How to price carbon in good times… and bad

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Policy brief
December 2014

Grantham Research Institute on
**Climate Change and
the Environment**

Global
Green Growth
Institute

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Acknowledgements

Executive summary

As the world economy slowly recovers from one of the longest and most severe global slowdowns in history, there has been growing interest in how fluctuations in economic activity interact with climate change policy. Of particular interest is how carbon pricing instruments, such as emissions trading systems and carbon taxes, are designed and operate. This policy brief analyses the relevant empirical evidence and theoretical research on how carbon pricing instruments function in recessions and booms.

Two clear policy recommendations emerge. First, whatever instrument is chosen to price carbon, it is preferable to apply it to as large a group of emitters as feasible. Second, the instrument should allow the stringency of regulation to respond to economic fluctuations through a transparent and predictable rule.

Making the stringency of regulation responsive to economic fluctuations can decrease the overall burden of regulation. In the context of emissions trading, this means that the cap is relaxed during economic expansions and tightened during recessions. In the case of a carbon tax, the tax is increased during booms and reduced during recessions.

Such responsiveness should work because it is the stock of greenhouse gases in the atmosphere, rather than the flow of annual emissions, that matters. As a result, over the long term, policy-makers can trade off slightly higher annual emissions during economic booms against slightly lower emissions during recessions. Doing so makes the instrument responsive to the business cycle without compromising the long term target of reducing emissions.

An effective responsiveness mechanism should take into account country-specific factors, be rules-based rather than discretionary, transparent and hard to manipulate. Preferably, it should be built in at the outset rather than retrofitted later.

The policy brief reviews how important variables, such as the level of emissions, the price of carbon and government revenues are influenced by fluctuations under different carbon pricing instruments. A key finding is that the same instrument will have different implications for these variables in advanced- and developing countries.

Fluctuations in developing countries are typically more volatile, more persistent and less predictable. Therefore the gains from having carbon pricing instruments that are responsive to economic fluctuations are likely to be greater in developing countries.

1. Introduction

As the world economy gradually recovers from one of the longest and most severe slowdowns in history, there has been growing interest in how fluctuations in economic activity interact with climate change policies.[1] Of particular interest are the operation and design of two carbon pricing instruments: carbon taxes and emissions trading, or 'cap-and-trade' systems.

Both emissions trading and a carbon tax seek to reduce emissions of greenhouse gases. An emissions trading scheme sets a cap on emissions, which usually tightens over time to achieve a long-term reduction target, but does not fix the carbon price. A carbon tax fixes the carbon price, which usually rises over time, but does not predetermine by how much emissions will fall. The way both instruments work, however, can be influenced by fluctuations in economic activity, which in part determines the level of annual emissions.

For example, many observers of the world's largest 'cap-and-trade' scheme, the European Union Emissions Trading System (EU ETS), have suggested that the collapse and continuing low level of the carbon price since 2008 is chiefly due to a combination of the recession cutting demand for emissions permits and the system being unable to respond to the changes in economic circumstances. Together these factors have undermined the long-term effectiveness and credibility of the carbon price signal the system is designed to generate.

This brief reviews the empirical and theoretical analyses of the relationship between carbon pricing instruments and fluctuations in economic activity, and recommends ways to make climate change policies work better.

Better climate chance policies are likely to particularly help developing countries as there is substantial evidence that their fluctuations in both economic activity and annual emissions are much greater and less predictable than in advanced countries.

Discussion of the operational basics of carbon taxes and emissions trading is omitted for brevity. However, a non-technical refresher can be found in Metcalf (2009); for the more technical reader, Weitzman (1974) provides an excellent treatment.

To simplify the discussion, the brief assumes that the long run target for the climate change policy, for example limiting global average surface temperature increases to no more than 2°C above its pre-industrial levels, and the national emissions trajectories consistent with the long run target, have been agreed upon and are being implemented. This is crucial for the analysis, which is mainly concerned with how best to implement the target when business cycle fluctuations are explicitly taken into account.[2] In particular, the brief is not about whether we know the right level of the target, or if and how we have reached agreement over the national burden-sharing associated with achieving it.

