in itself a reason for policy intervention.

A factor distorting the timing of subsidy is first-mover advantages. A subsidy offered by one country may, for instance, have negative impact on the welfare of other countries considering the same type of subsidy which creates a first mover advantage in the subsidy market. Rare R&D investments are good examples. A country that attracts a rare R&D investment through subsidy captures most of the welfare gains while the losing countries not only receive very little in welfare effects but may also have to wait for a long time for a similar opportunity to appear. In this case the best response is to become more aggressive in the subsidy market and as a consequence the subsidy market is heated up. Welfare is therefore sacrificed in order to ensure that the country wins the race to attract the investment. A second factor is free-riding effects in the market for subsidy. Here, the welfare that results from a subsidised investment is captured by other, non-subsidising, countries. For instance, if a country is offering a subsidy for green investments to combat climate change the welfare effects will be shared by all countries, including the non-subsidising ones. The best response is to become less aggressive in the subsidy market and the subsidy market is cooled down. Welfare is also here sacrificed because of the free riding effect.

We show that the welfare distortions caused by heating and cooling of a subsidy market can be corrected by a surprisingly simple policy intervention. This intervention takes the form of a tax, or transfer payments, linked to a country's actual subsidy payments. The tax is negative in the heated subsidy markets so that the non-subsidising countries receive payments calibrated to the subsidy payments of the subsidising countries. The tax is positive in the cooled subsidy markets so that the non-subsidising countries make payments calibrated to the subsidy payments of the subsidising countries. This scheme makes it more attractive not to pay subsidy in the hot subsidy markets and less attractive not to offer subsidy in the cold subsidy markets. Moreover, the scheme is incentive compatible in the sense that both the subsidising countries (who pay or receive tax payments) and the non-subsidising ones (who do not) have the same welfare and are therefore better off with the taxation scheme than without. Finally, the tax may be self-financing if the positive tax payments collected from the cold subsidy markets exactly offset the negative tax payments in the hot subsidy markets. We discuss implementation issues of such a scheme in the main body of the paper. The current approach to policy on climate change, based on agreements on targets, has had limited success. There is however no reason to think that targets remove the free riding problem in the investment subsidy market, and therefore the incentive for individual countries is to undersupply subsidy to green investments. The taxation scheme outlined in this paper will in contrast remove the free-riding problem and therefore the decision to subsidise green investments can be delegated to individual countries.

The related literature consists of several strands. There is a literature that discusses aspects of subsidy design in dynamic models (see, for example, Pennings, 2000, 2005; Yu et al., 2007; Asano, 2010). Our model extends this literature. There is also a strand of literature that discusses the welfare effects of FDI subsidy, surveyed in Besley and Seabright (1999). Related contributions are Black and Hoyt (1989), Albornoz et al. (2009), and Chor (2009). The essential division between their work and ours is that we use a dynamic model, allowing us to study timing effects. There is a growing literature on policy to encourage investments in green technology, but this literature is still relatively thin (see Dutz and Sharma, 2012 for an overview). Agliardi and Sereno (2012) build a model of the optimal switch from a non-renewable source of energy to a renewable one. They do not, however, analyse distortions to the timing of subsidy.

The paper proceeds as follows. In Section 2 we present the framework, including the earnings process that leads to commercial value for the firm, and the welfare effects of investment subsidy. Also, we set out the impact of preemption risk and free riding effects in this framework. In Section 3 we present the main theoretical findings, including the optimal form of investment subsidy, the optimal timing of subsidy, and the effects of preemption risk and free riding on the timing of subsidy. In Section 4 we discuss the results of the model and derive its policy implications, and Section 5 concludes the paper.

2. Framework

In this section we set out the model. The basic framework where the firm makes an investment under uncertainty is described in the first subsection. A country makes a subsidy decision under uncertainty, where the subsidy must be calibrated such that it solves the investment decision for the firm that receives it. The country therefore decides the timing of the subsidy. The second and third subsections describe these problems. Finally, the fourth subsection describes first-mover and free-riding effects that influence both decision problems.

[2] This argument assumes the absence of frictions. In frictional economies it may be optimal to sacrifice timing efficiency in order to preserve budgets for future subsidy.