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Taxing Carbon as an Instrument of Green Industrial Policy in Developing Countries

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Abstract

Two simultaneous and interdependent issues challenge today's development policy: poverty reduction and climate change. While economic growth is needed to tackle poverty reduction, governments need to set economic frameworks and incentive systems so that this growth remains within global environmental boundaries. When designed well, many of these measures can contribute to alleviating poverty and fostering competitiveness – that is, they can be used as green industrial policy measures.

This study focuses on carbon taxes as one possible green industrial policy instrument. It reviews existing evidence on competitiveness, employment and distributional effects with a view to informing the decisions of policymakers and bureaucrats in developing and emerging countries. To this aim, it pays particular attention to tax design options aimed at mediating negative and generating positive effects.

Carbon taxes have several advantages for developing and emerging countries. First and foremost, they provide a good tax base and raise revenues which in turn can be used to support social and economic aims. Their technical implementation is relatively easy and they send stable price signals, especially when compared to cap and trade schemes. Lastly, when formal and informal companies alike have to pay, carbon taxes reduce incentives for firms to remain in the informal sector.

Despite these advantages, only few developing and emerging countries have introduced or are considering introducing carbon taxes. One of the main reservations is the risk of negative impacts on economic and social aims. Ex post studies of competitiveness impacts in industrialised countries suggest that carbon or energy taxes have had neutral or even positive effects on competitiveness and gross domestic product (GDP). The studies also show that impacts depend crucially on the use of revenues.

To have similarly positive effects in developing countries, however, carbon taxes may have to be designed differently. After all, these countries have different administrative capacities, economic structures and abilities to adapt to carbon pricing. In particular, distributive and poverty effects need consideration as they impact on the optimal use of tax revenues. Tax revenues could, for example, be used for direct transfers or the cross-subsidisation of electricity lifeline tariffs to protect people living in poverty from the negative impacts of carbon pricing. Furthermore, empirical studies suggest that revenue recycling to subsidise basic goods, such as food, can have positive effects on poverty.

Keywords: Carbon taxes, carbon pricing, green industrial policy, developing countries, climate change

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Contents

Abbreviations

CDM	Clean Development Mechanism
CO_2	Carbon dioxide
EUR	Euro
GBP	British pound
GDP	Gross domestic product
OECD	Organisation for Economic Co-operation and Development
UNFCCC	United Nations Framework Convention on Climate Change
USD	US dollar

1 Background: the dual challenge of poverty and climate change

Two simultaneous and interdependent issues challenge today's development policy. First, many countries are still struggling to lift parts of their population out of poverty. According to World Bank estimates, in 2012 about 900 million people still lived in extreme poverty, that is, on less than US dollar (USD) 1.90 per day (World Bank, 2015a); over 2.1 billion people lived on less than USD 3.10 per day. The eradication of poverty requires economic growth in most of these countries – few, if any, can achieve this through mere redistributional measures. Growth, if inclusive, can indeed be very effective in reducing poverty. Over the past 20 years, per capita incomes in developing countries have increased by 80 per cent, and more than 660 million people have been able to escape from poverty (World Bank, 2012).

Second, science has provided increasing evidence that, if we are to avoid the most dangerous effects of climate change, we must reduce greenhouse gas emissions urgently and on an unprecedented scale. So far, we have failed to act according to this knowledge. Instead, global carbon dioxide emissions have been rising at an annual average of 2.7 per cent during the past decade, although at lower rates in 2012 and 2013 (Olivier, Janssens-Maenhout, Muntean, & Peters, 2012, 2014). While uncertainty is a feature of climate change scenarios, it is becoming increasingly clear that the window of opportunity for keeping global warming below 2°C is about to close. The commitment to staying well below the limit of 2°C has only recently been reinforced by the Paris Agreement, adopted in December 2015 by the 21st Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC). The final document (see UNFCCC, 2015) even makes a reference to limiting climate change to 1.5°C, which would require even more rapid and bold mitigation action.

To meet the dual challenge of creating acceptable living conditions for billions of poor people and preserving these conditions for future generations, we must de-link economic activity and resource depletion. This calls for drastic changes to the very fabric of our economies.

One of the most urgent requirements is the reflection of the true costs of our economic actions in market prices. The current rules of market economies allow economic agents to externalise many environmental costs. As a consequence, individuals and firms do not factor such costs into their economic decisions, but pass them on to society as a whole. Governments need to take measures to internalise environmental costs, that is, to ensure they are included in market prices.

Such measures can even bring about economic advantages, for example by maintaining or building natural capital, enhancing efficiency and spurring innovation (World Bank, 2012). However, they can also have negative effects on the economy, say, if firms are not given sufficient time to adapt to new cost structures. The question of how to design policy measures in developing country contexts – so that they reap the benefits and manage the trade-offs between environmental sustainability and development – is in many cases still unanswered. The impacts of policies on competitiveness, structural change, and social factors, such as employment and income distribution, are of particular relevance.

Carbon taxes[1] are among the most straightforward policy instruments used to internalise environmental costs. They not only send a clear price signal but also raise revenue. This provides the opportunity of reaping a ‘double dividend’ (Pearce, 1991) of environmental protection and of using the tax revenues for social and/or economic benefits.

Despite these advantages, many countries do not price external effects from carbon dioxide emissions and thereby forego tax revenues which could support social and developmental aims, for instance. The political barriers which stand against environmental tax reform are often based on competitiveness arguments. Enterprises fear for their position in international markets and lobby their governments for low input prices, often stating job losses as a key argument against carbon taxation. These concerns need to be taken seriously, in particular when countries’ economies are heavily based on activities vulnerable to carbon pricing, such as energy-intensive industries which need to compete globally.

This study thus aims to review existing evidence on the competitiveness, employment and distributional effects of carbon taxation. It does so with a view to informing the decisions of policymakers and bureaucrats in developing and emerging countries. To this aim, it will pay particular attention to tax design options to mediate negative and generate positive economic, social and environmental effects. Since empirical studies on carbon taxation in developing and emerging countries are still scarce, industrialised country cases will complement the body of empirical literature analysed. The study complements a report on “Environmental Taxes to Mitigate Climate Change” commissioned by the GIZ in 2015 and authored by Lilibeth Acosta which aims to shed light on the political economy of carbon tax implementation (Acosta, 2015).

The remainder of this study is organised as follows: Section 2 introduces the rationale and aims of carbon taxation, and gives an overview of international practice. Section 3 zooms in on carbon taxation in emerging and developing countries. Section 4 proceeds to assess existing evidence on the impacts of carbon taxes on competitiveness and structural change, distinguishing between effects on firms, sectors, and national economies. It furthermore discusses measures to mitigate negative and support positive effects on competitiveness. Section 5 turns towards social impacts, which are of high relevance to countries with persistently high poverty rates. It distinguishes between effects on employment and effects on income distribution. Section 6 offers conclusions.

2 Rationale, aims, and the international practice of carbon taxation

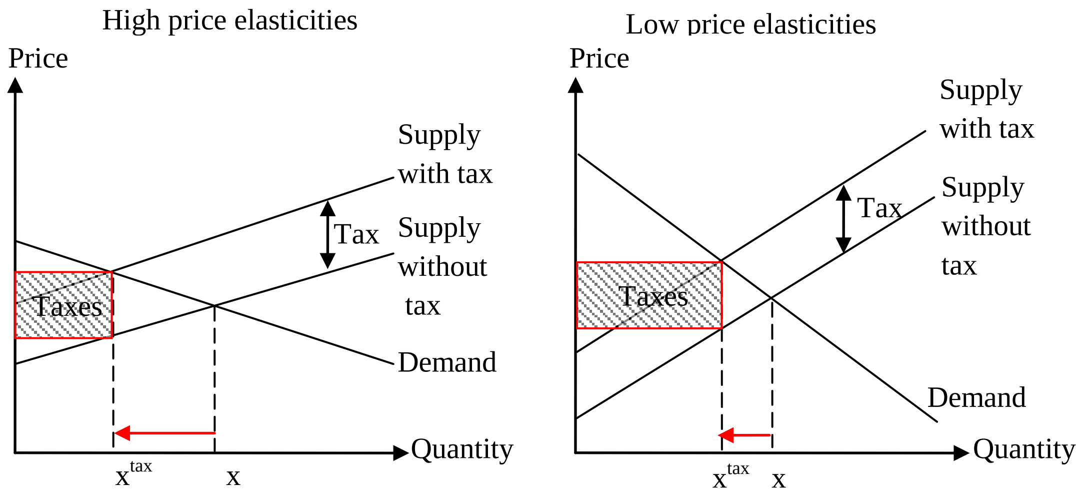
In his seminal work “The Economics of Welfare”, Alfred Pigou described in economic terms how the interests of individuals can differ from those of society as a whole (Pigou, 1920). When economic actors cause costs to society, for example through pollution, and these costs are not reflected in their individual cost calculations, the decision to pollute will be rational from the individual actor’s point of view, but the sum of individual actions will be suboptimal and inefficient for society. Economists later termed these effects ‘externalities’: costs or benefits which occur to society from the activities of individuals, and which are not reflected in market prices. Taxes are an instrument to internalise these

1 ‘Carbon taxes’ refers to the taxation of carbon dioxide emissions. These can be taxed explicitly, that is, as a price per unit of emitted CO_2, or implicitly, that is, as a price per unit of products whose use emits carbon. For a more detailed explanation, see Section 2.

costs, that is, induce firms and other actors to consider in their individual calculations the social costs caused by their activities.

