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USING THE MARKET TO ADDRESS CLIMATE CHANGE: INSIGHTS FROM THEORY AND EXPERIENCE

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ABSTRACT

Emissions of greenhouse gases linked with global climate change are affected by diverse aspects of economic activity, including individual consumption, business investment, and government spending. An effective climate policy will have to modify the decision calculus for these activities in the direction of more efficient generation and use of energy, lower carbon intensity of energy, and – more broadly – a more carbon-lean economy. The only approach to doing this on a meaningful scale that would be technically feasible and cost-effective is carbon pricing, that is, market-based climate policies that place a shadow-price on carbon dioxide emissions. We examine alternative designs of three such instruments – carbon taxes, cap-and-trade, and clean energy standards. We note that the U.S. political response to possible market-based approaches to climate policy has been and will continue to be largely a function of issues and structural factors that transcend the scope of environmental and climate policy.

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Using the Market to Address Climate Change: Insights from Theory and Experience

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1. Introduction

Virtually all aspects of economic activity – individual consumption, business investment, and government spending – affect greenhouse gas emissions and hence the global climate. An effective climate change policy would change the decision calculus for these activities to promote more efficient generation and use of energy, lower-carbon intensity of energy, and a more carbon-lean economy. There are essentially three ways to accomplish this: (1) mandate businesses and individuals to change their technology and emissions performance; (2) subsidize businesses and individuals to invest in and use lower-emitting goods and services; or (3) price the greenhouse gas externality commensurate with the harm to society that such emissions impose.

Externality pricing can promote cost-effective abatement, deliver efficient innovation incentives, avoid picking technology winners, and ameliorate, not exacerbate, government fiscal conditions. When all businesses and households face a common price per unit of greenhouse gases embodied in fuels, goods, and services, then no additional policies can lower the total cost of achieving a specified climate policy goal. By pricing carbon pollution, the government defers to private firms and individuals to find and exploit the lowest cost ways to reduce emissions and to invest in the development of new technologies, processes, and ideas that could mitigate future emissions. A variety of policy approaches fall within the concept of externality pricing, including carbon taxes, cap-and-trade, and clean energy standards.

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In contrast, the conventional approach to environmental policy employs uniform mandates to protect environmental quality. Although uniform technology and performance standards have been effective in achieving some established environmental goals and standards, they tend to lead to non-cost-effective outcomes in which some firms use unduly expensive means to control pollution. In addition, conventional technology or performance standards do not provide dynamic incentives for the development, adoption, and diffusion of environmentally and economically superior control technologies. Once a firm satisfies a performance standard, it has little incentive to develop or adopt cleaner technology. Indeed, regulated firms may fear that if they adopt a superior technology, the government may tighten the standard.

Given the ubiquitous nature of greenhouse gas emissions from diverse sources, it is virtually inconceivable that a standards-based approach could form the center-piece of a meaningful climate policy. The substantially higher cost of a standards-based policy may undermine support for such an approach, and securing political support may require a weakening of standards and lower environmental benefits.

Government support for lower-emitting technologies often takes the form of investment or performance subsidies. Providing such subsidies for targeting climate-friendly technologies requires revenues raised by taxing other economic activities (either contemporaneously or in the future with contemporaneous financing via deficit spending). Given the tight fiscal environment throughout the developed world, it is difficult to justify the kind of ramping up (or even continuance) of subsidies that would be necessary to change significantly the emissions intensity of economic activity.

Furthermore, by lowering the cost of energy, climate-oriented technology subsidies likely result in socially excessive levels of energy supply and consumption. Thus, subsidies can undermine incentives for efficiency and conservation and impose higher costs per ton abated than cost-effective policy alternatives. The design of subsidies in practice typically takes a technology-specific approach. By picking technology winners, such an approach yields a special interest constituency focused on maintaining subsidies beyond what may be socially desirable. In picking winners, subsidies provide little incentive for the development of novel, game-changing technologies.

In contrast with this, real-world experience demonstrates the power of markets to drive changes in the investment and use of emission-intensive technologies. The run-up in gasoline prices in 2008 resulted in a shift in the composition of new cars and trucks sold toward more fuel-efficient vehicles, while reducing vehicles mile traveled in the existing fleet.[2] Likewise, electric utilities responded to the dramatic decline in natural gas prices (and decline in the relative gas-coal price) in 2009 and 2010 by dispatching more electricity from gas plants that resulted in lower carbon dioxide (CO_2) emissions and the lowest share of U.S. power generation by coal in some four decades.[3] Longer-term evaluations of the impacts of energy prices on markets have found that higher prices have induced more innovation – measured by frequency and importance of patents – and increased the commercial availability of more energy-efficient products, especially among energy-intensive goods such as air conditioners and water heaters.[4]

Real-world experience with policies that price externalities illustrates the effectiveness of market-based instruments. So-called "congestion charges" in London, Singapore, and Stockholm have reduced traffic congestion in busy urban centers, lowered air pollution, and delivered net social benefits. The British Columbia carbon tax has reduced carbon dioxide emissions since 2008. The U.S. sulfur dioxide (SO_2) cap-and-trade program cut U.S. power plant SO_2 emissions more than 50 percent since 1990, resulted in compliance costs one half of what they would have been under conventional

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[2] Valerie A. Ramey and Daniel J. Vine. 2010. "Oil, Automobiles, and the U.S. Economy: How Much Have Things Really Changed? NBER Working Paper 16067.

