THE

carbon tax

alternative

An alternative to carbon trading

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Summary

A solid consensus has emerged among scientists and most public officials around the world that emissions of greenhouse gases from burning fossil fuels, especially carbon dioxide (CO_2), contribute significantly to climate changes which could have very serious, adverse effects. Wherever greenhouse gases originate they affect everyone because they disperse widely in the upper atmosphere and accumulate there for a century. Since every industrialised nation produces these emissions they all need to be part of the global effort to control them.

This paper examines the two most prominent strategies for reducing greenhouse gases: a global system of national caps on the emissions and tradable permits, modelled on the Kyoto Protocol, and global, harmonised, net carbon-based taxes. It finds that cap-and-trade systems can achieve their emissions targets year by year, but will introduce significant additional volatility in energy prices. These systems also entail substantial administrative complexities and costs, and their emissions goals can be undermined by evasion and manipulation. Carbon taxes are less certain to achieve their emissions targets year by year, but their levels can be adjusted to minimise this deficiency. They are also easier and less expensive to administer, less vulnerable to manipulation and evasion, and provide more reliable incentives to develop and use alternative fuels and more energy-efficient technologies. Based on economic analyses and evidence, we conclude that carbon taxes are the more environmentally effective and economically efficient strategy for addressing climate change.

Introduction

Scientists and most public officials around the world have come to a solid consensus that the greenhouse gases emitted when fossil fuels are burned, especially carbon dioxide (CO_2), contribute to climate changes that will have very serious effects on the planet. These greenhouse gases disperse widely through the upper atmosphere and remain there for about a century, so wherever they originate they affect everyone on Earth. Since every nation with an industrialised economy produces these emissions, a successful effort is needed to control them which must include all industrialised countries. With strong leadership, the world community may be able to come together to address this problem before the limited Kyoto agreement expires in 2012. To prepare, policymakers must very carefully analyse their alternatives, to ensure that the approach finally chosen is the most effective and efficient one available.

In this paper we examine the two leading strategies for reducing greenhouse gases: a global system of national caps on greenhouse gas emissions and tradable permits, based on the emissions targets and timetables created by the Kyoto Protocol (cap-and-trade); and global, harmonised, net carbon-based taxes (carbon taxes). Recent economic analyses and evidence strongly suggest that carbon taxes would be a more environmentally effective and economically efficient way to address climate change than a cap-and-trade system, and provide stronger incentives to develop alternative fuels and more energy-efficient technologies (Nordhaus 2005; Cooper 1998, 2005).

Other policies also affect climate change, especially steps to protect and re-plant tropical forests and to support new technologies that can reduce emissions or their adverse effects on the climate. Reforestation and such scientific advances will have to play important roles in any climate change effort. Forestry measures are the most cost-effective responses available for many Latin American and African countries (Enkvist et al 2007). Moreover, both a strict cap-and-trade program and carbon taxes impose substantial costs on emissions and the energy that produces them, creating incentives to reduce those costs by developing cleaner fuels and more energy-efficient technologies. As a political matter, the higher energy prices required to make progress will be difficult to sustain for longer periods without the prospect of technological advances that eventually can stabilise or even bring down those prices.

Both of the two principal policy approaches necessarily result in higher prices for fossil fuels, but in different ways. Carbon taxes raise the price of carbon-based energy directly, predictably and in a constant manner, imposing the greatest costs on those firms and economies that produce the most emissions. In so doing, carbon taxes create direct incentives to reduce carbon-based energy use or substitute cleaner forms of energy, until the cost of doing so is greater than the tax. A serious cap-and-trade program applies no direct charge to emissions up to its cap, but the cap for the system is set below its current or forecast emissions. Companies and countries whose emissions exceed their caps therefore either have to reduce them either by cutting their energy use or substituting cleaner forms of energy, or by purchasing permits to cover the gap from those whose emissions are less than their own caps. The costs of the permits or the steps taken to cut energy use or use cleaner fuels are passed on in higher prices, so once again countries and firms with higher emissions pay higher prices for energy. However, those price increases are less predictable and will vary month to month depending on the size of the gap.

The critical economic distinction is that cap-and-trade directly controls the *quantity* of emissions, while carbon taxes directly control their *price*.