Carbon taxes aim to internalise the social costs of climate change induced by carbon dioxide emissions. In that sense, they are ‘Pigouvian’ taxes, intending to correct what Lord Nicholas Stern calls the “greatest and widest-ranging market failure ever seen” (Stern, 2006, p. i). By changing relative prices, they create incentives to restrict the production and use of harmful goods and encourage sustainable substitutes. The reaction of producers and consumers to changing prices depends on price elasticities of supply and demand, that is, the change in the amount of the polluting good supplied and demanded per unit of change in price. High price elasticities mean that it is easy for producers or consumers to either forego or substitute the taxed good. The higher the price elasticities, the stronger the impact of taxes on the quantity of the traded good, and thus on emissions (compare the difference between x and x^{tax} in Figure 1). The relation of the price elasticities of supply and demand furthermore determines the incidence of carbon taxes on producers and consumers. The party with the higher price elasticity, that is, with more possibilities to substitute or forego the good, bears less of the taxes’ economic burden than the party with the lower elasticity.

Figure 1: Impact of a given level of carbon taxes on traded quantities and tax revenues under differing supply and demand elasticities



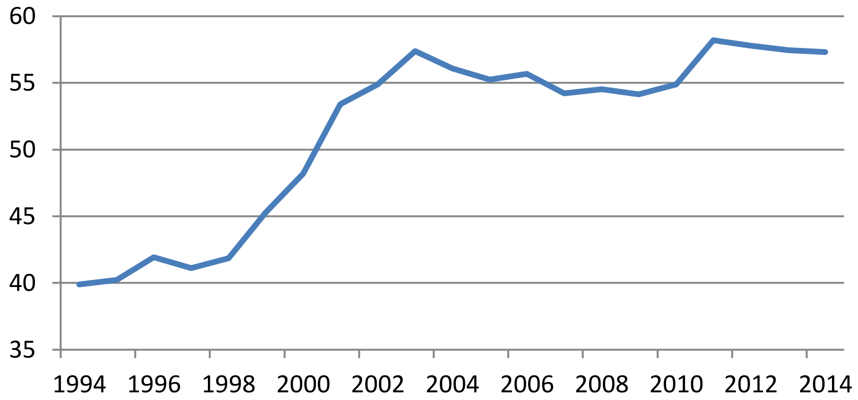
Source: Author

It may prove difficult for policymakers to estimate the exact price elasticity of supply and demand for a given good, which poses a challenge to determining the ‘right’ level of taxes for a given amount of emission reductions. Estimating the required level of a carbon tax would also require knowing the actual social costs of climate change, and therewith the necessary level of emissions abatement. While cost estimates are becoming increasingly accurate, there are still large uncertainties. However, to induce long-term change, it may not be vital to send the exactly ‘right’ price signal but, more important, to establish a cautious price signal that goes in the right direction (Hsu, 2011), and then adapt it according to experience with supply and demand reactions. Policymakers can also aim at increasing supply and demand elasticities by actively supporting low carbon solutions and thereby increasing the options of suppliers and consumers to substitute carbon-intensive goods. They can, for example, subsidise renewable energy technologies or low carbon transport options.

In contrast to regulation, which prescribes or restricts the use of certain technologies, carbon prices set incentives to implement the cheapest climate change mitigation options first, before moving to more costly options (Fay et al., 2015). In the case of firms, this can be a switch to more energy-efficient technology, a change in production mode, or a change in the product portfolio. Consumers can choose to consume different goods (for instance, travelling by train rather than flying), or use carbon-intensive goods more efficiently (say, car sharing). The search for the cheapest mitigation options induced by a clear price signal is a necessary condition for an efficient transition to sustainability. If the carbon tax sends a stable and significantly high price signal, it acts as an incentive for innovation.

In addition to the aim of reducing carbon emissions, carbon taxes also have the aim (and benefit) of raising revenues. The revenues from environmental taxes can be considerable: see Figure 2 for Germany. In 2014, German environmental taxes amounted to 8.9 per cent of total tax revenue (Statistisches Bundesamt, 2015a).

Figure 2: Revenues from environmentally related taxes in Germany, 1994-2014, in billion euros (EUR)



Note: Includes taxes on motor vehicles, aviation (from 2011), electricity, mineral oils/energy, nuclear fuel (from 2011), and revenues from emission allowances (from 2010).

Sources: OECD (2015a); Statistisches Bundesamt (2015b)

Regarding elasticities of supply and demand, the aim of raising revenues stands in opposition to lowering emissions: the lower the price elasticities – and thus the more difficult it is for consumers and producers to 'evade' the tax by using low carbon substitutes – the higher the tax revenues at a given level of carbon taxes (compare the size of the hatched rectangles in Figure 1). Low price elasticity of demand is one reason for the prevalence of energy taxes, which are often introduced for budgetary rather than environmental reasons.

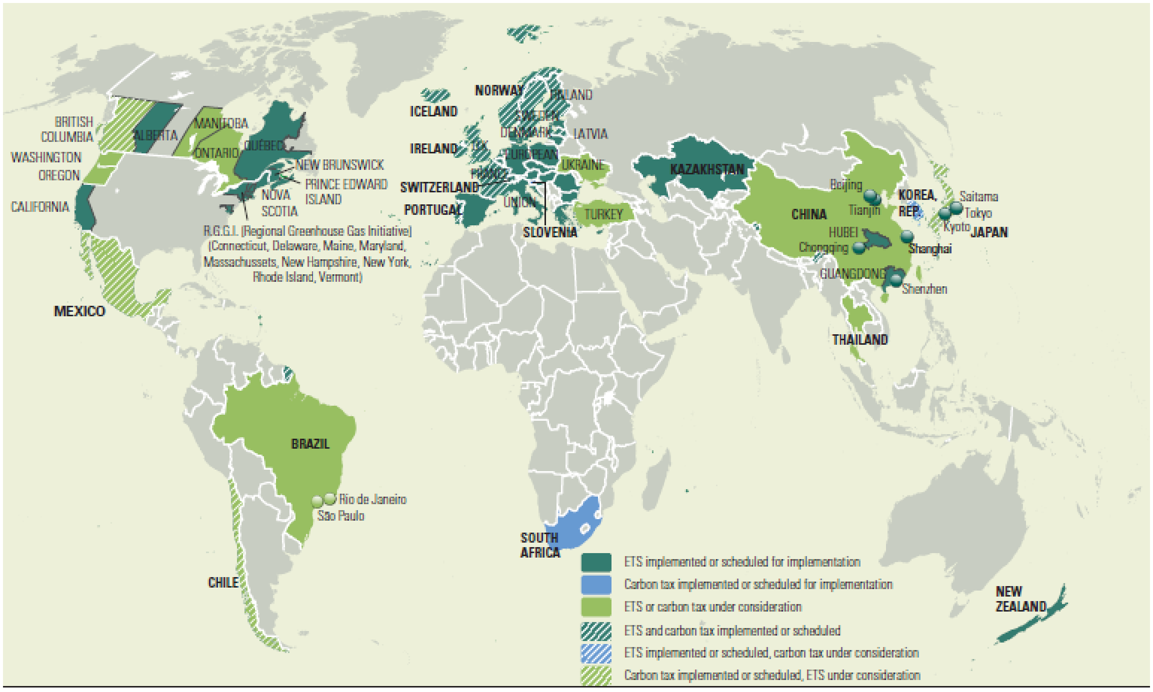
Apart from increasing the price of emitting activities, policymakers can implement measures to directly regulate (that is, cap) the quantity of emissions. This capping is usually complemented by a trading system for emissions allowances. This trading system guarantees that emission reductions take place where they are cheapest – not only in terms of mitigation activities, but also in terms of actors. When actor A can reduce emissions at a lower cost than actor B, it will make sense for B to buy an allowance from A rather than reduce his own emissions. This can be an argument for emissions trading instead of taxation. When governments auction emissions allowances, they generate revenues, making trading schemes very similar to taxes. However, while taxes send a stable price signal with fluctuating emissions quantities, trading schemes guarantee certain levels of emission reductions, but their price signal may be too unstable to induce structural change and innovation. In any case, enterprises tend to lobby for ‘grandfathering’ (that is, free allocation) of emission allowances. Revenues then accrue to enterprises rather than to government, limiting the options of policymakers to cushion unintended impacts on competitiveness or distribution. Avoiding potential negative effects on people living in poverty, or even creating positive effects by the raised revenue, is a central issue facing policymakers in developing countries.

