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Abstract

The debate seems to be well settled among economists in that the best policy instrument to reduce carbon emissions is a carbon tax. However and surprisingly, most of these discussions have taken place in a first-best setting. We think instead that second-best settings should be incorporated to the analysis with at least the same level of rigor. Therefore, a careful assessment under second-best conditions of all the available instruments, and their combination, seems well deserved. Here we build on the existing literature and try to provide an integrated, although preliminary approach, merging efficiency with other concerns, with the final goal of giving indications on which instrument, or instruments, seem better suited for climate policy.

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1.Introduction

The debate seems to be well settled among economists in that the best policy instrument to reduce carbon emissions is a carbon tax (for example, Newell and Pizer, 2008). Indeed, following from Pigou's ideas about the correction of externalities (Pigou, 1932), and adding Weitzman's ones about the choice between price and quantity instruments (Weitzman, 1974), carbon taxes seem to be the best policy instrument to induce a reduction in carbon emissions. Another issue of course is the right value for this tax (for a discussion of the social value of carbon see for example Tol, 2009).

However and surprisingly, most of these discussions have taken place in a first-best setting. Surprisingly because, first, there is a widespread recognition that first-best situations are mythical at best. Baumol and Bradford already stated in 1970 that 'generally, prices which deviate in a systematic manner from marginal costs will be required for an optimal allocation of resources, even in the absence of externalities'. In other words, any level of tax revenue to be collected by a government will ultimately produce some price distortion, and will therefore cause the economy to deviate from the first best. To this we may add a significant list of additional real-life distortions: previously existing, and not necessarily efficient, subsidies or other regulations for energy and economic activities, vested interests, additional market failures, etc.

The second reasons is that there is already a well-developed literature on the choice of policy instruments in second-best settings such as those in which modern economies must make their decisions, since the seminal work of Lipsey and Lancaster (1956)[1]. Although forgotten for some time, these ideas about instrument choice in second-best settings are returning to the debate – as we will show in the paper –, particularly for energy and climate policies, which are usually subject to many of the problems that are considered deviations from first-best situations.

Traditionally the debate has been generally focused on efficiency concerns. However, efficiency is not the only criterion for choosing instruments for environmental policies: other criteria such as distributional impacts, effectiveness, ease of implementation, etc., must also be considered, particularly if political and social acceptability is to be achieved. Dietz and Atkinson (2010), for

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[1] Indeed, this discussion started from Pigou himself, who was perfectly aware of the difficulty of attaining first-best conditions in real-life economies (Pigou, 1932)

example, found that people give the same weight to equity as to efficiency concerns when designing environmental policies. The evaluation of environmental policy instruments under these different criteria has already been addressed by other authors (for example, Goulder and Parry, 2008).

In the end, a second-best analysis may result in having to modify the value of the first-best carbon tax, but it may also conclude in the need to use alternative, and in some cases, multiple instruments. There is a risk, however, of taking this as an excuse to step aside and dismiss traditional economic analysis, and by doing this, justify any type of policy and any level of political intervention which, in fact is a common argument in many discussions about energy and climate policies.

We think instead that second-best settings should be incorporated to the analysis with at least the same level of rigor. Therefore, a careful assessment under second-best conditions of all the available instruments, and their combination, seems well deserved. Here we build on the existing literature and try to provide an integrated, although preliminary approach, merging efficiency with other concerns, with the final goal of giving indications on which instrument, or instruments, seem better suited for climate policy.

But before starting we would like to set the boundaries for our analysis. First, we will only address the reduction in carbon emissions, and not other possible policy objectives (such as general issues of energy security, or economic development, which would also interact with climate policies). Second, we will not deal here with international second-best issues, such as the political economy of climate negotiations (see for instance Bosetti and Victor, 2010); carbon offsets (De Cian and Tavoni, 2010); or trade imperfections (for example Ulph, 1996). Finally, we will not address the problems related to uncertainty about costs and benefits of environmental instruments, which have been already well covered in the literature (for instance, Weitzman, 1974), or about uncertainty in the future costs of abatement measures (e.g. Liski and Murto, 2010).