The two approaches differ in several other important ways. The critical economic distinction is that cap-and-trade directly controls the *quantity* of emissions, while carbon taxes directly control their *price*. The result is that cap-and-trade can produce a designated quantity of emissions, but with much greater potential volatility in energy and energy-related prices, while carbon taxes will produce more certain prices for energy and energy-intensive goods, but greater uncertainty about the quantity of total emissions. These two trade-offs are not equivalent. By regulating the quantity of emissions, a strict cap-and-trade program will drive the price of permits to whatever level is required to bring emissions under its cap. The price of permits and their underlying energy source will rise sharply when emissions increase, because, for example, an industry or country's growth accelerates or the winter weather is colder than expected. This price effect will introduce much greater up-and-down movements in national energy prices, on top of the normal increases and declines in global energy prices. Under a cap-and-trade program strict enough to affect climate change this increased volatility in energy prices will affect business investment and consumption. As the public learns to associate these unexpected price movements with the cap-and-trade system, their support for the effort could erode. As we will see, this price volatility is both evident and substantial in both the emission permits traded under the US acid rain program, the major US example of cap-and-trade, and in the first 22 months of CO_2 permit trading under the European Emissions Trading Scheme (ETS).

A carbon tax does not increase or accentuate the volatility of energy prices because it raises the unit-cost of energy by a constant amount (depending on its carbon

content), regardless of how fast a company, industry or nation's emissions are growing. The predictable cost of a carbon tax facilitates government and business decisions about investments and other steps to reduce emissions and thereby reduce the burden of the tax. While the tax will reduce emissions by raising the relative price of more carbon-intensive fuels (and lowering the relative price of less carbon-intensive alternatives), no one can predict the precise extent of those effects for any particular level of carbon tax, and consequently the tax may be set too low to achieve a particular emissions goal in a given year. However, this shortcoming is more easily offset than the price volatility of cap-and-trade. The environmental costs of greenhouse gases occur over a long term, and in principal a government can raise or lower the carbon tax rate year by year to achieve the long-term emissions reductions it seeks. While some proposals for cap-and-trade systems include provisions to reduce price volatility by auctioning or distributing additional permits when permit prices increase sharply, these provisions address the price volatility after it has already occurred and taken a toll on investment. Moreover, the distribution of additional permits in the face of rising prices may also sacrifice much of the environmental benefits of the cap-and-trade system.

A second important difference is that global carbon taxes have generally comparable effects from country to country, while a global cap-and-trade program usually does not. When slow growth or mild weather reduces the energy use and emissions of a country or an industry it will pay less carbon taxes, but in good times or bad times a uniform net carbon tax will impose comparable costs and provide comparable incentives from country to country to develop and adopt climate-friendly technologies and strategies. By contrast, a global cap-and-trade system creates a range of effects and incentives across countries, depending on the base from which it calculates the emissions targets for each country. Once a cap-and-trade agreement determines that a country's emissions should be reduced by a certain percentage relative to its current emissions or to its emissions in a previous base year, the country may be able to meet its target without taking any steps if its economy slows – or it could take serious measures to reduce emissions and still fail to meet its target because its economy is growing faster than normal.

The third important difference is that cap-and-trade programs are more difficult to administer and more vulnerable to evasion, corruption and manipulation than carbon taxes. The administration of a net carbon tax is straightforward: Each country would apply a tax rate to every energy source, which, after counting the country's current energy taxes and subsidies, would produce the global net carbon tax rate. Each country could also collect the receipts using the same mechanisms it relies on for existing energy or business taxes. Under cap-and-trade, each country first has to create a new system to distribute its national cap among its energy-related industries and their thousands of companies and plants in the form of permits; then it must set up a monitoring system to track energy production at every site before and after permits are traded.

Cheating also poses a more serious problem for cap-and-trade than carbon taxes. While some companies will try to evade their taxes, the government on the other side of the transaction has a strong interest in discovering and stopping it. Under cap-and-trade, if a company fraudulently understates its energy production and emissions so it can sell permits for some of them, the buyer on the other side of the transaction has no incentive to uncover or reveal the fraud. As a result, Yale economist William Nordhaus (2005) has concluded that "cheating will probably be pandemic" under cap-and-trade.