Carbon emissions can be taxed explicitly, that is, as a price per unit of emitted CO_2 (carbon dioxide), or implicitly, that is, as a price per unit of products whose use emits carbon. The most prominent product taxes in the case of carbon emissions are energy taxes. Energy taxes are widespread, but often introduced for reasons other than emissions abatement, such as raising revenue. Mineral oil and its products are often taxed higher than coal or gas. This can have several reasons. First, the price elasticity of demand for gasoline tends to be low, making it a reliable source of tax revenue (Lachapelle, 2011). Second, road transport contributes to externalities other than carbon emissions, such as noise, congestion and local air pollution. Third, a number of countries earmark at least part of transport fuel taxes for road infrastructure investments.

Explicit carbon pricing, too, is gaining ground globally. Many industrialised and some developing and emerging countries have implemented or scheduled emissions trading systems and/or carbon taxes, and others consider their implementation (see Figure 3).

However, the emissions covered by all these pricing schemes only cover a fraction of total global emissions (Fay et al., 2015). Tax rates or prices established by cap and trade schemes are often very low, but can still be considered an important first step upon which governments can build to successively increase future carbon prices.

Figure 3: Countries/states with carbon pricing schemes



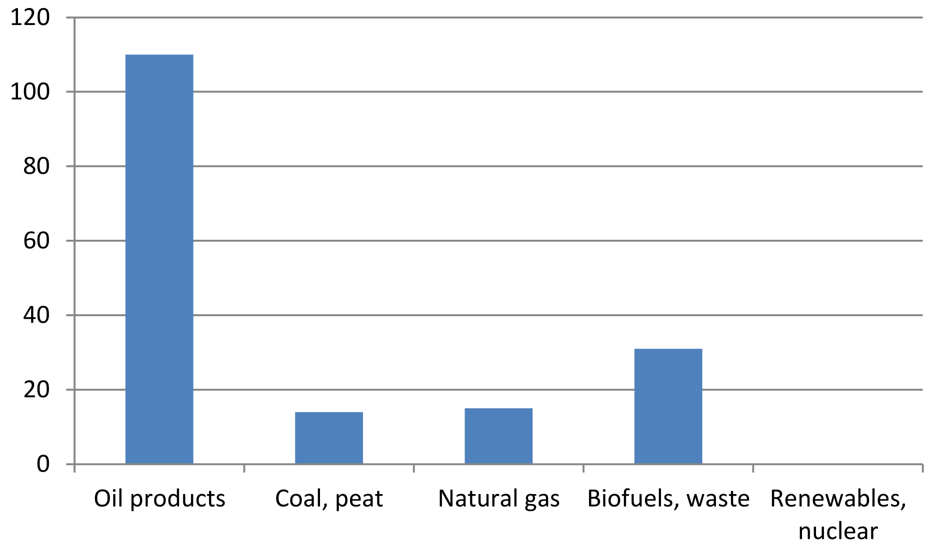
Source: Fay et al. (2015)

As shown in Figure 3, some 40 national and more than 20 subnational jurisdictions have implemented or scheduled explicit carbon taxes or cap and trade systems. Among those jurisdictions, there are several emerging countries: Mexico introduced a carbon tax in 2014, Chile enacted a carbon tax in 2014 which is to take effect in 2018, and South Africa has scheduled a carbon tax for implementation in 2017.

While explicit carbon taxation sends a clear and uniform price signal, implicit taxation – such as through energy taxes – does not put a uniform price on carbon across the economy. This can lead to distortions and inefficiencies in correcting the environmental externality of carbon emissions. As shown for member countries of the Organisation for Economic Co-operation and Development (OECD) (OECD, 2013), implicit carbon tax rates vary greatly between energy sources (see Figure 4 for implicit carbon taxation in a 'typical' OECD country). Even worse, as Lachapelle (2011) argues, the differences in carbon taxation can incentivise a shift towards the use of carbon-intensive fuels, such as coal. He therefore calls for an adjustment of existing energy taxes.

This picture is similar in many developing and emerging countries. According to the OECD (2015b), China only taxes oil products, mainly in the transport sector. Taxes on gasoline for road transport translate into an equivalent of about EUR 60[2] per tonne of CO_2, while coal as the main emission source remains untaxed. Indian taxes on gasoline for road transport translate into roughly EUR 56 and taxes on coal into about EUR 0.5 per tonne of CO_2. South Africa's gasoline tax translates into about EUR 90 per tonne of CO_2, while taxes on coal are equivalent to about EUR 2.5 per tonne of CO_2.

Figure 4: OECD simple average effective CO_2 tax rates from energy use by fuel type, EUR/tonne CO_2



Source: OECD (2013)

2 All exchange rates are of 14 October 2016, 1 Chinese Yuan (CNY) = EUR 0.1349; 1 Indian Rupee (INR) = EUR 0.0136; 1 South African Rand (ZAR) = EUR 0.0639.

3 Taxing carbon in emerging and developing countries

3.1 Advantages and disadvantages of carbon taxes versus cap and trade for emerging and developing countries

Carbon taxes, and energy taxes in particular, have several advantages for developing and emerging countries:

- They are technically relatively easy to implement,
- they provide a good tax base and raise revenues,
- they can reduce incentives for firms to remain in the informal sector, and
- they set stable price signals (Fay et al., 2015).

While governments need the capacity to monitor and collect revenue and to enforce tax payment to ensure effectiveness, the establishment, administration and monitoring of taxes is still easier than that of cap and trade schemes. This is due to several reasons: Most governments will already have a tax system in place which they can use for environmental purposes. In contrast, a trading scheme often needs to be set up from scratch, including institutions to monitor emissions, register allowances, and keep track of allowance trade. The regular discussion and revision of taxes in budget cycles enhances transparency and eases policy-learning, and the revenues are in the responsibility of the ministry which will also be responsible for revenue recycling, that is, the treasury. Taxes, other than cap and trade schemes, do not need a minimum number of market participants to work. When the number of market participants is too low, the risk of collusion in cap and trade schemes is high, which may inhibit the functioning of emissions trading.

What is a risk to the success of cap and trade systems is an advantage for carbon taxes. The typical concentration of players, or emission sources in the case of carbon taxes, eases carbon tax implementation. Emissions measurement at few point sources often suffices to capture most of total emissions. This concentration on a few large players significantly reduces monitoring, administration and other transaction costs. When point sources are many, the infrastructure to measure emissions is often already in place: when a carbon tax is raised on energy, for example, the infrastructure to measure energy use already exists, for instance in the form of electricity meters and fuel storage tanks. Energy taxes are, therefore, difficult to evade. Easy measurement lowers the administrative requirements and benefits the revenue potential of carbon taxes, not only when compared with cap and trade schemes, but also with, say, income taxes. In countries with a historically weak tax base but high carbon emissions, this can be an important argument. Furthermore, resources which taxpayers formerly spent on tax evasion (and governments on its detection) can then be spent on productive activities, thereby spurring growth. In a study conducted in 2013, Liu (2013) estimates that reduced tax evasion can lower the welfare cost of carbon pricing by as much as 97 per cent in countries such as China and India, where tax evasion is prevalent. Industrialised country experience shows that carbon taxes can indeed make substantive contributions to national budgets without hampering growth: explicit carbon taxes contribute 3 per cent of British Columbia’s budget and 1 to 2 per cent of Sweden’s budget without having negative effects on growth (Harrison, 2013).

Energy taxes as one form of implicit carbon taxes apply to the formal and informal sectors alike, since actors in both sectors consume energy. This distinguishes them from income or profit taxes, which only apply to the formal sector. Replacing taxes on formal economic activities with energy taxes therefore reduces the incentive to remain in the informal sector.

Lastly, carbon taxes send a stable price signal, whereas the carbon price established by cap and trade systems tends to fluctuate. Between 2008 and 2014, the price per tonne of CO_2 established by the European Emissions Trading Scheme fell from EUR 30 to about EUR 5. This price volatility poses a fundamental barrier to changes in investment behaviour.

Politically however, cap and trade systems may be easier to implement than carbon taxes. Firms may lobby against taxes and for trading schemes – if they expect to succeed in their lobbying for the free allocation of certificates. Unlike taxes, which impose additional costs on firms, freely allocated certificates bring additional gains, since they can be either used or sold in the market. It is hardly surprising that the explicit carbon tax recommended by the European Commission in the 1990s met with strong opposition from industry. The proposal was withdrawn in 2001 (Spash, 2010), to be followed by the introduction of the emissions trading scheme.