There is a large literature on the relative merits of a carbon tax versus emissions trading system to achieve a climate change policy target which is reviewed in a policy brief on 'The case for carbon pricing' (Bowen, 2011). In addition to the references therein, Hoel and Karp (2001 & 2002), Karp and Zhang (2005), Newell and Pizer (2003) and Pezzey and Jotzo (2012) study the

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1   Throughout, the terms recessions and booms, business cycles and economic fluctuations are used interchangeably.
2   In practice it is difficult to distinguish temporary but persistent business cycle deviations, from permanent/structural deviations. The latter require adjustments to the long term target.

factors that affect this choice. Goulder and Schein (2013) provide a recent and non-technical overview of the key arguments.

The next section summarises the results of empirical studies relating to fluctuations in economic activity and emissions. Section 3 discusses the theory of carbon pricing when fluctuations are explicitly taken into account. Section 4 states the policy recommendations and highlights issues important for their design and implementation. Section 5 traces the implications of the recommendations for the level of emissions, price of carbon and government revenues under constant and responsive policies. Using three examples of emissions trading systems from the European Union, Korea and California, section 6 shows how practical carbon pricing policy has met the challenges raised by economic fluctuations. Section 7 concludes.

2. Observed fluctuations in economic activity and emissions

Economic activity typically increases over long time horizons. For example, global real gross domestic product (GDP), a key measure of economic activity, increased almost six-fold between 1960 and 2012. Put differently, had the growth rate of GDP been the same year after year, a constant rate of 3.4 per cent per annum (p.a.) would be required to deliver the six-fold increase during this period. However, due to economic fluctuations, the annual growth rate of global GDP was far from uniform across years.

In fact, the growth rate of global GDP fluctuated within a wide range, between a contraction of 2.1 per cent p.a. and growth of 6.6 per cent p.a. Focusing on individual countries, the fluctuations in GDP growth rate were even higher. For example, during the Asian financial crisis in the late 1990s, high growth rates before 1998 of close to 10 per cent p.a. quickly turned negative for several countries in the region, and Indonesia and Thailand's economies contracted by more than 10 per cent p.a.

Economic fluctuations can be analysed at various levels of aggregation (for example, sector, region and country) and frequency (for example, monthly, quarterly and annually), and using a number of indicators (for example GDP, employment and unemployment). NBER (2014) provides a non-technical discussion of these issues in the US context. Against this background, the best way to study the interplay between carbon pricing instruments and economic fluctuations is to use annual real GDP data at the country level to identify the slowdowns and booms, which are defined as years in which real GDP is respectively below and above what would be considered normal for the country. How one determines the normal in a given year is a technical and, for the purposes of this brief, a relatively innocuous question (Canova, 1998; Burnside, 1998).

While economic fluctuations affect all countries, they do not experience them in the same way. It would be surprising if the fluctuations in China and the UK were similar in light of the differences in these countries' stage of development, economic structure, institutions, trading partners and so forth. The relationship between greenhouse gas emissions and economic fluctuations is also likely to differ because China and the UK have vastly different energy systems and endowments. Consequently, the same instrument for pricing carbon might trigger different outcomes in China and the UK.

The policy brief focuses on four important characteristics for describing the nature of economic fluctuations and their relationship to fluctuations in annual emissions:[3] size of economic fluctuations, persistence of economic fluctuations, correlation of economic- with emissions fluctuations, and the size of emissions fluctuations themselves.

When a country enters a recession, its GDP declines relative to normal times and vice-versa during periods of boom. The average **size of economic fluctuations** helps explain how large these departures are from the norm. A convenient statistical measure of this concept is the standard deviation of the fluctuations in GDP. A number of studies, for example Neumeyer and Perri (2005), find that advanced countries experience smaller GDP fluctuations.

Holding the size of economic fluctuations constant, how long does it take for the country to return to normal times? The answer is captured by the **persistence of economic fluctuations**.[4] Available evidence on the topic, for example Aguiar and Gopinath (2007), suggests that deviations from the norm for developing countries are more persistent.