By creating tradable financial assets worth tens of billions of dollars for governments to distribute and monitor among their industries and plants, cap-and-trade programs also introduce incentives to cheat by corrupt and radical governments. Corrupt governments will almost certainly distribute their permits in ways that favour their supporters and understate their actual energy use and emissions. By doing so they can "earn" billions of dollars in hard foreign currencies trading "excess" permits, and in the process undermine the program's environmental goals. A global cap-and-trade program also has no way to prevent radical governments from using such transfers to finance whatever purposes they choose, whether it is education or domestic oppression, foreign assistance or foreign terrorism. Corrupt and radical states can use carbon-tax revenues for such purposes too, but at least the resources come from their own economies.

Given these drawbacks, cap-and-trade's principal attraction appears to be political feasibility. Many environmental activists assume that a global cap-and-trade program is more achievable than global carbon taxes, because much of the world agreed to Kyoto and most people resist higher taxes. On close analysis, the Kyoto agreement is too weak to signify a meaningful consensus for the kind of strict caps needed to address climate change. This disappointing result reflects three major political compromises that eroded most of Kyoto's environmental potential: 1) its exemption for all developing countries, including major greenhouse-gas producers such as China, India and Brazil; 2) its effective exemption for Russia and the Eastern European countries, and substantial leeway for many Western European countries, based on the selection of the base year from which reductions are calculated; and 3) a system of transfers that would have imposed such disproportionate costs on the world's largest economy, the United States (along with Australia and a few others), that it declined to ratify the agreement.

People and companies in every country resist higher taxes. Yet Sweden and Denmark have applied carbon taxes, or their equivalent, and are now among the most

FIGURE 1

US ACID RAIN PROGRAM: ANNUAL PERCENTAGE CHANGE IN CLEARING PRICES FOR SO_2 PERMITS, 1993–2006

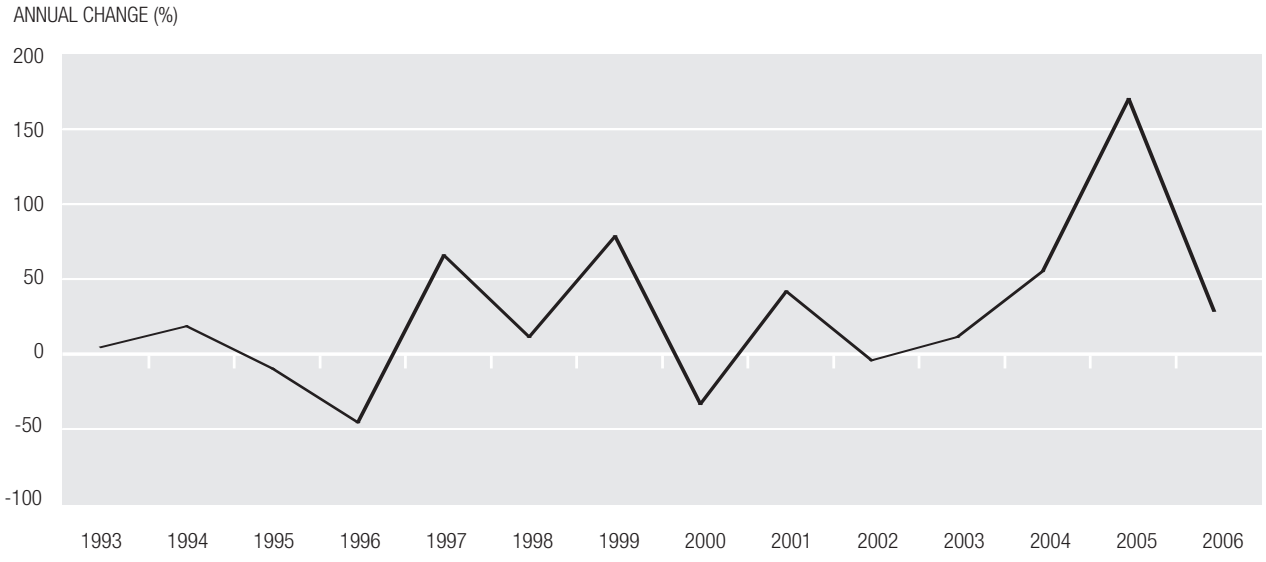

FIGURE 2

EUROPEAN EMISSIONS TRADING SCHEME: DAILY PRICE MOVEMENTS OF CO_2 PERMITS, MARCH 2005–JANUARY 2007

emission-efficient economies in the world. A global carbon tax sufficiently high to affect climate change may also be seen more broadly as politically achievable when governments recognise that they can use its revenues to reduce their existing payroll or corporate taxes or finance popular pension or health-care programs. On balance, if the world community intends to take serious steps to slow and ultimately reverse climate change, the evidence strongly suggests that a global carbon tax would be preferable to a global cap-and-trade system on economic, environmental and even political grounds.