As the following sections show, some emerging countries are already making use or planning the implementation of carbon taxes. Others, such as China, opt instead for emissions trading schemes. China recently introduced subnational cap and trade schemes which are to be linked on a national basis and will then form one of the largest emissions trading schemes globally.

3.2 Developing and emerging country cases

3.2.1 Mexico

Mexico introduced a carbon tax on fossil fuel sales and imports in 2014. Its level is relatively low at an average rate of about USD 3.5 per tonne of CO_2 (ranging from USD 1 to 4 per tonne of CO_2 depending on the fuel type). While the level was initially to be set at USD 5 per tonne of CO_2, it was lowered in the course of the law's passing through Mexican Congress: the tax is calculated according to the difference in carbon emissions of the taxed energy source as compared to natural gas (World Bank, 2014). This in effect exempts natural gas from the tax. The maximum tax rate is capped at 3 per cent of the fuel sales price. It covers approximately 40 per cent of Mexican emissions (World Bank, 2014).

Companies can choose to meet their tax liability by using credits generated through the Clean Development Mechanism (CDM)[3] in Mexican projects. The estimated revenue of the tax is USD 1 billion per year (Secretaría de Medio Ambiente y Recursos Naturales [SEMARNAT], 2014).

One of the stated aims of the tax is to create awareness of CO_2 emissions, in addition to putting a price on carbon and promoting the use of cleaner fuels. The impact of the tax on

3 The CDM is a mechanism under the UNFCCC Kyoto Protocol which allows emission-reduction projects in developing countries to earn certified emission reduction credits. Industrialised countries can use these to meet a part of their emission reduction targets.

national competitiveness can be expected to be minimal, given the low level of the tax. Furthermore, the Mexican economy is not very energy-intensive: its gross domestic product (GDP) per oil equivalent in 2012 was USD 10.5, compared to only USD 4.6 in South Africa (World Bank, 2015c). 16 per cent of the female and 29 per cent of the male workforce were employed in industry in 2011.

3.2.2 Chile

Chile enacted its carbon tax in October 2014. It is a first of its kind in South America, but it will not take effect until 2018. Its initial rate is set at USD 5 per tonne of CO_2, and it applies to about 42 per cent of Chilean emissions (World Bank, 2015b). This initial rate is below the current rate of the European Emissions Trading Scheme, which is criticised as being too low. However, it is above the Mexican initial rate of USD 3.5 per tonne of CO_2. The tax targets large industry and the electricity sector (generators larger than 50 megawatts (MW)). Concentrating on few large emitters, it is relatively easy to monitor and enforce. It can be seen as an important first step to phase in carbon pricing, give enterprises time to adapt, build carbon pricing institutions and create the foundation to successively increase the price of carbon emissions. The policy enactment was embedded in a larger tax reform, which may have been central to its success (Galbraith, 2014). It was part of a fiscal reform package which included a substantive increase of corporate taxes, so that the carbon tax as such raised less debate than it might have if introduced in isolation. One stated aim of the tax reform package was to raise revenue for investment in the educational system (World Bank, 2015b), which may have won it additional support. Eventually, the carbon tax is expected to generate USD 160 million per year (Fay et al., 2015).

The impacts of the tax at current levels on the national economy and its competitiveness can be expected to be low. For a tax level of USD 20 per tonne of CO_2, Benavides et al. (2015) calculate a GDP growth reduction by 0.15 percentage points. The impact of a USD 5 tax can be expected to be even lower.

3.2.3 South Africa

South Africa has been discussing the introduction of a carbon tax for several years. A cap and trade scheme is not in the focus of discussion because of its administrative complexity and the low number of potential market participants. The 2012 National Budget included the outline of a carbon tax from which highly trade-exposed and energy-intensive industries were initially to be exempted, and only included later (Alton et al., 2014). Implementation has been delayed several times. In the latest draft carbon tax bill, the introduction is scheduled for January 2017 at a rate of ZAR 120 (USD 9.45) per tonne of carbon dioxide equivalent (Republic of South Africa, 2015). However, industry opposition is strong, so the realisation of the scheduled introduction date in 2017 is uncertain.

Since the carbon tax has not been implemented yet, there are no ex post studies on competitiveness effects available. However, several authors have modelled the effects of different hypothetical levels of carbon taxation.

Devarajan, Go, Robinson, and Thierfelder (2009) assume a carbon tax of USD 12.72 per metric tonne and calculate a reduction in the output of energy-intensive sectors of up to 15 per cent. Other industries, such as wood and agriculture, would gain. In total, the welfare costs of a carbon tax would be very low, and a tax which directly targets carbon would be more efficient than other taxes aiming to reduce emissions, such as energy taxes. As the authors show, their results depend on labour market rigidities, such as unemployment and labour market segmentation, and the possibilities to substitute technologies.

South African unemployment rates are high, with 22.3 per cent of the male and 28 per cent of the female South African labour force unemployed in 2013 (World Bank, 2015c). Safeguarding employment is thus one of the major policy aims of the South African government. However, while South African industry is energy-intensive and would thus be affected by a carbon tax, it is not very labour intensive. The majority of South Africans in employment work in the services sector (male: 62 per cent, female: 83 per cent), while only 32 per cent of the male and 13 per cent of the female working population are employed in industry (World Bank, 2015c). Winkler and Marquard (2009) argue that a fiscally neutral mix of instruments, that is, a mix that does not raise net revenues, can positively affect employment in South Africa, particularly if investment in new capital is taken into account. They nonetheless argue for the exemption of highly energy-intensive industries and suggest copying the Swedish model, where these industries can apply for a tax exemption but need to implement independently monitored disclosure and energy efficiency programmes.

On the other hand, Alton et al. (2014) calculate a reduction in national welfare (measured in GDP) and employment by 1.2 and 0.6 per cent, respectively, in 2025 compared to a business-as-usual scenario when introducing a domestic carbon tax of USD 30 per tonne of CO_2. In conformity with that, Merven, Moyo, Stone, Dane, and Winkler (2014) calculate a net negative effect on economic output for carbon tax levels of between USD 10 and 50 per tonne of CO_2. The lowest tax rate results in a GDP drop in 2040 of 0.7 per cent as compared to the baseline scenario, while the highest tax rate results in a drop of 6.1 per cent.

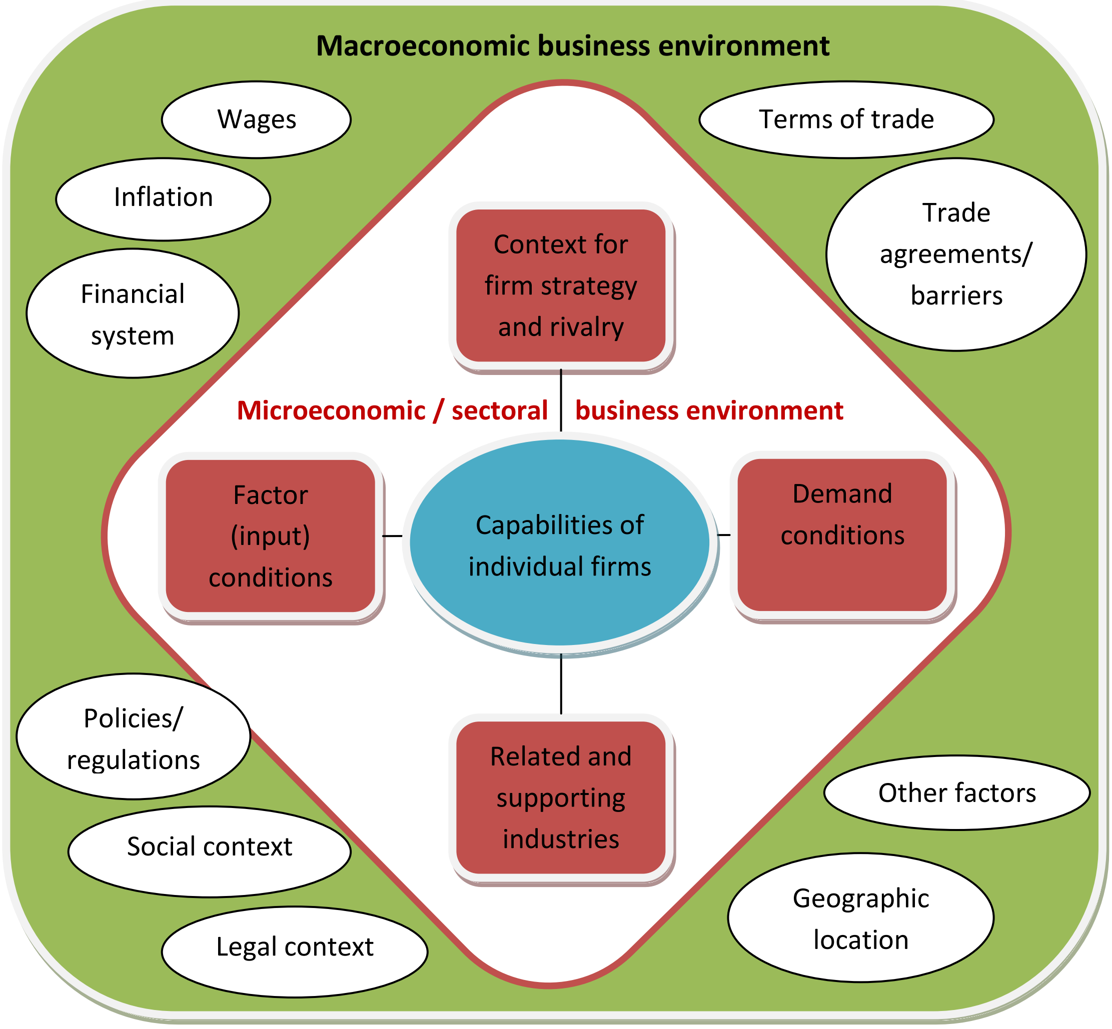
The studies show that the overall effects on competitiveness and welfare depend crucially on the level of the carbon tax and the use of the generated revenues. When revenues from carbon taxation are, for example, invested in food price reduction, a ‘triple dividend’ (positive environmental impacts, GDP and employment effects, and poverty reduction) could be created for South Africa (van Heerden et al., 2005).