How emissions change as the economy experiences booms and recessions is shown by the **correlation of emissions and GDP fluctuations**. One would expect emissions to be lower than normal in recessions and higher in booms. Available evidence, for example Doda (2014), suggests emissions are pro-cyclical, or positively correlated with GDP over the business cycle. There is also evidence that the strength of the association is greater in advanced countries, so when the economy is in a boom, it is more likely that the emissions will be higher than normal compared with developing countries.

The final characteristic is the **size of emissions fluctuations**, especially relative to the size of GDP fluctuations. It is possible to measure the size of the emissions fluctuations by their standard deviation as well. Here, the evidence suggests that the size of fluctuations declines as countries become more advanced. In addition, Doda (2014) finds that the size of these changes relative to the size of the economic fluctuations also decline as countries become more advanced. For example, in an average advanced country, GDP and emissions fluctuate within 2 per cent and 4 per cent of their normal values, respectively, while in an average developing country the analogous figures are more like 3 per cent and 10 per cent.

To summarize, business cycles are pervasive across countries and tend to be larger and more persistent in developing economies than in advanced countries. Emissions typically move in the same direction as GDP but the strength of the association between fluctuations in GDP and emissions is weaker in developing countries. Finally, emissions are more variable in developing countries relative to their advanced counterparts. These observations suggest that climate change policy could be improved by taking such fluctuations explicitly into account.

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3   The term 'emissions fluctuations' is used to denote the year to year variability in annual emissions of a country relative to what would be considered normal in that country.

4   The more persistent the business cycle shocks, the more difficult it becomes to specify the 'right' long term emissions target for climate policy. As stated above, the paper abstracts from this important issue.

3. Carbon pricing theory with fluctuations in economic activity and emissions

Putting a price on carbon is an effective way to address the externality created by greenhouse gases that impose a cost on others through the impacts of climate change. However, it is not obvious whether carbon pricing instruments can work better by taking economic fluctuations explicitly into account. For example, during a recession the price of permits in an emissions trading system will fall due to reduced demand, and in a boom the scarcity of permits will drive their price up. The extent of these price fluctuations is determined by the rules of the emissions trading system. A well-designed system can prevent prices from falling too low during a recession and so maintain the abatement incentive, or from overshooting in a boom and excessively constraining production by regulated firms precisely when they are at their most productive.

Economic theory provides insights into how carbon pricing instruments can be designed to even out the costs of abatement over the business cycle. Heutel (2012) finds that optimal policy allows carbon emissions to be pro-cyclical: increasing during expansions and decreasing during recessions. To achieve these optimal changes in emissions, he suggests that carbon pricing instruments must be responsive, that is, adjusted period by period to account for fluctuations. Specifically, the cap in the emissions trading system in his framework is tightened in recessions and relaxed during booms. Alternatively, if a carbon tax is used, then it is higher in booms and lower in recessions.[5] In both cases, the variability in emissions, relative to the case when there is no policy intervention, is reduced. The implied reduction in the size of emissions fluctuations and how much to adjust the cap or the tax depends on the characteristics discussed in the previous section.

Allowing firms to raise production, and with it emissions, above normal takes advantage of the temporarily higher productivity of boom periods, but must be compensated for with lower than normal emissions when productivity is low during recessions in order to meet long-term targets. This trade-off is possible over an extended period of business cycles, when there are both booms and recessions, because climate change damages are related to the stock of accumulated emissions in the atmosphere, rather than how much is emitted each year. Like Heutel (2012), Lintunen and Vilmi (2013) find that the optimal carbon tax, or emissions trading system cap, is pro-cyclical in a similar model. Chang et al (2009) also reach a similar conclusion, albeit in the case of a flow pollutant.

The design of responsive carbon pricing instruments faces several challenges. First, it requires timely and accurate knowledge of the state of the economy. This can simply be assumed in theoretical models. In practice, the required information is costly, or may even be impossible, to acquire.