Price volatility

When the world's nations negotiated the cap-and-trade arrangements of the Kyoto agreement in the 1990s, many economists and environmental activists supported the process and its result as a politically acceptable, market-based way of improving the global environment. By the late 1990s, however, researchers identified a number of serious problems with cap-and-trade, and many began to favour carbon taxes as a better alternative. William Nordhaus (2005) recently published a literature review covering recent economic research in this area, and much of the following discussion draws on that review and the research on which it is based.

One serious problem is the well-documented tendency of regulations that directly limit the quantity of something that people need to produce large volatility or swings in the price of what is regulated. A powerful demonstration occurred from 1979 to 1982, when the US Federal Reserve Board shifted from targeting the price of credit (interest rates) to its quantity (monetary aggregates). As demand for credit increased or waned, while the quantity of credit remained strictly regulated, interest rates moved much more sharply than at any time before or after this brief experiment in "monetarism".

The same price volatility is evident in the leading US instance of a cap-and-trade based environmental regulation, the acid rain program. The program applies cap-and-trade arrangements to major emitters of SO_2 (sulfur dioxide) and NO_x (nitrogen oxide). Recent analysis has found that the trading prices for the SO_2 and NO_x emission permits have ranged from $66 per ton to as high as $1,700 per ton, moving up and down by an average of 10 per cent per month and 43 per cent per year, or several times the volatility seen in oil prices or stock-market prices (EPA). Moreover, this volatility has increased in the last three years as permit prices have risen by an average of more 80 per cent a year despite the use a "safety valve" provision under which the US Environmental Protection Agency has auctioned additional permits to temper the volatility.

The European Union's Emissions Trading Scheme (ETS) for CO_2 emission permits issued under the Kyoto guidelines has also experienced great price volatility. Its permit prices have moved up or down by an average of 10 per cent per month in its first 12 months and 23 per cent per month from March 2006 to January 2007 (European Energy Exchange 2007). From March 2005 to February 2006, permit prices predominantly moved up, increasing by 17 per cent per month in the first four months and an average of 6 per cent per month in the first 12 months. From March 2006 to January 2007, ETS permit prices generally moved down, with average price declines of 23 per cent per month. In contrast to the constant impact of a carbon tax, those sharp declines in permit prices greatly reduce incentives for firms to limit their emissions (IHT 2006).

For this and other reasons, the ETS is failing to reduce overall emissions. In 2005 total CO_2 emissions increased by 0.4 per cent in the EU-25 and by 0.6 per cent among the EU-15, despite the "caps" (European Energy Exchange 2006). Looking ahead, the European Environmental Agency (EEA) projects that the EU is likely to achieve no more than one-quarter of its Kyoto-targeted reductions by 2012, and much of that will reflect credits purchased from Russia or other transitional countries, with no net environmental benefits (Egenhofer, et al. 2006; European Energy Exchange 2006).

Comparable price fluctuations for CO_2 permits under a serious, global cap-and-trade program would have significant economic costs. The largest producers of CO_2 emissions are electricity-generating utilities, especially those powered by high-polluting coal. Under a strict cap-and-trade program, when a particularly cold winter or hot summer occurs or an economy grows faster than trend, CO_2 emissions will rise sharply with electricity consumption. Since the quantity of emission permits would be capped, their price would also rise sharply and be passed on to the consumer as higher electricity prices. The same dynamic would occur in oil and gasoline prices when demand for those fuels rise.

These national-based price movements will not only tend to dampen business investment, especially in energy-incentive areas such as manufacturing, where the additional costs could make the difference between financially acceptable and unacceptable rates of return. More important, unexpected and accentuated energy-price increases publicly linked to a cap-and-trade system could undermine public support for the effort and force governments to roll back or suspend their caps, potentially unravelling the entire program.