The above country examples illustrate that governments are very mindful of economic and social effects when introducing carbon taxes. The subsequent sections therefore seek to assess impact channels and empirical evidence for the positive or negative effects of carbon pricing on competitiveness, structural change, employment, and income distribution.

4 Impacts of carbon taxation on competitiveness as a main industrial policy aim

Impacts of carbon taxes on competitiveness can occur at the level of individual firms, entire sectors, or the national economy (UK Green Fiscal Commission, 2009). At the level of the firm, competitiveness refers to the ability of firms to sell the produced goods or services and stay in business (OECD, 2010), compared to national or international competitors. These abilities, aggregated over firms in a sector, define sectoral competitiveness. At the national level, competitiveness refers to the aggregated ability of firms in a country to produce goods and services for international markets, while maintaining and, in the long term, expanding the real incomes of nationals (OECD, 1992). This ability depends on the individual capabilities of firms, but also on their micro- and macroeconomic contexts, that is, the conditions they find in their respective sectors and the national economy (see Figure 5).

Figure 5: Determinants of competitiveness



Source: Based on OECD (2010); Porter, Ketels, & Delgado (2007)

Figure 5 shows that, while competitiveness is a widely used concept, the influencing factors form a complex and interactive system. It is therefore not an easy task to identify the effects of carbon taxation on competitiveness, and any empirical attempt needs to distinguish between the firm, the sectoral and the national level (UK Green Fiscal Commission 2009, p. 68).

The capabilities of individual firms are a factor which can be influenced by the firm itself. They can vary largely within sectors, leading to different effects of carbon taxation on individual firms (see Subsection 4.1).The microeconomic business environment (‘Porter diamond’) refers to

a) the efficiency, quality and specialisation of factor inputs available to firms. Factor inputs include natural, human and capital resources, and physical, administrative, information and technological infrastructure;
b) the context for firm strategy and rivalry, which may encourage or discourage investment and productivity. This includes institutional aspects, such as incentives for capital investments, but also the intensity of local competition;
c) demand conditions, referring to expectations and needs of local customers who ideally anticipate larger demand elsewhere in the country or abroad; and
d) the presence of and access to capable related and supporting industries, ideally forming local clusters.

Effects of carbon taxes on the microeconomic business environment and sectoral competitiveness are discussed in Subsection 4.2.

The macroeconomic business environment includes factors which can be influenced by national and international policy, such as trade agreements, the legal context or, to some degree, the financial system and inflation. However, it also comprises other factors which are more difficult or even impossible to influence, such as the social context or geographic location. The effects of carbon taxes on the macroeconomic business environment and national competitiveness are discussed in Subsection 4.3.

4.1 Competitiveness of firms

The effect of carbon taxes on the competitiveness of firms can be measured by several determinants of their economic success, such as profits, turnover, investment, value added, output or the survival of plants at their current location (Arlinghaus, 2015). Firms can lose competitiveness through a carbon tax, if

a) their cost structure is strongly related to carbon emissions,
b) adaptation to lower carbon production modes is costly or impossible,
c) they cannot pass the additional cost on to preceding or subsequent stages of the value chain, and, crucially,
d) competitors (national or international) find themselves in a better position.

Firms are thus less affected or can even gain competitiveness when their modes of production are already relatively low in carbon intensity, when low cost alternatives to carbon-intensive processes or inputs are available (or when they become available through innovation), when they are able to pass through cost increases to input suppliers or customers, or when their competitors are subject to similar regulation.

In addition to the direct effects of carbon taxation on firms' cost structure, there can be indirect effects when firms adopt lower carbon production modes. They can be positive when the new modes are more efficient, allow for product differentiation, provide access to new markets, improve stakeholder relations, or open up new business opportunities (Ambec & Lanoie, 2008; OECD, 2010). However, they can also be negative, when switching to the new modes requires investment in new machinery, lowers the quality of the goods produced, or reduces productivity. The latter can happen when the switch to lower carbon production processes causes disruptions, or when new machinery is not as productive. This said, the pressure to adapt can also spur the innovativeness and efficiency of a firm, leading to a competitive edge vis-à-vis its competitors in the longer term.

Developing countries have not yet implemented carbon taxes at levels which can be expected to strongly affect the competitiveness of their industries (see Section 3). There are thus no ex post studies available on the competitiveness effects of carbon taxation in developing country contexts. Experience from industrialised countries suggests that governments are very careful to avoid negative effects and make ample use of the measures to protect competitiveness as described in Subsection 4.4. However, ex post studies suggest that these measures would in many cases not be necessary.

Flues and Lutz (2015), for example, find that Germany's electricity tax, which translates into a carbon tax of about EUR 44 per tonne of CO_2, has no effect on the competitiveness of industries. In their study, they compare firms which are just above with those which are just below the threshold of tax reduction eligibility, but are otherwise comparable. The firms just below the threshold did not perform worse between 1999 and 2004 in terms of national and international turnover, exports, value added and investment. Flues and Lutz conclude that the tax reduction could be gradually removed.

Martin, de Preux, & Wagner (2014) come to a similar conclusion by studying the effects of the UK's Climate Change Levy[4]. They compare firms which were subject to the full Levy with firms which participated in Climate Change Agreements and were thus eligible for an 80 per cent discount on the Levy. Since the targets of the Climate Change Agreements were not difficult to achieve, they can be taken to represent business as usual. The authors find significant environmental effects: plants which were subject to the full Levy reduced their carbon emissions by 8.4 to 22.4 per cent compared to plants which were eligible for reductions. The authors do not, however, find any statistically significant effects of the Levy on gross outputs and total factor productivity. This suggests that the environmental effects could be much stronger, without strong impacts on competitiveness, if the reductions to the Levy were gradually phased out.

4.2 Competitiveness of sectors

Firms in the same sector are often characterised by similar input needs, production modes and customers. However, firms may differ in their adaptive capacities and will as a result gain or lose competitiveness compared to firms in the same sector. Carbon taxes influence

4 Effective tax rates of the Levy vary by fuel, from GBP (British pound) 31 per tonne of CO2 for electricity, GBP 30 for natural gas, GBP 22 for petroleum, to GBP 16 for coal (Arlinghaus, 2015).

the microeconomic business environment of firms in a sector by raising the cost of carbon-intensive inputs, such as energy from fossil fuel sources (see Figure 5).

When production modes in a sector are such that they either directly lead to carbon emissions, or rely on inputs which cause high levels of carbon emissions, the sectoral impact of carbon taxation will be negative. Demand conditions may also be influenced by carbon taxes since the introduction of these taxes is usually accompanied by societal discourse. When this discourse raises environmental awareness, firms can be faced with higher demand for low carbon products from their customers. Those firms which can cater for this demand gain a competitive advantage within their sector, even to the point that new sectors arise driven by that demand.

Purely national shifts in competitiveness between sectors will not have large negative effects on the overall level of national production but will simply induce structural change. This is, in principle, a desired outcome of carbon taxation. However, governments tend to concentrate on those actors who may lose from a change in policy (OECD, 2007). One reason for this may be that losers lobby harder than potential winners (Baldwin & Robert-Nicoud, 2007; Pegels, 2014). As a result, many carbon tax schemes entail exemptions for large polluters, which reduce their potential as a driver of structural change, their environmental effectiveness and their revenue raising potential. They may be at least temporarily necessary to avoid abrupt structural change and give industries time to adapt. An alternative to exemptions is the stepwise introduction of carbon taxation to give firms sufficient time to change their modes of production.