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5   When viewed in the context of an optimally looser cap in an emissions trading system during booms, it may be counter-intuitive that during booms the tax needs to be raised making the instrument more stringent. This happens because keeping the tax constant results in emissions rising by *too much* in booms.

Second, the theory assumes there is effectively one policy-maker, one citizen and one firm. But this hugely oversimplifies the problem. The real world is fragmented; there are a multitude of countries at different stages of development, each with their economic shocks and policy preferences. The shocks affecting individual countries, or regulated sectors within countries, may deviate from global shocks. They are typically much more volatile and imperfectly correlated with each other. Moreover, the theory ignores political economy considerations that stem from the fragmentation. The citizen and the policy-maker in the idealised world are oblivious to the differences between a carbon tax and an emissions trading system. There is no lobbying to recycle the tax revenues collected or to receive free emissions permits because a sector is energy-intensive or trade-exposed.

Third, there are likely to be transaction costs or policy implementation lags. For example, in the European Union, policy-makers and politicians took more than a year to negotiate a temporary reduction in the number of permits, so called 'backloading', in its flagship Emissions Trading System.

Finally, the theory abstracts from important features of the world. For instance, there are no market failures other than the greenhouse gas externality, no factors of production other than capital and no pre-existing distortions in the economy. Consequently, the implications of theory for the design of carbon pricing instruments may need to be modified in light of the potentially significant interactions with other policy areas where governments in the real world are active, such as distortionary income taxation/redistribution, public good provision, correction of other externalities, etc.

4. Recommendations for carbon pricing policy instruments

In light of these theoretical and practical observations, this policy brief recommends that whatever instrument is chosen to price carbon, it should be applied to as large a group of emitters as feasible. Furthermore, it is recommended that the stringency of regulation should respond to fluctuations in economic activity through transparent and predictable rules.

Recent research using general equilibrium models suggests that if a ton of carbon abated during a boom has approximately the same effect as that abated during a recession, a responsive policy is likely to improve welfare relative to no policy or constant policy (Chang et al, 2009; Fischer and Springborn, 2011; Heutel, 2012; Lintunen and Vilmi, 2013). The cap in the emissions trading system, or the carbon tax, should be higher during economic expansions relative to normal times and lower in recessions. Existing emissions trading systems and carbon taxes often do not respond in this way to prevailing economic conditions.

Even though this recommended responsiveness is based on theoretical models which are global and general equilibrium in nature, it remains relevant at the country level. The parameters of the mechanism implementing responsiveness must be conditioned on country-specific factors, such as the stage of development, characteristics of the fluctuations in economic activity and emissions, policy preferences, and institutional capacity, among others. Using partial equilibrium models, Jotzo and Pezzey (2007), Sue-Wing et al (2008), Newell and Pizer (2008) and Branger and Quirion (2014) all discuss whether and how the caps in emissions trading systems should be indexed to GDP, but reach different conclusions. In other words, as yet there is no consensus on what constitutes a 'good' responsiveness mechanism and

additional research on this topic is needed. However, a few properties of a 'good' mechanism can be identified.

In order to minimise the potential for manipulation through lobbying or market power, the stringency of regulation should be governed by a transparent and hard-to-manipulate rule. Conditioning stringency on an observable, market-based indicator of the business cycle, such as recent GDP or measures of the output gap, may be considered. Alternatively, an independent technocratic body with a clear rules-based mandate can be set up using lessons learned from the operation of the monetary policy committees of independent central banks in advanced countries (Monnet and Temzelides, 2014).

Building the responsiveness mechanism into the system from the start is preferable to adding it on at a later date. The latter can create uncertainty about the system's core design features, undermining its credibility and the predictability of outcomes. It also creates incentives for lobbying by making the system appear open to discretionary changes.