The paper is organized as follows. First, we identify and classify the reasons for deviating from a first-best analysis both under efficiency concerns and also under other criteria; we then look at the issue of multiple instruments and coordination. Finally, we provide some recommendations on instruments for climate policy under second-best.

2. Second-best situations

Lipsey and Lancaster stated in 1956 that 'if there is introduced into a general equilibrium system a constraint which prevents the attainment of one of the Paretian conditions, the other Paretian conditions, although still attainable, are, in general, no longer desirable'. This is the formal definition of a second-best setting. Although it was conceived basically for efficiency concerns, it may be easily extended to other constraints (distributional requirements, administrative ease of use and so on). Therefore, we will start analyzing the different constraints that may arise in climate policies which prevent attaining the first-best solution.

We may distinguish two types, as to say, of second-best situations: the "pure efficiency" one, in which the design of environmental instruments tries to maximize their economic efficiency under distorting prices, taxes, etc.; and a more comprehensive one, in which equity, political acceptability, behavioral issues, or other non-efficiency aspects come into play. In this paper we will take this "comprehensive" approach for the analysis of second-best instruments.

2.1. Distorsionary taxes

2.1.1. Optimal taxation

As indicated before, there has been a gradual departure from the initial interpretations which considered carbon taxes only to solve the externality problem towards more comprehensive approaches that related these taxes to the general fiscal structure. This is linked to the fact that a distortionary tax system is in place and, therefore, the first-best Pigouvian prescription (a carbon tax rate equal to the marginal damage caused by emissions, whose revenues are returned lump sum) does not hold anymore.

Thus two separate issues are related to the presence of existing distortionary taxation. The first one has to do with the effects on the carbon rate structure, and the second on the use of tax revenues. Revenue recycling will be also considered in the next sections, and the debate here is mainly related to the gains (a second dividend) from reducing those existing distortionary taxes through the carbon tax revenues. In general, the literature favors the use of environmental tax revenues to reduce other distortionary taxes, although without precluding a net welfare gain with respect to the situation without the tax (only a welfare gain with respect to the non-reclycing alternative: a 'weak' double dividend). This will depend of course on many factors: the pre-existing relative prices and taxes (for example Babiker et al, 2003), the stringency of the climate policy (Anger et al, 2010) and others.

With respect to the effects of distortionary taxes on the carbon rate structure, the literature was originally favourable to tax rates that would guarantee larger revenues (to exploit distortionary tax reductions). Lee and Misiolek (1986), for instance, argued that this could lead to higher or lower environmental tax rates, depending on the tax elasticity of emissions at the environmental optimum achieved through the Pigouvian tax. However, an important shift in the understanding of this issue took place in the early nineties. Bovenberg and de Mooij (1994), through the use of a static general equilibrium model, showed that in most cases environmental taxes exacerbate the distortions brought about by conventional taxes. As a consequence of the extra costs, it was argued that environmental tax rates should be below the Pigouvian rates.

2.1.2. Other instruments

In addition to the impact of pre-existing distortionary taxes on the determination of the value of the carbon tax, this second-best situation may even recommend the choice of a different instrument. Although Quirion (2004) concludes that, under pre-existing distortions, the case for a tax compared to a quota is even stronger, there is a more comprehensive discussion on this issue, which is based on two elements: the revenue-generating capacity (Parry and Williams, 1999) and the creation of rents (Fullerton and Metcalf, 2001).

Parry and Williams (1999) argue that the revenues generated by the different instruments can be used to reduce pre-existing distortionary taxes, and therefore to improve the efficiency of the instrument. Indeed, Goulder et al (1999) argue the discussion should not be centered on taxes versus other instruments, but rather on the presence or absence of revenue recycling. If, for example, taxes are returned lump-sum, then their efficiency may be lower than that of an auctioned cap-and-trade system. In another study, Goulder et al (1999) found that standards may be more efficient than emission permits if the permits are not auctioned. Parry and Williams (1999) in turn show that, with no revenue recycling, performance standards are more cost-effective than taxes or cap-and-trade. This would also lead us to the conclusion that subsidies, which need additional revenue, would be the worst instrument on efficiency grounds.