Kyoto shortcomings

The Kyoto agreement was signed and ratified by 165 nations, still awaits ratification by two other nations (Croatia and Kazakhstan), and was signed by two more countries that subsequently declined to ratify it (the US and Australia). Despite its broad global support, Kyoto commits only 38 industrialised countries – 36 with the withdrawal of the US and Australia – to take action before it expires in 2012. The agreement covers six emissions – CO_2 (carbon dioxide), CH_4 (methane), N_2O (nitrous oxide), HFC (hexafluorocarbon), PFC (perfluocarbon) and SF_6 (sulfur hexafluoride).) These 36 countries agreed to achieve specific reductions in their CO_2 and other greenhouse emissions, ranging from 8 per cent below 1990 levels for the EU and 6 per cent below 1990 for Japan, to 10 per cent above 1990 emissions for Iceland. The Kyoto agreement also allows countries and companies to buy and sell rights to produce emissions. Since the cost of reducing emissions differs from plant to plant, industry to industry and country to country, this trading provision creates a market for emission rights that can help to ensure that emission reductions consistent with the overall targets occur where they can be achieved relatively inexpensively.

In addition to price volatility, the Kyoto-based arrangements embody two problems that seriously impair its effectiveness and efficiency, namely, the base year from which its targeted reductions are calculated, and the exclusion of developing nations from the targets. Both aspects were necessary to achieve a political agreement, but together they profoundly weaken the project.

In 1997 the parties to Kyoto designated 1990 as the base year from which it would calculate its 2008–2012 national targets for lower emissions. The choice of 1990 created serious distortions which were well recognised at

the time. First, 1990 was the peak year of economic activity in the Soviet Union and Eastern Europe before their state-directed economic systems unravelled. The World Bank (2006) reports that Russia's economic production slumped from $385 billion in 1990 (2000 dollars) to $286 billion in 2002, and its corresponding CO_2 emissions fell from 2.26 million tons to 1.43 million tons. Since Russia's Kyoto target is an 8 per cent reduction from its 1990 levels of 2.26 million tons, the 1990 base year allows Russia to increase its emissions from 1.43 million tons to 2.08 million tons (2.26 x 0.92) or 45 per cent, and earn an enormous financial windfall by selling its excess tradable permits until its emissions reach that level. According to one estimate, if the 38 nations assigned targets under Kyoto all participated on a strict basis Russia and Eastern Europe could take in about $40 billion a year (1990 dollars) by selling their excess permits, principally to companies in the US, Australia, Canada and Japan (Nordhaus 2005; Nordaus and Boyer 2000).

Kyoto's 1990 base year also allows Germany and the United Kingdom, which together account for 80 per cent of the EU-15's targeted reductions, to avoid taking serious steps to reduce their emissions. Following Germany's reunification in October 1990, much of East Germany's out-dated and high-polluting, state-owned industrial plants were dismantled or closed down. As a result, Germany's target of 8 per cent reductions from a 1990 base also became a license to increase emissions. Similarly, the privatisation of British coal mining in 1995 cut coal use in Britain just as its North Sea natural gas operations expanded, allowing Britain to actually increase its emissions and still meet an 8 per cent reduction target calculated from a 1990 base (Aldy et al. 2003).

The 1990 baseline also penalises countries that had already made substantial progress in reducing emissions. The Netherlands, Sweden, Denmark and Japan, which had controlled much of their emissions by 1990, will find it more difficult and expensive to further reduce them and will have to purchase additional permits from Russia and Eastern Europe (Cooper 2001). The Kyoto baseline also penalises the US, Australia, Ireland and few other countries for experiencing strong growth and consequent increases in energy use since 1990 (Canes 2003). For them, the 1990 base year produces 2012 caps which they cannot meet regardless of how much they invest in new technologies and alternative fuels. Instead, they would have to pay Russia and Eastern Europe tens of billions of dollars for their excess permits (Cooper 1998).

Kyoto's prospects for affecting climate change are further undermined by the exemption granted to developing countries, including major sources of CO_2 emissions such as China, India and Brazil. Those and other developing nations agreed to ratify Kyoto only if it imposed no constraints on their economic development, and as recently as 2006 China reiterated its position of never accepting emission caps. These exemptions concentrate all of the reductions in 38 countries that produce just over half of all worldwide emissions; with the US and Australian withdrawal, the agreement covers just 30 per cent of global emissions (Nordhaus 2005). The exemptions for developing countries also seriously impair the program's economic efficiency, since about half of the most cost-effective opportunities for reducing emissions would occur as developing economies replace old industrial plant, build new energy infrastructure, and find alternatives to deforestation.