[3] U.S. Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2009*.

[4] See: David Popp, "Induced Innovation and Energy Prices" *American Economic Review* 92(1): 160-180, and Richard G. Newell, Adam B. Jaffe, and Robert N. Stavins, "The Induced Innovation Hypothesis and Energy-Saving Technological Change" *Quarterly Journal of Economics* 114(3): 941-975, 1999.

regulatory mandates.[5] The success of the SO_2 allowance trading program motivated the design and implementation of the European Union's Emission Trading Scheme (EU ETS), the world's largest cap-and-trade program, focused on cutting CO_2 emissions from power plants and large manufacturing facilities throughout the Europe.[6] The lead phase-down of gasoline in the 1980s, by reducing the lead content per gallon of fuel, served as an early, effective example of a tradable performance standard.[7] These positive experiences provide motivation for considering market-based instruments – carbon taxes, cap-and-trade, and clean energy standards – as potential approaches to mitigating greenhouse gas emissions.

2. **Designing a Carbon Tax**[8]

In principle, government imposition of a carbon tax represents the simplest way to price greenhouse gas emissions. The government could set a tax in terms of dollars per ton of CO_2-equivalent on greenhouse gas emissions by all sources covered by the tax. To be cost-effective, such a tax would cover all sources, and to be efficient, the carbon price would be set equal to the marginal benefits of emission reduction, represented by estimates of the social cost of carbon.[9] Over time, an efficient carbon tax would increase to reflect the fact that as more greenhouse gas emissions accumulate in the atmosphere, the greater the incremental damage from one more ton of CO_2. Imposing a carbon tax

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[5] Curtis Carlson, Dallas Burtraw, Maureen Cropper, and Karen Palmer. "SO_2 Control by Electric Utilities: What Are the Gains from Trade?" *Journal of Political Economy* 108(2000): 1292-326

[6] A. Denny Ellerman and Barbara K. Buchner. "The European Union Emissions Trading Scheme: Origins, Allocation, and Early Results." *Review of Environmental Economics and Policy*, volume 1, number 1, winter 2007, pp. 66-87.

[7] Robert N. Stavins. "Experience with Market-Based Environmental Policy Instruments." *Handbook of Environmental Economics*, Volume I, eds. Karl-Göran Mäler and Jeffrey Vincent, Chapter 9, pp. 355-435. Amsterdam: Elsevier Science, 2003.

[8] For an example of a carbon tax proposal, refer to Gilbert E. Metcalf, "A Proposal for a U.S. Carbon Tax Swap," The Hamilton Project Discussion Paper 2007-12.

[9] Interagency Working Group on Social Cost of Carbon, United States Government. 2010. Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.

would provide certainty about the marginal cost of compliance, which reduces uncertainty about returns to investment decisions, but would leave uncertain economy-wide emission levels.

The government could apply the carbon tax at a variety of points in the product cycle of fossil fuels, from fossil fuel suppliers based on the carbon content of fuel sales ("upstream" taxation/regulation) to final emitters at the point of energy generation ("downstream" taxation/regulation). Under an upstream approach, refineries and importers of petroleum products would pay a tax based on the carbon content of their gasoline, diesel fuel, or heating oil. Coal-mine operators would pay a tax reflecting the carbon content of the tons extracted at the mine mouth. Natural-gas companies would pay a tax reflecting the carbon content of the gas they bring to surface at the wellhead or import via pipelines or liquefied natural gas (LNG) terminals. Focusing on the carbon content of fuels enables the design to capture about 98% of U.S. CO_2 emissions with a relatively small number of covered firms – on the order of a few thousand – as opposed to the hundreds of millions of smokestacks, tailpipes, etc. that emit CO_2 after fossil fuel combustion. Such a tax approach could also cover other greenhouse gases.

A carbon tax would be administratively simple and straightforward to implement. The tax could incorporate existing methods for fuel-supply monitoring and reporting to the regulatory authority, possibly the U.S. Department of Energy. Given the molecular properties of fossil fuels, monitoring the physical quantities of these fuels yields a precise estimate of the emissions that would occur during their combustion. An emission tax would be similar in form to taxes that many fuel suppliers already pay,[10] so it would be easy for firms to understand and account for it in their operations.