However, Fullerton and Metcalf (2001) argue that raising revenue is neither necessary nor sufficient as an attribute for an optimal policy under a second-best setting. Instead, they point to the creation of privately-owned scarcity rents as the reason for the differences between policies. Revenue recycling will only be relevant when scarcity rents are created. Therefore, non-revenue recycling policies such as standards, or even subsidies, might be superior when compared to policies which create scarcity rents but which are not captured by the government and therefore recycled. That is, the advantages of economic instruments regarding setting prices right (correcting externalities, dynamic efficiency), may be negated if, instead of reducing the pre-existing distortions in the economy they exacerbate them when their rents are not recycled.

Therefore, the conclusion of this analysis is that, under pre-existing distortionary taxes, the most efficient instrument will be one in which the scarcity rents created – which are good for other purposes – are captured by the government (taxes, auctioned cap-and-trade). If other issues preclude this recycling, then other instruments should be contemplated.

2.2. Knowledge spillovers

Jaffe and Stavins (1995) already argued that policies with large economic impacts – climate policies are a clear example – should be designed to foster rather than inhibit technological change. The reason – suggested by their evidence – is that environmental policies alone are not strong enough to overcome technology market failures.

In fact, technological change is expected to play a key role in mitigation and adaptation policies, and should therefore be promoted strongly. However, although a price for carbon should in principle incentive the use of carbon-free technologies, this does not take into account the market failures present in this sector, namely knowledge spillovers, and also credibility problems, learning-by-doing effects (Fischer and Newell, 2008), or risk of decreasing costs in the future.

Therefore, specific technology-promotion instruments will be required. Fischer (2008) has shown that the social return from technology policies depends on the degree of spillover, and also on the share of marginal social cost priced. If there is no social cost pricing (carbon pricing, in our case) there will be no incentive to innovate. On the other hand, if we assume a minimum rate of carbon pricing, the higher is the knowledge spillover, the higher will be the social return from public investments in technology.

However, Fischer also shows that technology policy cannot substitute completely for mitigation policy: waiting for costs to decrease requires huge investments and forgoes cost-effective emissions reductions. Therefore, we may need both carbon prices and technology policies. Indeed, Fischer and Newell (2008) conclude that multiple instruments will be required to correct both externalities, and will in fact be cheaper than a single instrument.

The challenge of course is to determine the right combination of instruments, accounting for the interactions between them. For example, Weber and Neuhoff (2010) argue that, when innovation is included in the model, innovation effectiveness may change the optimal carbon price, and also may make quantity instruments more attractive than taxes. More research is clearly needed on this critical issue.

2.3. Other market failures

Carbon policies respond to a market failure, the non internalization of the damages of carbon emissions. We have also addressed innovation market failures. However, there are other market failures which also create a second-best setting for the definition of carbon policies.

The first one is the asymmetry of information, which gives rise to option values which differ from "optimal" ones (Metcalf, 1994); or to the principal-agent problem, which in turn explain part of the energy efficiency paradox (Linares and Labandeira, 2010). Another of those is the coordination problem (Rodrik, 1996), that is, the lack of complete information transfers between the different parties affected by carbon policies, which is further complicated by the time lags and uncertainties involved. In the presence of this problem, complementary measures may be required, targeted at the different agents who may play a role in the reduction of carbon emissions (Hanemann, 2010).

Network externalities (related to the supporting infrastructure required by carbon-free technologies, such as smart grids, fuel distribution, etc.) may also be at play, creating path dependence or technology lock-in, and therefore specific measures may be required to change path. Scale economies may also be an issue which requires specific support. Both should be discontinued once the problem is removed.

Finally, other authors have also identified other market barriers (not necessarily market failures) or pre-existing advantages for fossil fuels which may prevent the efficient deployment of carbon-free technologies (Sovacool, 2009).