Unsurprisingly, an econometric simulation of the costs and benefits for the world's regions estimates that the benefits will exceed costs only for those countries that are exempt from the costs (Nordhaus 2005). If the US participated, however, it could face net long-term costs of more than $5 trillion, while Western Europe, Japan, Canada and Australia together would face $2 trillion in net costs (Aldy et al. 2003).

The designation of those countries subject to Kyoto targets and those which are exempt has no economic or environmental justification. It is not based on a nation's ability to bear the costs, since Kyoto exempts wealthy Middle Eastern states such as Qatar with a per capita GDP of $43,110, and the United Arab Emigrates, Kuwait and Brunei with per capita GDP of more than $20,000 (World Bank 2006). The exempt countries also include many major producers of greenhouse gases, including several with substantial per capita GDPs such as Singapore, Taiwan, Korea and Hong Kong.

One justification commonly cited is a sense of historical equity – since the developed countries are responsible for most of the current atmospheric stock of greenhouse gases, they should bear the cost. Wealthy countries were largely responsible for the greenhouses gases produced in the 1970s and 1980s. However, by 2002 when Kyoto was approved, six major exempt countries – China, India, Korea, Brazil, Mexico and South Africa – accounted for more than 25 per cent of global CO_2 emissions (World Bank 2006). By 2012, China and those five other large, exempt nations will produce more than one-third of global CO_2 emissions.

The result of the combination of these exemptions and the 1990 base year is that Kyoto will produce little progress on global warming. Even if the US shifted course and participated, and Kyoto's provisions were all strictly implemented and enforced, the program would abate the expected increase in global temperatures between now and 2050 by just 0.02° to 0.28°C (Nordhaus 2005).

The complex trading arrangements of a cap-and-trade program also present problems that tend to degrade its environmental results and increase its costs. Once negotiators determine a global cap and distribute it across the involved nations, each government is free to distribute its nation's permits among its industries and companies as it chooses. Even in a transparent and democratic society, distributing a scarce and valuable benefit through the normal

political process invites pressures that often produce special preferences for influential interests and companies. For example, the German government announced in June 2006 that it would exempt its coal industry, the country's largest greenhouse-gas producer, from its CO_2 caps under the European ETS. In countries without a transparent democratic process – Russia, the Ukraine, and many others – these pressures may go unchecked, and political favouritism and corruption will almost certainly substantially determine how the permits are distributed.

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The subsequent trading of the permits introduces more problems. To have much effect, a global cap-and-trade program will have to cover hundreds of thousands of installations in scores of countries, and the trades among them will require accurate measurements of the energy production or emissions on both sides of each transaction, before and after the trade. That may be plausible in advanced countries with elaborate, professionalised regulatory systems, but it's considerably less likely in transitional economies such as the Czech Republic and Romania, and frankly implausible in places such as Russia and China. Cap-and-trade systems also have built-in incentives for cheating and corruption, because both buyer and seller can gain by understating their emissions. Even if only the seller cheats by understating its emissions (creating or increasing the permits it can offer for sale), the buyer has no incentive to discover or reveal the fraud.

Finally, cap-and-trade programs create new temptations for countries to cheat, because, as Nordhaus (2005) notes, "limiting emissions [through caps] creates a scarcity where none previously existed – in essence printing money for those in control of the permits". A global cap-and-trade system will include countries ruled by corrupt or radical regimes – as does Kyoto – presumably eager to raise billions of dollars or euros by understating emissions and then trading artificially inflated numbers of excess permits. Under a global-cap-and-trade program, countries such as Iran, Syria and the Sudan might be able to raise international capital by selling permits; and even under Kyoto they can receive credits for clean-energy investments which can be traded like permits to raise funds (Torvik 2002).

Tax relief

The first burden for any tax-based regulatory approach is to minimise its effects on "relative prices", which can make an economy less efficient. The gist of this issue is that whatever is taxed becomes more expensive relative to what remains untaxed, so what consumers and corporations buy and use is no longer determined simply by prices reflecting the costs to produce them. Since taxes of some kind are unavoidable the challenge is to design them so they distort these relative prices as little as possible. Part of the answer is to make the base of the tax broad, so its rate can be low and most people and activities are affected equally. Carbon taxes generally meet this criterion, although not as well as broad income or consumption taxes. Moreover, the economic drawback of raising the price of carbon-intensive products and operations, relative to those which are not, is the environmental purpose of a carbon tax.