Empirical studies show that the impacts of carbon and energy taxes on sectors can vary largely. Commins, Lyons, Schiffbauer, and Tol (2009), for example, assess the effects of energy taxes and the European Emissions Trading Scheme on European sectors based on 1996 to 2007 data (see Table 1). They find that on average, an increase of energy taxes by 10 per cent would increase the growth rate of total factor productivity across sectors by about 2.5 per cent, returns to capital by about 2.5 per cent and investment by about 0.1 per cent. However, these results show large variation by sector and indicator: a 10 per cent increase in energy taxes costs the recycling, tobacco and leather sectors about 6 to 13 per cent of their total factor productivity growth, while office machinery, metal mining and electrical machinery gain about 6 to 8 per cent. Water transport, refinery and wood products are the largest losers of return on capital (about 6 to 9 per cent), while air transport, gas extraction and tobacco gain about 12 to 17 per cent in return on capital. Lastly, a 10 per cent increase of energy taxes induces a more than 20 per cent increase of investment in the air transport sector, and a more than 35 per cent decrease in the tobacco sector.

The authors do not find the specific energy or technology intensity of sectors to offer any explanations of these variations; grouping sectors according to these parameters did not reveal any systematic effects of energy taxes. This means that industries which are similar in energy and technology intensity can still experience very different impacts from energy tax increases. The authors instead explain the variations with differences in innovation rates, and the substitution of labour for capital.

Table 1: Variation of energy tax increase impact between sectors, based on 1996-2007 data			
10% energy tax increase	**Total factor productivity (TFP) growth (%)**	**Return on capital (%)**	**Investment (%)**
Weighted average	2.5	2.5	0.1
Recycling, tobacco, leather	-6.0 to -13.0		
Tobacco			-35.0
Office machinery, metal mining, electrical machinery	6.0 to 8.0		
Water transport, refinery, wood products		-6.0 to -9.0	
Air transport, gas extraction, tobacco		12.0 to 17.0	
Air transport			20.0
Source: Author, based on Commins et al. (2009, pp. 8-12)			

4.3 National competitiveness

Similar to winners and losers among firms within sectors, there are winners and losers among sectors, whose aggregate performance on international markets is a determinant of national competitiveness. The country's general openness to trade, the exposure of its sectors' products to trade, the homogeneity of exported products and thus international price competition, and carbon pricing in competitor countries determine the scale of impacts.

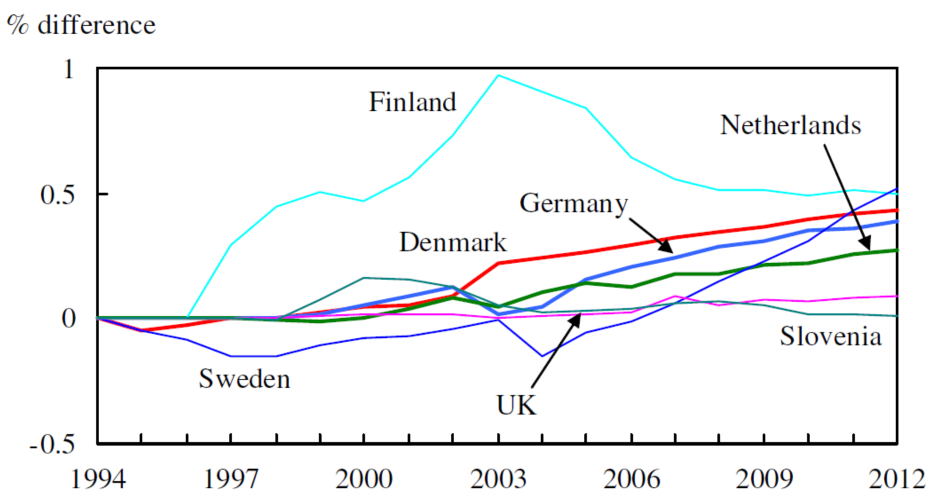
When firms choose to relocate their activities to other countries rather than to lower carbon emissions or pay taxes, and establish similarly polluting activities in countries without carbon pricing, there is a negative impact on the national economy and no positive effect on the environment in general. Rutherford (1992) termed this issue carbon 'leakage'. Sectors which are exposed to negative impacts on competitiveness as described above, and which can relocate their productive activities relatively easily, are particularly sensitive to carbon leakage (Meunier & Ponssard, 2014). There seems to be little empirical evidence, however, that environmental taxes cause sectors to relocate internationally (UK Green Fiscal Commission, 2009).

For lack of data availability, most empirical studies to date concentrate on the short-term effects of carbon pricing (Arlinghaus, 2015). In the long run, the national economy benefits when the carbon price signal induces innovation or improvements in efficiency which do not take place in other countries (UK Green Fiscal Commission, 2009). Michael Porter (1990) established the hypothesis that strict environmental regulation improves competitiveness since it forces firms to upgrade technology and innovate. In this regard, carbon taxation has an advantage over the determination of technology standards by governments since it maintains the incentive to upgrade and innovate. Countries with 'first mover' advantages in new green technologies can gain substantive shares in fast-growing markets, such as renewable energy technologies. Pegels (forthcoming) will show, for example, that Germany has been able to build on its first mover advantage in wind converters and is now competing with Denmark for world market leadership.

However, this argument in favour of carbon taxation may not be highly relevant for developing countries. The knowledge intensity of new green technologies may give industrialised countries with well-educated workforces and a capacity for innovation a first mover advantage. Countries that do not satisfy those requirements may not be able to reap similar advantages. They may, however, be able to reap second mover advantages: when Germany created a lead market for solar photovoltaics, Chinese firms soon started to mass-manufacture solar panels and export them to the German market, thereby exerting pressure on German manufacturers (Pegels & Lütkenhorst, 2014). Denmark was more successful in the field of wind energy, where it is still world market leader.

In terms of impact on gross domestic product, there is increasing evidence that environmental tax reforms can have positive effects (Withana et al., 2013), in particular when revenues are used to promote growth. Andersen et al. (2007) compiled an extensive report on the effects of environmental tax reforms in European countries, in which they show that using tax revenues to lower labour costs has led to higher GDPs in six European countries (Denmark, Finland, Germany, the Netherlands, Slovenia, Sweden, and the United Kingdom; compare Figure 6). They find positive impacts on employment in Denmark, Germany, Sweden and the United Kingdom, which will be discussed in further detail in Subsection 5.1.

Figure 6: Effects of environmental tax reforms on GDP of six European countries, 1994-2012, percentage difference



Note: 'Percentage difference' is the difference between the base case with, and the counterfactual reference case without environmental tax reform.

UK: United Kingdom

Source: Andersen et al. (2007, p. 383)

4.4 Mitigating negative and supporting positive effects on competitiveness

In many cases, the mitigation of negative effects of carbon taxes on competitiveness will not be necessary. The Green Fiscal Commission of the United Kingdom concludes from a comparison of a number of firms in various different sectors that only the marginal, already struggling firms are challenged by environmental regulations. Average firms are able to cope well, while competitive firms even gain in competitiveness since they are spurred to innovate (UK Green Fiscal Commission, 2009). This effect may even be stronger for carbon taxes than for regulation. Once firms comply with regulation, there are no further innovation incentives. When they are subject to carbon taxes, in contrast, they need to pay continuously for the use of the limited absorptive capacity of the global atmosphere. This creates continuous incentives for innovation, but may also raise the firms' costs of compliance compared to regulation. The net outcome clearly depends on the level of the tax and the ability of firms to adapt. This ability may be lower on average in developing countries, but with high variation across firms caused by the structural heterogeneity of the private sector in developing countries. A conclusive and generalised answer to the question of carbon tax net impact is therefore unlikely to be found.

For this reason, and because the mitigation of possible negative impacts can create vital political buy-in from powerful stakeholders, governments need to address the question of mitigation measures. Reinaud (2008) groups the measures available to policymakers to mitigate the negative effects of carbon taxes into three categories:

- national measures to directly mitigate costs accruing to affected firms,
- trade measures to adjust the additional costs at the border, and
- measures of international cooperation to persuade other countries to impose similar taxes on their polluting firms.

National measures include carbon tax exemptions and revenue recycling. Exempting firms which are most exposed to the potential negative effects of a carbon tax from the tax liability is the most intuitively straightforward measure. This, however, means that the carbon tax loses some of its environmental effectiveness, since it will often be the most polluting firms which are exempt.