2.4. Behavioral issues

Behavioral issues may be another reason for modifying our first-best choice for climate policy. We term as such the seemingly irrational behavior of consumers when making decisions, and which is also known as bounded rationality (Simon, 1955): the lack of capacity of decision makers to incorporate all the information and criteria available when making their decisions. This fact has been shown in several studies regarding energy efficiency (Linares and Labandeira, 2010), which is a similar framework to the one being discussed here.

Jaffe and Stavins (1995), for example, found that, even after correcting for different market failures, the effect on technology diffusion of up-front technology costs was much greater than equivalent longer term energy prices. Therefore, technology adoption subsidies had much larger effects than equivalent Pigouvian taxes.

In general terms, bounded rationality reduces the response to economic instruments. Therefore, when emissions reductions are required, we may require product-specific instruments, such as building codes or standards for energy efficiency, which move the load of the proof away from consumers. However, these standards should be as flexible as possible, to allow cost-effective alternatives and ongoing incentives for improvement.

2.5. Political acceptability

Although not very frequently addressed in the economic literature, the political acceptability of environmental policy instruments plays a large role. In general terms, carbon prices are not well accepted by voters, and therefore are usually politically difficult to swallow. Even considering the same attributes, the word "tax" creates an instantaneous rejection by people (Brannlund and Persson, 2010). By the contrary, subsidies and standards are much more popular, although they will typically be more inefficient, as mentioned already in previous sections (Metcalf, 2009a)[2].

[2]Although it should be reminded that a more accepted instrument may in practice become more efficient if acceptability increases effectiveness.

If the price (the implicit tax) results from a cap-and-trade system, the government will be strongly tempted to intervene – generally to keep prices at a reasonable level[3] –, thus destroying the credibility of the market; if it results from a carbon tax, then the tax itself may not pass through the legislative body (there are plentiful examples of this, the most recent the French one).

Thus, governments may be interested in lowering ex-ante the perceived cost of the policy to an acceptable level, and this can be done with complementary measures, which basically make more elastic supply and demand curves for emission reductions (see for instance Linares et al, 2008). This can be achieved with public investments or support policies for carbon-free technologies, as has been done in many countries with support policies for renewable energy[4].

Another option for the government is to hedge against uncertain costs of the policy, but without losing credibility. One way of doing this is to use hybrid instruments, combinations of price and quantity instruments. Roberts and Spence (1976) showed that a price and quantity instrument, such as the safety valve proposed in the US for climate policy, may be superior to a single price or quantity instrument. Metcalf (2009b) presents a more sophisticated version of this instrument.

Webster et al (2010) show that indexed caps may be superior to safety valves when there is a high correlation between the cost uncertainty and the index uncertainty. Quirion (2004), in turn, argues that contingent instruments such as indexed caps are even less appropriate under second-best (pre-existing taxes) conditions.

A second element besides the perceived cost that determines acceptability is the distribution of the cost of the policy among the different segments of society. As mentioned before, equity concerns may drive policy as much as efficiency ones, as shown by Dietz and Atkinson (2010) or Brannlund and Persson (2010): a climate policy will be more acceptable when it is not regressive, and when it is shared by others.

This is one of the reasons for the opposition to carbon taxes: they fail to distribute explicitly the rents created, and also make polluters pay for the whole of emissions, not only for the cost of

[3] It may be argued, even based on official documents, that the EU ETS has determined allowance allocation so as not to result in higher-than-acceptable carbon prices.

[4] Although these policies are also justified by other policy objectives: energy security or industrial development

abatement[5]. Instead, a cap-and-trade system, by separating the efficiency and equity concerns, gives more room for adjusting the second (Stern, 2009). For example, Goulder (2000) found that a cap-and-trade system with only a small degree of grandfathering can create enough rent to eliminate the opposition from the hardest-hit sectors, while being only slightly more costly.

Therefore, more equitable policies either directly or through redistribution of the revenue, will probably be more acceptable. Also, since public research and development costs are usually distributed more broadly than carbon prices, which fall on a more specific set of actors, their political acceptability will also probably be higher.

2.6. Government failures

Finally, we should not forget that the correction of market failures should be balanced against the possibility of government failures. Pigou (1932) already noted that regulation will be inevitably imperfect when proposing the use of environmental taxes: 'governments may not have the necessary expertise, may be subject to pressures, and prone to corruption'.