Further, a close analysis shows that these traditional concerns about efficiency effects are largely moot for carbon taxes. Efficient markets and correct relative prices depend on a close correspondence between the prices of goods and services and the total costs to produce them. However, economists have long recognised that the pollution created by the production and use of fossil fuels is a cost not captured in the prices of these fuels. These "externality" costs fall on those who happen to live or work close to where the fuel is produced or used, usually in the form of higher health care costs. In the case of greenhouse gases and climate change these costs are borne by almost everyone, but again based not on how much fuel a person uses but on where he or she lives.

A carbon-based tax could capture the externality costs of those pollution emissions and embed them in the market price of fuel, creating what economists call a market-perfecting Pigouvian tax (after Arthur Pigou, the English economist who first wrote about these issues). Using a Pigouvian tax that raises the price of a fuel to reflect its externality costs should improve economic efficiency by better aligning the relative prices of things with all of their costs, especially if the revenues were used to offset the costs borne by those subject to its pollution. While we do not know what precise level of carbon tax would capture all of these costs, a tax which embeds a significant part of those costs should improve the efficiency of prices.

Another economic issue is the degree to which a carbon tax would focus environmental improvements where they can be achieved most cheaply or efficiently. Cap-and-trade programs achieve this by using tradable permits, at least in principle. Carbon taxes also can achieve this form of economic efficiency and without a cumbersome trading mechanism susceptible to base-year distortions, exemptions and cheating. The tax would raise the price of carbon-based energy in proportion to its carbon content, so that countries and companies which can reduce their carbon emissions for less than the incremental cost of the tax can be expected to do so, while those which find that reducing emissions would cost more than the tax will pay it. The

consequent reductions in emissions should be greatest where the costs of achieving them are lowest, within each country and worldwide. Carbon taxes should also create more reliable incentives for companies to develop environmentally-friendly technologies or abatement strategies. The tax would provide "a continual incentive to reduce the costs of carbon abatement", as one expert has put it (Chupka 2001), because the permanent increase in the cost of carbon-intensive energy would raise the rate of return on the development and use of technologies that reduce the consumption of those forms of energy.

Administrative ease

A global carbon tax regime would still present serious challenges. Significant CO_2-producing countries have to agree on what is to be taxed, the rate, and how to treat other taxes and government spending that may reduce or increase the effective burden of a carbon tax for particular industries. However, it would be unrealistic to expect governments to strip their budgets and tax codes of all preferential treatment for energy companies or energy-intensive manufacturers. Instead, the agreement could set a uniform net carbon tax for countries and create an arbitration body to determine each country's current net carbon tax burden based on its existing fuel-related subsidies, taxes, credit programs and other preferences, plus the additional tax required to achieve a roughly uniform carbon tax level (Victor 2001). These issues are complicated, but technically manageable. The International Monetary Fund (IMF) could review these net carbon tax burdens as part of its annual consultations with countries about their macroeconomic and fiscal policies (Cooper 1998). Panels of experts could resolve technical disagreements on the model of the panels that resolve technical issues in trade disputes before the World Trade Organization.

Once the terms of the tax are established, most countries would apply it at the points where energy is generated or distributed, based on the fuel's carbon content, much as caps and permits are usually distributed at such points. In other respects a carbon tax should be relatively simple and inexpensive to administer and enforce. While cap-and-trade requires additional administrative systems and structures to allocate the permits and monitor their subsequent trades every government has a tax system in place already, and most of them already tax energy.

For all of these reasons a carbon tax regime should be more environmentally effective and less economically disruptive than a cap-and-trade program. This expectation is supported by recent econometric modelling that compared the impact on CO_2 emissions of the Kyoto version of cap-and-trade with and without US participation, and a hypothetical global carbon tax which limited CO_2 concentrations to twice their pre-industrial levels by 2075 (Nordhaus 2005). By 2025 the hypothetical carbon tax would reduce worldwide CO_2 emissions by 17 per cent compared to their 1990 levels, while Kyoto could reduce those emissions by 12 per cent with US participation and by 3 per cent without the US. By 2045, the carbon tax would bring down emissions by 30 per cent from their 1990 levels, while Kyoto would produce reductions of 15 per cent with US participation and still 3 per cent without the US. By 2075, the hypothetical carbon tax would reduce emissions by fully 40 per cent compared to their 1990 levels, while Kyoto could achieve only a 16 per cent reduction with US participation and less than 4 per cent without it.

