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Environmental policy and macroeconomic dynamics in a new Keynesian model

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ABSTRACT

This paper studies the dynamic behavior of an economy under different environmental policy regimes in a New Keynesian model with nominal and real uncertainty. We find the following results: (i) an emissions cap policy is likely to dampen macroeconomic fluctuations; (ii) staggered price adjustment alters significantly the performance of the environmental policy regime put in place; (iii) the optimal environmental policy response to shocks is strongly influenced by the degree to which prices adjust and by the monetary policy reaction.

Introduction

This paper seeks to understand the importance of different environmental policy regimes as a further conditioning factor for the dynamic response of the economy to nominal and real shocks. To this end, we formulate a dynamic stochastic general equilibrium (DSGE) model of New Keynesian (NK) type embodying pollutant emissions and environmental policy.

The model that we construct has three key features. First, as in a standard NK model, the model embeds nominal price rigidities, and monetary policy is described by a simple interest-rate rule.[1] In particular, nominal price rigidities stem from a time-dependent price-adjustment framework *à la* Calvo (1983), in which each period only a fraction of intermediate good producers are assumed to be able to change their prices, while the other fraction must satisfy all demand at the previously quoted prices. Second, for what concerns the real side of the economy, we depart from the very basic model by introducing capital accumulation and capital adjustment costs, so that our setup generates more plausible response of the main macrovariables to shocks and is more general, embodying a Real Business Cycle (RBC) model as a special case. Third, the model includes pollutant emissions which are a byproduct of output. Emissions are assumed to be costly to firms which are so pushed to limit the environmental impact of their production activity by undertaking abatement measures. Emissions and firms abatement activities depend on the type of environmental regime adopted, namely: cap-and-trade (i.e. an exogenous limit on aggregate emissions), emission intensity target (i.e. an exogenous limit on emissions per unit of aggregate output) and tax policy (e.g. a carbon tax).

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[1] See Woodford (2003) and Galí (2008).

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With this characterization the paper asks the following questions: What is the impact of emissions regulations on the business cycle when we allow for imperfect price adjustment and monetary policy? To what extent do nominal rigidities influence the macroeconomic effects of the environmental policy regime put in place? How does environmental policy optimally respond to business cycle in the presence of nominal rigidities? What impact has the monetary regime on the optimal environmental policy response to shocks?

Preventing dangerous climate change is considered a priority of utmost importance by the international community. In this respect, a substantial cut of anthropogenic greenhouse gas emissions at worldwide level is advocated as a means to keep global warming under control. From this perspective it is clear why over the last decades the debate on the relationship between economic growth and environmental policy has attracted increasing attention in academic and policy circles. The debate mainly focuses on how protection of environment and economic activity could be seen as mutually consistent and not as competing aims.[2] However, at least in the short- to medium-term, environmental policy and economic activity are portrayed as being in conflict with one another and, as a consequence, the policy actions undertaken play an important role in making the trade-off between environmental quality and economic efficiency more or less painful. While regulations that manage to decouple environmental degradation from economic activity are less likely to affect the business cycle, climate actions are considered to have pervasive effects at macroeconomic level, since the additional costs of decarbonising an economy involve directly and/or indirectly both households and firms, changing their systems of incentives and, eventually, their attitude toward uncertainty and shocks.[3] For instance, the commitment to a cap-and-trade scheme implies greater certainty about future emissions levels, but greater uncertainty about compliance costs, while intensity targets, allowing for fluctuations in aggregate emissions caused by fluctuations in economic activity, should reduce the uncertainty related to compliance costs.[4] In this respect, our paper aims at contributing to the theoretical debate on this trade-off, by analyzing how alternative environmental policies are likely to condition the business cycle behavior of an economy whose equilibrium is distorted by the existence of imperfect competition and nominal rigidities.