Government failures may arise for a number of reasons. With a different wording than Pigou's, we may argue that the most common are the disalignment of incentives, and the lack of complete information by the regulator on the regulated activities.

Regarding the former, Anthoff and Hahn (2010) argue that, in energy and environmental policy, evidence shows that governments are not driven by efficiency or even distributional concerns. Instead, they tend to prefer instruments which are easier to understand, which hide the costs of the policy while emphasizing the benefits, and which offer a greater degree of control over the distributional impacts. As a result, governments tend to prefer standards rather than economic instruments, which are moreover imposed only on new sources. When choosing between taxes and quotas, they also choose quotas. These choices are backed by industry, which demands regulation to restrict entry, to support prices, to provide subsidies, or to capture scarcity rents (Keohane et al, 1998).

[5] This can be fixed through a careful design of the tax , for example partial exemptions, but complex tax structures are not well received either.

Another type of government failure is the impossibility of governments to commit in the long-term. This will make carbon prices, or carbon quotas, scantly credible by investors. This is presented by Stern (2009) as an argument to promote technology policies directly.

As for the lack of information, when the capacity of regulators to observe output measures is limited, voluntary approaches such as management-based regulation may be more effective (Bennear, 2007). Two-part instruments –generalizations of deposit-refund systems, as proposed by Fullerton and Wolverton, (2000) –, or combinations of taxes on various inputs and outputs may also increase welfare in these situations.

3. Multiple instruments and coordination

The previous analysis has assumed the choice of a single instrument to address the single environmental problem of reducing carbon emissions (as advised by Tinbergen). However, it is true that, under this cover, other market failures may exist. Of course, multiple market failures do not necessarily require multiple instruments: sometimes one instrument can be designed to address multiple problems (Bennear and Stavins, 2007). For example, a carbon tax could be used to raise revenue, reduce emissions, induce innovation, etc. However, the same authors argue that in a second-best setting the use of multiple policy instruments may be optimal.

In a previously mentioned paper, Fischer and Newell (2008) found that the combination of carbon prices and technology policies will be cheaper for reducing emissions that each single instrument. Following the same line, Acemoglu et al (2009) also showed that the optimal climate policy should combine a carbon tax with research subsidies or profit taxes to direct research towards carbon-free technologies. However, in this case, the authors argue that a carbon tax alone would lead to excessive distortions in the economy, so the optimal policy should rely more on direct encouragement to the development of clean technologies, to counteract the market size effect of innovation.

Again, these results were obtained under an efficiency-maximization paradigm. If we add to this the already mentioned existence of other market failures and barriers, of bounded rationality, or of government failures, we may need more instruments to address these issues.

Therefore, a major conclusion is that coordination is critical, because of the frequent unintended and negative consequences of instrument interaction (e.g. Metcalf, 2009a)

4. Conclusions

Climate policy is an appropriate environment in which to paraphrase Herbert Simon (1955): in the presence of incomplete information, limited resources, multiplicity of goals, etc, the decision maker is not able to optimize anything, and it may be advisable instead to try to attain non-optimal but reasonable solutions.

In this paper we have described the many reasons that justify this second-best approach to climate policy: pre-existing distortionary taxes, knowledge spillovers, information asymmetry, network externalities, bounded rationality, political acceptability, equity concerns, government failures….Indeed, it seems that a traditional first-best setting (and therefore the optimal instrument under it) is absolutely unrealistic. That is, a carbon price will not reach the level required to compensate the externality, and even in that case, it may not be sufficient or appropriate due to other distortions. Therefore, a carbon tax alone may not be the best instrument to deal with climate policy. It seems rather that, as we already said at the beginning, complex problems really require complex solutions. Climate policy requires a combination of instruments to address the multiple market failures and other second-best situations that arise in the real world.