Overseas results

In 2005 New Zealand proposed a carbon tax, scheduled to take effect in April 2007, but reversed course in December 2005 after elections increased the influence of minor parties supporting the government but opposed to the tax. Sweden and Denmark have had substantial carbon taxes in place since the early 1990s. While all Western European countries impose significant taxes on gasoline and other transportation fuels, only Denmark and Sweden also apply them to carbon-based energy used by industry. In 2000 their taxes, respectively, were $67 and $64 (PPP $) per ton of CO_2 for coal in industrial uses and $72 and $52 per ton of CO_2 for diesel, oil and other fuels used for industrial purposes (Baranzini, Goldenberg and Speck 2000). By contrast, Germany, the UK, Australia, the US and most other advanced economies imposed no taxes on coal used for industrial purposes and modest taxes on other fuels used by industry.

These tax differences play a significant role in differences in their relative emissions. For each dollar (PPP) of GDP, the Swedish economy in 2003 generated 0.221 kg of CO_2 and the Danish economy 0.301 kg of CO_2, compared to an average of 0.460 kg of CO_2 for all high-income OECD economies, 0.380 kg of CO_2 per dollar of GDP in Germany, 0.353 kg in Britain, 0.604 kg in the US and 0.717 kg in Australia (World Bank 2006). These results confirm the vast body of analysis and evidence that carbon-based taxes are a highly effective way to reduce and control greenhouse gas emissions.

The evidence from cap-and-trade systems is less encouraging. The chief example, the ETS, is expected to show little genuine progress on European emissions. As noted earlier, among the EU-15, total CO_2 emissions actually increased by 0.6 per cent in 2005. Nor are the signs heartening for the 2008–2012 Phase 2 of the ETS. As of December 2006, 11 of the EU-25 had failed to submit completed plans for Phase 2 (EU 2006), and analysts found that among those that did comply, most projected higher base emissions than most independent analyses in order to reduce their future burdens (Rathmann, Reece, Phylipsen and Voogt 2006). Further, Climate Action Network Europe, the region's leading umbrella group for environmental organisations, has found that many ETS members have little capacity to monitor or verify the energy

use or emissions of those who hold permits (Rathmann et al. 2006). Finally, as also noted earlier, the EEA has projected that the entire ETS effort is likely to achieve no more than one-quarter of the EU's Kyoto-targeted reductions by 2012 (EEA 2006), with much of those "reductions" reflecting credits purchased from Russia or other countries outside the EU with no net environmental benefits.

Conclusion

As the risks of climate change continue to grow, few countries seem prepared to pay a significant price to reduce their greenhouse gas emissions. The Kyoto agreement was achieved only after ensuring that most nations would pay little or no price for many years, ultimately producing little progress on climate change. The EU's Emissions Trading Scheme, based on the Kyoto targets, will likely achieve even less. Moreover, there are powerful reasons to doubt that a better-designed cap-and-trade system could effectively control global greenhouse gas emissions. The world's major CO_2-producing, developing countries, including China and India, have vowed never to join a cap-and-trade regime. Its complex administrative mechanisms and internal incentives are likely to produce substantial cheating by both companies and some governments. Perhaps most important, the energy-price volatility likely to arise in countries that strictly enforce genuine caps on their emissions could rapidly undermine public support and unravel the system. On balance, an alternative approach based on global, harmonised net carbon taxes, can better contain the risks of climate change, and do so in an economically efficient and politically feasible way.

The task is to persuade the world's major energy producing and consuming countries to adopt harmonised carbon taxes. The first step of simply expanding the public debate to include rigorous environmental and economic analyses of the advantages and disadvantages of carbon taxes and a cap-and-trade regime will be challenging. The current US Congress and President oppose higher energy taxes. On the other side of the world, the Australian Government recently issued a task force report, concluding that emissions trading would be preferable to carbon taxes, but it failed to address the current results from the European Trading Scheme, the environmental effectiveness of Scandinavian carbon taxes or the growing economics literature on the subject (Australian Government 2007). The importance of these matters for every country deserves serious and dispassionate analysis.

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