A stream of empirical literature has made the case that slow price adjustment and monetary policy act as drivers of the business cycle, significantly altering the short-term course of the real economy (for an overview, see Clarida et al., 1999; Woodford, 2003; Galí, 2008). For this reason nominal rigidities represent a key distortion in the NK models, where the emphasis is more on nominal shocks, rather than on productivity shocks, as drivers of economic fluctuations.[5] In this context it is then possible to study the impact of environmental regulations from a different angle, where different sources of the business cycle may yield different outcomes, depending on how prices adjust to the changed economic conditions.

Our paper is related to the strand of literature that combines environmental economics and macroeconomics, aiming at a clear understanding of the interaction between environmental indicators and macroeconomic variables as well as of the potential effects of environmental regulations on the economy.[6] In particular, the closest predecessors of our paper are those studying environmental policy in a DSGE framework. Prominent examples include Fischer and Springborn (2011), Heutel (2012), Angelopoulos et al. (2010, 2013) who study environmental policy in RBC models.[7] In detail, Fischer and Springborn (2011) explore the macroeconomic performance of an emissions tax, an emissions cap and an intensity target in a RBC model in which production requires a polluting input, so that emissions abatement results from reductions in production in response to shocks and to the environmental policy regime put in place.[8] They find that with respect to the no policy case, the variability of the main macroeconomic variables is lower under a cap and higher under a tax policy, while the two regimes perform similarly in terms of central tendencies, below those obtained in the no policy case. An intensity target, instead, is shown to produce higher mean values and lower welfare costs than other policies, with a volatility level not higher than that recorded with no policy. Heutel (2012) develops a RBC model in which emissions are a byproduct of production and firms are able to reduce pollutant emissions thank to a costly abatement technology they have at their disposal. In this framework the author shows that in a centralized economy the optimal environmental policy allows emissions to be procyclical; likewise, in a decentralized economy the optimal emissions quota and the optimal taxation are found to move procycally. Finally, Angelopoulos et al. (2010) compare the performance of alternative environmental policy rules in a RBC model with uncertainty on total factor productivity, allowing also for exogenous shocks to the ratio of emissions to output, source of environmental uncertainty. In their model emissions are a byproduct of production, but only the government can engage in pollution abatement activity. The second-best policy prescription is found to depend crucially on whether environmental or technological uncertainty prevails. In a similar setup,

[2] On the importance of approaching the issue of climate change from an economic perspective, the R.T. Ely lecture given by David Stern at the AEA 2008 Meeting represents a riveting introduction. See Stern (2008).

[3] Nevertheless, the regulatory response to climate change also presents significant opportunities with new markets and technologies developing as part of the slow transition toward a lower carbon economy.

[4] Intensity-based targets are expressed as pollutant emissions per unit of economic activity, which can be measured at an aggregate level, for example, in terms of GDP, or at a more detailed level, based on measures of firm's own output. In particular, indexing carbon dioxide emissions to GDP is considered an appealing option for developing economies.

[5] Direct evidence on price rigidities is provided by Álvarez et al. (2006), Bils and Klenow (2004), Dhyne et al. (2006), Klenow and Malin (2011), among others. In general, a marked heterogeneity in the frequency of price adjustment is found across sectors, while prices seem to change less frequently in Europe than in the United States.

[6] See Fischer and Heutel (2013) for a complete overview on the macroeconomic approach to the study of environmental related issues.

[7] A number of previous studies deal with the relationship between economic fluctuations and environmental policy, but not in the context of a RBC model. See e.g. Kelly (2005) and Bouman et al. (2000).

[8] Starting with the seminal contribution of Weitzman (1974), several other papers compare the performance of alternative environmental policies for regulating emissions, accounting or not for economic uncertainty, either in partial equilibrium settings (e.g. Hoel and Karp, 2002; Newell and Pizer, 2008; Quirion, 2005 among others) or in general equilibrium models (e.g. Goulder et al., 1999; Parry and Williams, 1999; Dissou, 2005; Jotzo and Pezzey, 2007).