[10] For example, U.S. petroleum refineries pay an 8¢ oil spill liability tax on every barrel of crude oil they refine. A carbon tax could piggyback on this existing tax. In effect, the government could collect about $4.30 per barrel for every $10/tCO2 of carbon tax at refineries. The administrative ease of employing the existing excise tax infrastructure may be an even more important issue for the design of emission mitigation policies in developing countries. On this, see: Joseph E. Aldy, Eduardo Ley, and Ian W.H. Parry. "A Tax-Based Approach to Slowing Global Climate Change." *National Tax Journal* 61(2008): 493-517.

A crediting system for downstream sequestration could complement the emission tax system. A firm that captures and stores CO_2 through geological sequestration, thereby preventing the gas from entering the atmosphere, could generate tradable CO_2 tax credits, and sell these to firms that would otherwise have to pay the emission tax. Similar approaches could be undertaken to promote biological sequestration in forestry and agriculture and potentially emission-reduction projects ("offsets") in other countries.

As fuel suppliers face the emission tax, they will increase the cost of the fuels they sell. This will effectively pass the tax down through the energy system, creating incentives for fuel-switching and investments in more energy-efficient technologies that reduce CO_2 emissions.

The impact of a carbon tax on emission mitigation and the economy will depend in part on the amount and use of the tax revenue. An economy-wide U.S. carbon tax of $20 per ton CO_2 would likely raise more than $100 billion per year. The carbon tax revenue could be put toward innumerable uses. The revenue could allow for reductions in existing distortionary taxes on labor and capital, thereby stimulating economic activity and offsetting some of a policy's social costs. For example, reducing the payroll tax by 2 percentage points in 2012 could be financed with an economy-wide carbon tax on the order of $15-20/ton of CO_2. Other socially valuable uses of revenue include reduction of debt, and funding desirable public programs, such as research and development of climate-friendly technology. The tax receipts could also be used compensate low-income households for the burden of higher energy prices, as well as compensating others bearing a disproportionate cost of the policy.

The implementation of a carbon tax (or cap-and-trade system) will increase the cost of consuming energy and could adversely affect the competitiveness of energy-intensive industries. This competitiveness effect can result in negative economic and environmental outcomes: firms may relocate facilities to countries without meaningful climate change policies, thereby increasing emissions in these new locations and offsetting some of the environmental benefits of the policy. This so-called "emission leakage" may actually be relatively modest, because a majority of the emissions in developed countries occur in non-traded sectors, such as electricity, transportation, and residential buildings. However, energy-intensive manufacturing industries that produce goods competing in international markets may face incentives to relocate.

Additional emission leakage may occur through international energy markets – as countries with climate policies reduce their consumption of fossil fuels and drive down fuel prices, those countries without emission mitigation policies may be induced to increase their consumption. Since leakage undermines the environmental effectiveness of any unilateral effort to mitigate emissions, international cooperation and coordination becomes all the more important. These competitiveness impacts on energy-intensive manufacturing could be mitigated through policy designs we discuss below.

3. **Designing a Cap-and-Trade Program**[11]

A cap-and-trade system constrains the aggregate emissions of regulated sources by creating a limited number of tradable emission allowances – in sum equal to the overall cap – and requiring those sources to surrender allowances to cover their emissions. Faced with the choice of surrendering an allowance or reducing emissions, firms place a value on an allowance that reflects the cost of the emission reductions that can be avoided by surrendering an allowance. Regardless of the initial allowance distribution, trading can lead allowances to be put toward their highest-valued use: covering those emissions that are the most costly to reduce and providing the incentive to undertake the least costly reductions.

In developing a cap-and-trade system, policymakers must decide on several elements of the system's design. Policymakers must determine how many allowances to issue – the size or level of the emission cap. Policymakers then must determine the scope of the cap's coverage: identify the types of

[11] For an example of a cap-and-trade proposal, refer to Robert N. Stavins, "A U.S. Cap-and-Trade System to Address Global Climate Change," The Hamilton Project Discussion Paper 2007-13.

greenhouse gas emissions and sources covered by the cap, including whether to regulate upstream (based on carbon content of fuels) or downstream (based on monitored emissions).

After determining the amount of allowances and scope of coverage, policymakers must determine whether to freely distribute or sell (auction) allowances. Free allocation of allowances to firms could reflect some historical record ("grandfathering"), such as recent fossil fuel sales. Such grandfathering involves a transfer of wealth, equal to the value of the allowances, to existing firms, whereas, with an auction, this same wealth is transferred to the government. The government would, in theory, collect revenue identical to that from a tax producing the same amount of emissions abatement. As with tax receipts, auction revenues could be used to reduce distortionary taxes or finance other programs.