The carbon price is a crucial signal to co-ordinate decisions across different economic activities, countries and time periods. Ideally, for every economic decision-maker the carbon price that emerges from regulation should be the same. The importance of co-ordination can be illustrated with the cost-benefit analysis governments typically require for investment projects. In these analyses, both the costs and benefits associated with the carbon emissions of the projects are valued using a reference price. If the reference price is the one implied by the carbon pricing instrument used elsewhere in the economy, its level and the predictability become key factors in the evaluation of a project's merits. If the price is too low relative to the present value of damages or other countries' carbon prices, there will be underinvestment in socially beneficial projects. If the carbon price is highly variable or unrelated to macroeconomic conditions, its value as a co-ordinating mechanism will be diminished (Caballero and Pindyck, 1996).

As a consequence, it is important that the regulation applies to as large a group of emitters as possible, ideally to the world as a whole, because this reduces the inefficiencies arising from different carbon prices. It does so by pooling the volatile and imperfectly correlated economic shocks that affect different sectors and countries. This is particularly relevant for developing countries. The gains from including most, if not all, emitters are likely to be larger in developing countries where economic shocks are typically more volatile, more persistent and less predictable.

5. Implications for key policy variables

The level of emissions, the carbon price and the potential for raising revenue are key variables of interest for policy-makers. When market-based instruments are used to control greenhouse gas emissions, the burden of regulation is ultimately determined by the carbon price. Moreover, both carbon taxes and emissions trading systems raise revenue for governments, provided the pollution permits in the latter are auctioned to emitters. The total size and variability of the revenue stream associated with these instruments are relevant for the debate about green fiscal reform.

Naturally, each of these variables will behave differently under traditional policies, which do not vary with respect to the business cycle, and under the responsive policies recommended in this paper. Table 1 provides more details. In an emissions trading system with an unresponsive cap, the level of emissions is fixed in advance by design because aggregate emissions are determined by the cap.[6] The price of carbon, however, is determined by market forces. As demand for permits varies over the business cycle so will the carbon price in the market. The empirical observations described in section 2 suggest that the price is likely to increase in booms and decline in recessions. The price variation in turn determines the behaviour of revenues raised by auctioning permits. An emissions trading system with a fixed cap features emissions levels that are determined by the cap and do not depend on the business cycle, i.e. acyclical. The carbon price established in the system is volatile and pro-cyclical, and hence the revenues raised will also be volatile and pro-cyclical.

Table 1: Implications of alternative carbon pricing instruments for key policy variables			
	Level of emissions	Carbon price	Government revenue
ETS[†] with a fixed cap	fixed, acyclical	volatile, pro-cyclical	volatile, pro-cyclical
Fixed carbon tax	volatile, pro-cyclical	fixed, acyclical	volatile, pro-cyclical
ETS with a responsive cap	more volatile, pro-cyclical	less volatile, pro-cyclical	pro-cyclical
Responsive carbon tax	less volatile, pro-cyclical	more volatile, pro-cyclical	pro-cyclical

[†]Emissions trading system (ETS)

The outcomes for the level of emissions and the carbon price are reversed under a fixed carbon tax. Specifically, the carbon price, which is determined by policy, is fixed and acyclical in this case but the level of emissions will now be volatile and pro-cyclical as the economy experiences business cycles. Similar to an emissions trading system with a fixed cap, the revenues collected by the government will be volatile and pro-cyclical, but the variability of revenues in this case is caused by the fluctuations in emissions.

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6   To be precise, the level of total emissions is fixed over the time horizon during which the cap applies. Moreover, it is assumed that the cap is binding.

The responsive policies recommended in this paper would raise the caps in the emissions trading systems, or the carbon taxes, in a boom and reduce them in a recession. Put differently, they would introduce pro-cyclical variability to carbon pricing policy instruments. Provided the mechanism implementing responsiveness is well designed, the price of carbon with a responsive policy for an emissions trading system would likely become less volatile relative to its fixed cap counterpart but would remain pro-cyclical. Similarly, a responsive carbon tax policy would reduce the volatility of the emissions relative to a fixed tax.

The implications of alternative policies for the volatility of government revenues are less clear cut because they ultimately depend on how responsiveness is implemented. However, with responsive policies, government revenues would remain pro-cyclical as the product of two variables that are high in a boom will be high as well, and vice versa for recessions.