We will still need carbon prices, as a necessary companion to other policies. For example, a carbon price is required along with technology policies, in order to provide the right incentives for these policies to work. How to generate these prices? Here carbon taxes may be more attractive theoretically. However, auctioned cap-and-trade systems, while retaining the rent-capturing feature of taxes, also allow for redistributing more explicitly and more easily than taxes a part of the cost, and may therefore be more politically acceptable. Their acceptability would even be higher if they are combined as hybrid instruments, such as safety valves, to hedge against unexpected high costs.

These more efficient instruments should probably be coupled in some sectors – those closer to the final customer – with technology standards to account for bounded rationality and also to improve acceptability; with technology policies (both market-pull and market-push, depending on their situation in the learning curve) to counteract knowledge spillovers; with education and training policies to reduce bounded rationality and to decrease perceived costs, and with voluntary approaches when performance is not easily observable.

As mentioned before, given the different objectives addressed by these complementary measures, they may be required only temporarily, and might eventually be phased out, once the transition to a carbon-free technology has been achieved.

The ideal approach should therefore combine political pragmatism, economic efficiency, distributional concerns, environmental effectiveness, and behavioral aspects. And of course, the multiplicity of instruments will require a strong coordination, to look for synergies and avoid unexpected effects.

Along this line, and based on our conclusions, it would be highly recommended to check how could revenues from taxes or allowance auctioning be used to finance research and development policies or other policies, instead of using them to reduce labor taxes. Given that the evidence for the double dividend of green tax reform is sometimes not that strong, recycling revenues through these complementary instruments might prove to be efficient also. This is a specific area where research is much needed, particularly on the political economy of coupling automatically these instruments.

To conclude, the challenge now is to determine, using sound economic analysis, which is the right combination of these multiple instruments, accounting for these interactions. Some research is already being produced on this issue, and the ideas presented here only reinforce this need.

In this sense, we would like to insist in that a second-best setting does not preclude the use of rigorous economic analysis, but rather reinforces it. Using the existence of multiple market or government failures as an argument for whatever may fit political or social demands is not acceptable. For example, requesting drastic changes in the way we generate our energy by assuming an infinite benefit from doing this does not make much sense. Therefore, we still need economic analysis to determine the goals for these second-best instruments. Of course the complexity of the problem will make it less tractable, and less precise. But rigor is, and should still be required.

References

Acemoglu D, Aghion P, Bursztyn L, Hemous D(2009) The environment and directed technical change. NBER Working Paper 15451

Anger N, Böhringer C, Löschel A (2010) Paying the piper and calling the tune? A meta-regression analysis of the double-dividend hypothesis. Ecological Economics 69:1495-1502

Anthoff D, Hahn R (2010) Government failure and market failure: on the inefficiency of environmental and energy policy. Oxford Review of Economic Policy 26:197-224

Babiker M, Metcalf G, Reilly J (2003) Tax distortions and global climate policy. J Environ Econ Manage 46:269-287

Baumol W, Bradford D (1970) Optimal departures from marginal cost pricing. Am Eco Rev 60:265–283

Bennear L (2007) Are management-based regulations effective? Evidence from state pollution prevention programs. Journal of Policy Analysis and Management 26:327–348

Bennear L, Stavins RN (2007) Second-best theory and the use of multiple policy instruments. Environmental and Resource Economics 37:111-129

Bosetti V, Victor DG (2010) Politics and economics of second-best regulation of greenhouse gases: the importance of regulatory credibility. FEEM Nota di Lavoro, 2010-029

Bovenberg AL, de Mooij R (1994) Environmental levies and distortionary taxation. Am Econ Rev, 94:1085-1089

Brannlund R, Persson L (2010) Tax or no tax? preferences for climate policy attributes. CERE Working Paper 2010:4

De Cian E, Tavoni M (2010) The role of international carbon offsets. FEEM Nota di Lavoro 2010-033

Dietz S, Atkinson G (2010) The equity-efficiency trade-off in environmental policy: evidence from stated preferences. Land Economics 86:423-443

Fischer C (2008) Emissions pricing, spillovers, and public investment in environmentally friendly technologies. Energy Economics, 30:487-502

Fischer C, Newell R (2008) Environmental and technology policies for climate mitigation. J Environ Econ Manage 55:142–162