A second option is to use the accruing revenues to support the most affected firms in other ways, for example by reducing other taxes. The effect of this form of revenue recycling depends on the taxes which are reduced: business taxes, for example, can directly mitigate negative competitiveness effects. The net effect will differ between firms, while some will have net gains, others will lose. Germany, for example, introduced energy taxes and used the revenues to reduce pension insurance contributions (Forum ökologisch-soziale Marktwirtschaft [FÖS], 2015). Labour intensive firms gain more from this shift than firms with energy-intensive production processes, which may lose (Ekins & Speck, 2014). The rationale behind this shift is to obtain a 'double dividend' by stimulating demand for labour while lowering the demand for energy and thus carbon emissions. Therefore, reductions in social security contributions or income tax are among the most commonly used revenue recycling options in industrialised countries.

When firms are concerned about their performance compared to international competitors, governments can use trade measures to level the playing field. These measures have the advantage of safeguarding the effectiveness of national decarbonisation incentives while protecting national firms from competitive disadvantages in international markets. This is of particular importance for carbon-intensive sectors which are subject to intense international competition. The European Union (EU), for example, regularly determines sectors at risk, such as coal mining or metal production (European Commission [EC], 2014). These sectors are provided with higher shares of free emissions allowances than other sectors.

Once a larger group of countries imposes carbon border taxes, the barrier to implement national carbon taxes for other countries will decrease. After all, they already face a loss in international competitiveness because of the trade barriers, which will be removed once they implement own carbon taxes. Carbon border adjustments can thus also be used as one of the instruments in the third category, measures to convince other countries to implement own carbon taxation. Global carbon taxes at a level in line with costs from environmental damage would be the first best option in terms of efficiency and effectiveness. However, even coordinated carbon pricing which only concentrates on a group of countries can lead to substantial emission reductions despite some element of carbon leakage, as is suggested by Braathen (2014) for the group of OECD countries. The larger the group of countries, the lower the likely negative impact on regulated sectors, since more international competitors are likely to be subject to regulation, too. In the long run, countries should work towards a global coordination of carbon pricing, thus eliminating the option of firm relocation to unregulated countries. However, political realities make this kind of coordination a challenging endeavour. Any unilateral carbon border adjustments need to be in line with World Trade Organization (WTO) rules, and they entail the risk of being used as protectionist instruments.

If carbon taxes are to diffuse globally, political acceptance is vital. Several aspects can increase the chances of political acceptance of carbon taxes (OECD, 2007). Governments can soften the impact by phasing the tax in gradually, thereby giving firms time to adapt. Furthermore, introducing the new taxes as part of a broader fiscal reform can strengthen political acceptance. A common understanding of the issue at hand, its causes, impacts, and possible measures, can be strengthened by including relevant stakeholders and co-designing instruments with those affected. The OECD (2007) suggests the creation of green tax commissions, including relevant ministries, industrial organisations, trade unions and environmental organisations. Studies conducted by independent research organisations can help to establish a sound empirical basis for the discussions in such commissions. However, one aspect central to the acceptance of any tax reform is trust in the capability and willingness of governments to use the revenues in a way which benefits society. The lack of said trust in many developing countries is a prevalent barrier to the implementation of any kind of tax.

5 Considering social impacts

It is a main aim of carbon pricing to reduce emissions by inducing firms to switch to more carbon-efficient production modes in the short run, and by inducing structural change to less carbon-intensive activities in the long run. Both direct price effects and structural change can impact on employment and income distribution. Both are issues of major concern to many developing and emerging country governments, and need to be considered when new policies are introduced.

5.1 Employment

The net effects of carbon taxes on employment will differ by design of the tax, and can be influenced by the choice of revenue recycling option. When the revenues are used to reduce such labour costs as social security contributions, the impact on formal employment is likely to be positive (EC, 2012). Admittedly, employment in most developing countries is characterised by a high share of informal activities, and social security systems are often underdeveloped or lacking. Insights from industrialised countries can only be transferred to these contexts to a limited degree. In addition, when firms are concerned about competitiveness and relocation is easy, they can choose to shift their activities to other countries. Depending on how many jobs would be created as a result of the policy in low carbon sectors, this may result in a net job loss for the country. An option here is to use the above mentioned measures to safeguard competitiveness, including international coordination in carbon pricing and the gradual phasing-in of carbon pricing.

As the OECD (2011) shows, structural change towards low carbon activities is unlikely to result in large employment losses in OECD countries. In 2004, the sectors which were responsible for 82 per cent of the OECD's CO_2 emissions only provided employment to 8 per cent of the total workforce. This may be a specificity of the OECD's economic structure, and may differ from rapidly industrialising countries. But even in countries such as South Africa, whose economic output is strongly based on emissions-intensive activities such as mining and metals production, industry provides jobs to only 13 per cent of the female and 32 per cent of the male working population, while the less emissions-intensive services sector employs 83 per cent of the female and 62 per cent of the male working population (World Bank, 2015c).

Since only very few developing countries have introduced carbon taxes, and these are at low levels (compare Section 3), no ex post assessments of employment impacts in developing countries are available. However, some studies assess the job effect of carbon taxes in industrialised countries, of which Arlinghaus (2015) and Withana et al. (2013) provide useful overviews. Most studies seem to come to the conclusion that carbon taxes have no or only slight positive effects on employment, with the exception of Commins et al. (2009) and Alton et al. (2012) (see below).

Flues and Lutz (2015) study the effects of the German electricity tax of about EUR 44 per tonne of CO_2 between 1999 and 2004. Comparing firms which are eligible for electricity tax reductions, but otherwise similar to firms which are not eligible, they find no significant differences in employment. Firms which had a lower tax liability thus did not perform better in terms of employment than firms which had to pay the full tax rate.

Martin et al. (2014) assess the effects of the United Kingdom’s Climate Change Levy. They compare firms which were subject to the full levy with firms which chose to voluntarily participate in Climate Change Agreements and where then granted an 80 per cent reduction on the levy. While the environmental effect of the levy was substantial (energy intensity was reduced by 18.1 per cent and electricity use by 22.6 per cent), no adverse effect on employment can be found. Furthermore, the authors do not find any evidence for increased plant exit or relocation.

In an extensive modelling exercise, Andersen et al. (2007) calculate positive impacts of environmental tax reforms on employment in Denmark, Germany, Sweden and the United Kingdom. These positive impacts occur specifically when countries recycle revenues to lower employers’ social security contributions, thereby lowering wage costs. The effect for Denmark is strongest, with the country’s level of employment being about 0.5 per cent higher throughout the modelling period than in the reference case.

Commins et al. (2009), in contrast, find slightly negative impacts on employment. Assessing energy taxes and the European Emissions Trading Scheme between 1996 and 2007, they find that, while total factor productivity growth, returns to capital and investment increased on average, employment in the analysed sectors decreased by an average of 0.1 per cent. This said, the disaggregated values differ largely between sectors, with the strongest positive effect in the wearing apparel sector, where a 10 per cent tax rise leads to a 7 per cent increase in employment, and the strongest negative effect in the air transport sector, where a 10 per cent tax rise leads to a 15 per cent reduction in employment.

In a modelling exercise for South Africa, Alton et al. (2012) find that the phasing in of a carbon tax to a level of USD 30 per ton of CO_2 by 2022 would reduce national employment by 0.6 per cent relative to a baseline without carbon pricing. For this outcome, they assume no change in the behaviour of South African trading partners. If trading partners were to unilaterally impose carbon taxes with border tax adjustments, South Africa would experience declining export prices and forego carbon tax revenues. Under this scenario, a domestic carbon tax may increase national welfare and employment. Devarajan et al. (2011) qualify that impacts on the South African labour market are likely to depend on labour market distortions and rigidities rather than on the carbon tax implementation itself.

All the above studies assess impacts on formal employment. There are only very few studies to date on the impacts of carbon taxes on informal employment. Among them is Kuralbayeva (2013), whose results suggest that environmental taxes can produce a ‘triple dividend’ of a cleaner environment, lower unemployment and higher after-tax income of the private sector. However, they also suggest that governments need to take measures to protect people living in poverty, since the lower unemployment rates in the modelling exercise result from a higher tax burden on people in the informal sector, which leads to higher pressure to seek formal employment. If this employment cannot be found, the informally employed are left with the higher tax burden. Furthermore, the study suggests that environmental taxes can have negative poverty impacts by shifting income from rural to urban areas.

In sum, it is not possible to make general statements about the impacts of carbon taxation on employment. The impacts depend on the level of taxes, existing labour market distortions, the reactions of trading partners, and, importantly, the use of revenues. Positive impacts occur specifically when countries recycle revenues to lower employers' social security contributions, thereby lowering wage costs. This, however, does not take informal employment into account.

5.2 Income distribution

The effect of newly introduced policies on income distribution is a highly relevant question for developing countries. With large shares of the population still living in poverty, these countries cannot afford to implement policies with regressive effects without, at the same time, implementing mitigating measures. In contrast, it is a major aim of policymaking to ameliorate the economic situation of people living in poverty and to design policies, or their accompanying measures, in such a way that their effect is progressive.