It is worth highlighting a number of more general points that relate to the results in Table 1. Perhaps the most obvious and almost tautological observation is that a fixed policy can control the level of emissions or the carbon price but not both, so the volatility of unregulated variables, i.e. the emissions under a fixed tax and the prices in an emissions trading system with a fixed cap, are higher than their counterparts under responsive policies.

Second, the evidence reviewed in section 2 suggests that the fluctuations in economic activity in developing countries tend to be more volatile, more persistent and less correlated with emissions than in advanced countries. These characteristics are likely to put a strain on the fixed policies, so adopting well-designed responsive policies may be more beneficial in developing countries.

Third, whether the economic fluctuations are caused by demand or by supply shocks can also be important. Shocks to aggregate demand need not affect real GDP in an economy with flexible prices and so may require no policy intervention. However, they can have a big effect if some prices fail to adjust as required, i.e. if they are 'sticky'. The effect can be particularly strong if monetary policy is not responsive to shocks and cannot compensate for price 'stickiness'. The impact of supply shocks also depends on how flexible relative prices are and the degree of substitutability in production and consumption. Supply shocks in the energy sector are likely to have different effects than shocks in other sectors, particularly if machines or workers can be substituted for energy (and vice versa) in the short run.

6. An illustration with three emissions trading systems

Existing carbon taxes are typically designed to not be responsive to business cycles. However, an instructive illustration of the policy recommendations is provided by examining three emissions trading systems in the European Union, in South Korea and in California. A broad overview of their relevant features is in Table 2.

Table 2: Coverage and responsiveness in three emissions trading systems			
	European Union	**Korea**	**California**
Start date	1 January 2005	1 January 2015	1 January 2013
Coverage	• Multinational • 31 countries • ~45% of members' total GHG emissions	• National • ~70% of Korea's total GHG emissions	• Subnational • ~35% of California's total GHG emissions (2013-2014) • ~85% of California's total GHG emissions (2015-onward) • ~7% of total US GHG emissions
Responsiveness	• Provision for additional permit sales when price too high according to a pre-specified rule • Recent addition of a provision for altering the schedule of permit auctions • Currently no provision for rule based permit removal but proposal to introduce "Market Stability Reserve" in 2021	• Rules exist for triggering price stabilization measures, for example sales from allowance reserve, limits on banking/ borrowing/ offsets, etc. • The parameters of the stabilization measures will be determined at the discretion of Ministry of Environment	• Sell permits from 'Allowance Price Containment Reserve' at a pre-specified price ceiling • Add permits to 'Allowance Price Containment Reserve' if there is excess supply at a pre-specified price floor

Source: Author's summary based on European Commission (2014b), Bloomberg (2013), Gtowacki Law Firm (2014), Climate Policy Initiative (2014).

The extent of coverage differs widely across the three systems. The European Union emissions trading system (EU ETS) is a multinational system that regulates emissions of highly polluting sectors in 31 countries. Together, the sectors covered account for about 45 per cent of the annual aggregate emissions of the participating countries. The Korean emissions trading system (K-ETS), which will start operating in 2015, is expected to cover about 70 per cent of the country's emissions, while the coverage of the Californian emissions trading system (C-ETS) in 2013-2014 has been approximately 35 per cent of state emissions, but will expand from 2015 to 85 per cent of state emissions with the inclusion of the distributors of transportation fuels, natural gas and other fuels. However, California's annual emissions account for only about 7 per cent of the United States.

As a consequence, decision-makers face a wide range of carbon prices, with resulting inefficiencies. More than 50 per cent of total European emissions originate from sectors not covered by the EU ETS and these sectors either face no carbon price or one that is determined independently by, and potentially differing greatly across, Member State governments. For example, in the UK, sectors outside the EU ETS are charged a higher effective carbon price and the Department of Energy and Climate Change uses a higher carbon price than that in the EU ETS for planning purposes (Advani et al., 2013).