Fullerton D, Metcalf G (2001) Environmental controls, scarcity rents, and pre-existing distortions. Journal of Public Economics 80:249–267

Fullerton D, Wolverton A (2000) Two generalizations of a deposit refund system. Am Econ Rev 90:238-242

Goulder L, Parry I, Williams III R, Burtraw D (1999) The cost-effectiveness of alternative instruments for environmental protection in a second-best setting. Journal of Public Economics 72:329-360

Goulder L (2000) Confronting the adverse industry impacts of CO2 abatement policies: what does it cost?, Climate issues brief 23, Resources for the Future, Washington DC

Goulder LH, Parry I (2008) Instrument Choice in Environmental Policy. Review of Environmental Economics and Policy, 2:152-174

Goulder LH, Parry I, Burtraw D (1997) Revenue-raising versus other approaches to environmental protection: the critical significance of preexisting tax distortions. The RAND Journal of Economics, 28:708-731

Hanemann M (2010) The impact of climate change: An economic perpective. In Cerdá E, Labandeira X (eds) Climate Change Policies. Global Challenges and Future Prospects. Edward Elgar, Aldershot, UK and Brookfield, US.

Jaffe A, Stavins R (1995) Dynamic incentives of environmental regulations: the effects of alternative policy instruments on technology diffusion. J Environ Econ Manage, 29:43–63

Keohane N, Revesz R, Stavins R (1998) Choice of Regulatory Instruments in Environmental Policy. Harv Environ Law Rev 22:313-367

Lee D, Misiolek W (1986) Substituting pollution taxation for general taxation: some implications for efficiency in pollution taxation. J Environ Econ Manage 13:338-347

Linares P, Santos FJ, Ventosa M (2008) Coordination of carbon reduction and renewable energy support policies. Climate Policy 8:377-394

Linares P, Labandeira X (2010) Energy efficiency: economics and policy. Journal of Economic Surveys 24:573-592

Lipsey R, Lancaster K (1956) The general theory of second best. The Review of Economic Studies 24:11-32

Liski M, Murto P (2010) Uncertainty and energy saving investments. MIT-CEEPR Working Paper 2010-005

Metcalf GE (1994) Economics and rational conservation policy. Energy Policy 22:819-825

Metcalf GE (2009a) Tax policies for low-carbon technologies. NBER Working Paper, 15054

Metcalf G (2009b) Cost containment in climate change policy and incentives for technology development. NBER Working Paper, 15125

Newell RG, Pizer WA (2008) Indexed regulation. J Environ Econ Manage 56:221–233

Parry I,Williams R (1999) A second-best evaluation of eight policy instruments to reduce carbon emissions. Resource and Energy Economics 21:347–373

Pigou AC (1932), The economics of welfare. MacMillan, London

Quirion P (2004) Prices versus quantities in a second-best setting. Environmental and Resource Economics 29:337-360

Roberts MJ, Spence M (1976) Effluent charges and licenses under uncertainty. Journal of Public Economics 5:193-208

Rodrik D (1996) Coordination failures and government policy: a model with applications to East Asia and Eastern Europe. Journal of International Economics 40:1-22

Simon HA (1955) A behavioral model of rational choice. Quarterly Journal of Economics 69:99-118

Sovacool BK (2009) The importance of comprehensiveness in renewable electricity and energy-efficiency policy. Energy Policy 37:1529-1541

Stern N (2009) Imperfections in the economics of public policy, imperfections in markets, and climate change. FEEM Nota di Lavoro, 2009-106

Ulph A (1996) Environmental policy instruments and imperfectly competitive international trade. Environmental and Resource Economics 7:333-355

Weber T, Neuhoff K (2010) Carbon markets and technological innovation. J Environ Econ Manage 60:115-132

Webster M, Wing S, Jakobovits L (2010) Second-best instruments for near-term climate policy: intensity targets vs. the safety valve. J Environ Econ Manage 59:250-259

Weitzman ML (1974) Prices vs. quantities. Review of Economic Studies 41 :477-491