The effects of direct or indirect carbon taxation on incomes therefore merit particular scrutiny. In 2014, the OECD published a comprehensive review of literature on the distributional impacts of carbon and energy taxation (OECD, 2014). The following sections draw from these insights.

In many of the assessed cases, low-income households carry a proportionately larger share of the overall tax burden than higher-income households. This regressivity materialises particularly when governments raise taxes on electricity and space heating. However, this may have to do with the fact that most empirical evidence refers to industrialised countries and developing countries with a cool climate, where space heating is a necessity. Findings may differ in countries of moderate or tropical climate, where space heating is obsolete for most of the year and indoor cooling is an option rather than a necessity. The significance of substitutability and expendability, or, in other words, the luxury aspect of the taxed good, becomes even more evident when transportation fuels are taxed. Private car ownership is usually more expendable than space heating (depending, of course, on climatic conditions and alternative transport options), and wealthy people are more likely to own cars than poor people. Therefore, people living in poverty are typically less affected by taxation of transportation fuels which are predominantly used in individual transport, such as gasoline, which in many cases leads to a progressive effect. In contrast, taxation of public transport fuels, such as diesel, can lead to regressive effects.

The studies also show that regressive effects can be mitigated to the extent that the overall effect is neutral, or even progressive, so that poorer households benefit. This requires a simultaneous reform of existing tax and benefit schemes, or the introduction of new schemes to counter the negative effects on poor households, such as direct transfer schemes. The preferred design of compensation schemes will vary with country backgrounds. Options are lump-sum rebates on energy services which can be directly targeted to poor households, raising threshold exemptions on income taxes, or funding climate change adaptation measures for poor households (Acosta, 2015).

However, when revenues are recycled to mitigate distributional impacts, they cannot be used to reduce other distortional taxes which act as a barrier to economic growth, such as labour taxes. Some of the cases reviewed by the OECD (2014) therefore show a trade-off between equity and economic efficiency. A triple dividend of positive environmental, economic and social impacts seems to be difficult to achieve.

The fact that taxes raise revenues, however, may enable a double dividend, or, if this cannot be achieved, at least a single dividend and no regret outcome. This distinguishes taxes from other green growth measures, such as subsidies. When subsidies have detrimental effects on the economy or on poverty, they do not simultaneously generate resources to mitigate these effects.

Studies which substantiate these findings have been conducted in a number of developing and emerging countries. Most of the studies assessed are modelling exercises which either use microsimulation models, computable general equilibrium models, input output models, or a combination of these models. Only few are ex post empirical studies.

A number of studies focus on China. China is one of the central countries in the mitigation of greenhouse gases. The studies show that it is important to distinguish between effects in rural and urban areas. Brenner, Riddle and Boyce (2007), for example, find that recycling of carbon tax revenues on an equal per capita basis would benefit people living in rural areas. People in rural areas tend to emit less carbon than those in urban areas since they use less energy, so that they would have to pay less carbon taxes. When revenue recycling follows a lump-sum approach, inhabitants of rural areas would be overcompensated for their carbon tax expenses. Yusuf and Resosudarmo (2008) find similarly progressive effects of carbon taxation and lump-sum revenue recycling for Indonesia. Sun and Kazuhiro (2011) come to a similar conclusion regarding the distributional effects of a Chinese carbon tax, which they find to be progressive in rural and regressive in urban areas. As a measure to mitigate the regressive effects they suggest a reduction in household electricity prices. This, however, may conflict with the carbon taxes' aim of environmental protection, since it would reduce the incentive to save energy. Liang and Wei (2012), in contrast, find regressive effects of a Chinese carbon tax in rural as well as in urban areas. They find these negative distributional effects to be minimised by a reduction of indirect taxes and increased benefits for rural households.

Gonzalez (2012) finds similar effects for carbon taxation in Mexico, where relative carbon intensity matters for distributional effects. Since carbon intensity varies between urban and rural areas, so too will distributional effects vary. Furthermore, Gonzalez finds that the mode of revenue recycling impacts on the progressivity or regressivity of carbon taxes. He observes regressive effects when revenues are used to reduce manufacturing taxes, and progressive effects when they are used to finance food subsidies.

The insight that subsidies of basic goods, such as food, can have net positive effects on the poor is substantiated by van Heerden et al. (2006). In a study on South Africa, the authors find that recycling revenues of explicit or implicit carbon taxes by subsidising food can even lead to a triple dividend of protecting the environment, fostering growth, and decreasing poverty. If distributional effects remain unmitigated, however, Alton et al. (2012) find regressive effects of carbon taxation on South African low-income households.

A study by Corong (2008) broadens the range of revenue use options by concluding that carbon taxes in the Philippines decrease poverty when revenues are recycled to lower income taxes.

The impact of implicit carbon taxation depends on the type of good which is taxed, and on the consumption patterns of different income groups. Fofana, Chitiga, & Maubugu (2009) find regressive effects of a price increase of heating fuels in South Africa, while higher prices for transportation fuels affect higher income groups more strongly. Yusuf and Resosudarmo (2008) confirm these findings in their study on Indonesia. Price increases of heating fuels and transportation fuels have regressive effects, which can be avoided if only transportation fuels are subject to price increases.

Blackman, Osakwe and Alpizar (2010) provide a more detailed picture of the effects of transportation fuel price increases by differentiating between increases in gasoline and diesel prices in Costa Rica. Since diesel is mostly used in public transport, which people living in poverty are more likely to use than individual motorised transport, increases in diesel prices tend to have regressive effects. Gasoline price increases, in contrast, have progressive effects, since car use is more widespread among wealthier households.

In sum, carbon taxation indeed tends to have regressive effects on income distribution. For implicit carbon taxation, the effects depend on the taxed good, for example the type of fuel, and the consumption patterns of various different income groups. However, the assessed studies confirm that potential regressive effects can be mitigated, and in some cases overcompensated, by the use of the tax revenues.

6 Conclusions

Carbon pricing is gaining ground in industrialised and some developing countries, but not to the extent necessary to achieve a uniform global price of carbon and avoid exceeding the limit of 2°C global warming. One of the main reservations of governments against carbon pricing, and carbon taxes in particular, is the risk of negative impacts on competitiveness. Where carbon pricing is implemented, governments therefore make ample use of measures to protect competitiveness, most notably reductions of or even exemptions from carbon taxes. However, ex post studies of competitiveness impacts on firms in industrialised countries suggest that these measures would in many cases not be necessary, and could be phased out gradually. Only in a few cases are industries strongly affected and vulnerable to international competition. However, there is no compelling evidence that environmental taxes have led to the relocation of companies on a significant scale (UK Green Fiscal Commission, 2009), and a number of studies show that carbon or energy taxes in industrialised countries have even had positive impacts on competitiveness and GDP. Furthermore, environmental taxes can spur innovation and induce structural change in the longer term.

It is notable that most of the evidence exists on carbon tax implementation in industrialised countries, and circumstances in developing countries differ. Therefore, the results may not be directly transferable. Since there are few developing and emerging countries that have introduced or consider introducing carbon taxes, there is little evidence available. Mexico, Chile, and South Africa are notable exceptions, but the initial levels of carbon taxes in these countries are too low to expect significant impacts on competitiveness or growth.

Despite the lack of implementation experience, there are indications that carbon taxes can have several advantages for developing countries, especially when compared to other taxes or to cap and trade schemes (Fay et al., 2015). Carbon taxes provide a good tax base and raise revenues, typically with relatively easy monitoring of a few point sources and an established network of measuring infrastructure in the case of energy taxes. In addition, energy taxes reduce incentives for firms to remain in the informal sector, since formal and informal companies have to pay them alike. The technical implementation of carbon taxes is easier than that of cap and trade schemes, since most countries already have a tax system in place, while institutions for cap and trade would often need to be set up from scratch. Carbon taxes also send more stable price signals than those created by cap and trade schemes.

The use of revenues, which has been so crucial for the positive impacts of carbon taxation in industrialised countries, is likely to be central for carbon tax impacts in developing countries as well. However, revenues may need to be used differently in developing countries. In industrialised countries, they have often been used to lower labour costs (such as social security contributions) to generate positive impacts on employment. In developing countries, in contrast, economic activity and employment often take place in the informal sector, and social security schemes are sketchy. Lowering taxes on formal economic activities on the basis of revenues accrued through the carbon tax will reduce incentives to stay in the informal sector, but may not have a positive impact on overall employment. Other revenue use options may, in contrast, be more important in developing than in industrialised countries. In particular, the distributive and poverty effects need to be considered. Tax revenues could, for instance, be used for direct transfers or the cross-subsidisation of electricity lifeline tariffs to protect people living in poverty from the negative impacts of carbon pricing. Furthermore, empirical studies suggest that revenue recycling to subsidise basic goods, such as food, can have positive effects on poverty.

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