Conversely, the coverage of C-ETS is very high but Californian emissions constitute a relatively small share of the aggregate emissions for the United States. In other words, almost all emitters will face the same carbon price in California but emitters in neighbouring states may face higher or lower prices. Korea appears to lie in the middle, suggesting there is a trade-off between the amount of emissions covered and the number of jurisdictions involved in negotiating the establishment of an emissions trading system.

The three emissions trading systems also differ in their approaches to responsiveness. The EU ETS currently has an asymmetric responsiveness provision in that the supply of permits might be increased if prices rise too much according to a pre-specified rule, but until recently it had no such provision for reducing the supply if the price falls too much. In fact, the falling price turned out to be the applicable case when the financial crisis and the subsequent recession caused the demand for permits to decline substantially. The regulator has reduced the volume of the permits to be auctioned in 2014-2016 with a view to returning those permits to the market in 2019-2020 so as not to compromise the long term target. This proposal, known as backloading, is primarily discretionary, arguably late, and may yet be ineffective (Taschini, 2013). More fundamental reform proposals relate to the creation of a 'Market Stability Reserve' which releases permits when there are too few in circulation, and withdraws them when there are too many (European Commission, 2014a). The proposals have been critiqued in Taschini et al. (2014).

The protracted negotiations surrounding the structural reform of the EU ETS, to be implemented from 2021, show just how difficult it can be to reform the core design features of an existing system. Clearly, it would be prohibitively costly, if it were even possible, to design a system that will work well under all contingencies. However, substantial evidence suggests that building responsiveness in at the outset avoids costly re-negotiation and improves the credibility of the system. In this respect, the designs of the Korean and Californian emissions trading systems provide some encouraging signs of having learnt from the experience of the EU.

K-ETS and C-ETS have explicit rules to trigger action to adjust the cap in their respective systems. The rules are stated in terms of permit prices or volumes traded in the market, variables which are highly correlated with economic fluctuations. However, the stabilisation measures differ between the two systems. At the time of writing the Korean Ministry of Environment retains substantial discretion in applying the rules, while in California the rules on 'Allowance Price Reserves' are spelled out and available to all stakeholders. C-ETS comes closest to implementing this paper's recommendation on responsiveness because it uses a well-specified, rule-based mechanism that was built into the system at the outset.

This comparison of the three emissions trading systems shows that policy-makers must consider the appropriate interaction between carbon prices and economic fluctuations. Table 2 and the policy recommendations in this brief can provide valuable guidance, not only in adapting the design of emissions trading systems but also for optimising the design of carbon taxes, where the issues relating to coverage and responsiveness are just as relevant.

7. Conclusions

In an increasingly carbon-constrained world the sluggish recovery from the 2008 economic slowdown has affected the operation of existing carbon pricing instruments, and raised questions about whether and how they should interact with economic fluctuations. This policy brief recommends ways to make carbon pricing instruments more effective in a world with business cycles.

The brief makes the case for building responsiveness into the design of carbon pricing instruments and shows that allowing stringency of regulation to respond to economic fluctuations can reduce the burden by distributing it more evenly over time. Relative to an emissions trading system in which the cap is fixed with respect to business cycles, this can be achieved by relaxing the cap during economic expansions and tightening it during recessions. Similarly, a carbon tax regime in which the tax is relatively higher during expansions, and relatively lower during recessions, is likely to improve welfare compared to a tax that does not respond to business cycles at all. Notably, the changes implied by such responsiveness are distinct from a pre-determined declining path of caps and increasing profile of carbon taxes, which are required for a climate change policy consistent with a given long run target.

As yet there is no consensus on how best to incorporate responsiveness into carbon pricing instruments. While the details of an effective mechanism will most likely depend on country-specific circumstances, such as the stage of development, the characteristics of the fluctuations in economic activity and emissions, and policy preferences, it should be rules-based rather than discretionary, transparent and hard to manipulate. It should also be built in at the outset rather than after the fact.

In summary, whatever instrument is chosen to price carbon, it is better to apply it to as large a group of emitters as feasible, and allow the stringency of regulation to respond to fluctuations in economic activity through a transparent and predictable rule.

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