In an emission trading program, cost uncertainty – unexpectedly high or volatile allowance prices – can undermine political support for climate policy and discourage investment in new technologies and research and development. Therefore, attention has turned to incorporating "cost-containment" measures in cap-and-trade systems, including offsets, allowance banking and borrowing, safety valves, and price collars.

An offset provision allows regulated entities to offset some of their emissions with credits from emission reduction measures lying outside the cap-and-trade system's scope of coverage. An offset provision can link a cap-and-trade system with an emission-reduction-credit system. Allowance banking and borrowing effectively permits emission trading across time. The flexibility to save an allowance for future use (banking) or to bring a future period allowance forward for current use (borrowing) can promote cost-effective abatement. Systems that allow banking and borrowing redefine the emission cap as a cap on cumulative emissions over a period of years, rather than a cap on annual emissions. This makes sense in the case of climate change, because it is a function of cumulative emissions of gases that remain in the atmosphere for decades to centuries.

A safety valve puts an upper bound on the costs that firms will incur to meet an emission cap by offering the option of purchasing additional allowances at a predetermined fee (the safety-valve "trigger price"). This effective price ceiling in the emission allowance market reflects a hybrid approach to climate policy: a cap-and-trade system that transitions to a tax in the presence of unexpectedly high mitigation costs. When firms exercise a safety valve, their aggregate emissions exceed the emission cap. A price collar combines the ceiling of a safety-valve with a price floor created by a minimum price in auction markets or a government commitment to purchase allowances at a specific price.

Increasing certainty about mitigation cost – through a carbon tax, safety valve or price collar – reduces certainty about the quantity of emissions allowed. Smoothing allowance prices over time through banking and borrowing reduces the certainty over emissions in any given year, but maintains certainty of aggregate emissions over a longer time period. A cost-effective policy with a mechanism insuring against unexpectedly high costs – either through cap-and-trade or a carbon tax – increases the likelihood that firms will comply with their obligations and can facilitate a country's participation and compliance in a global climate agreement.

In a similar fashion as under a carbon tax, domestic cap-and-trade programs could include some variant of a border tax to mitigate some of the adverse competitiveness impacts of a unilateral domestic climate policy and encourage trade partners to take on mitigation policies with comparable stringency. In the case of a cap-and-trade regime, the border adjustment would take the form of an import allowance requirement, so that imports would face the same regulatory costs as domestically-produced goods. Border measures under a carbon tax or cap-and-trade raise policy questions about the application of a trade "stick" to encourage broader and more extensive emission mitigation actions globally, as well as questions about their legality under the World Trade Organization.[12]

[12] For a discussion of relevant trade policy and legal questions, refer to: Lael Brainard and Isaac Sorking, eds., *Climate Change, Trade, and Competitiveness: Is a Collision Inevitable?* Brookings Institution Press, 2009; and Jeffrey Frankel, "Global Environment and Trade Policy," in Joseph E. Aldy and Robert N. Stavins, eds., *Post-Kyoto*

4. **Designing a Clean Energy Standard**[13]

The purpose of a clean energy standard is to establish a technology-oriented goal for the electricity sector that can be implemented cost-effectively. Under such standards, power plants generating power with technologies that satisfy the standard create tradable credits that they can sell to power plants that fail to meet the standard, thereby minimizing the costs of meeting the standard's goal in a manner analogous to cap-and-trade. An important distinction is that cap-and-trade establishes the policy goal in terms of the externality (greenhouse gas emissions), while clean energy standards establish the policy goal in terms of a set of technologies with zero- or low-emission characteristics.

For example, state renewable electricity standards (RESs), a restricted type of a clean energy standard, typically specify the objective of the standard as a specific renewable share of total power generation (that increases over time).[14] A few states have implemented alternative energy standards in their power sector that target renewables, new nuclear power generating capacity, and advanced fossil fuel power generating technologies. Proposals for national standards have targeted a combination of all power generating technologies except conventional coal.[15]

Clean energy standards that focus on technology targets do not explicitly price the greenhouse gas externality and thus impose a higher cost for a given amount of emission reductions than a carbon tax or cap-and-trade program. A renewable mandate treats coal-fired power, gas-fired power, and nuclear power as equivalent – none of these technologies create credits necessary for compliance –

International Climate Policy: Implementing Architectures for Agreement, pp. 493-529. New York: Cambridge University Press, 2010.

[13] For an example of a clean energy standard proposal, refer to Joseph E. Aldy, "Promoting Clean Energy in the American Power Sector," The Hamilton Project Discussion Paper 2011-04.

[14] See: U.S. Congressional Budget Office. *The Effects of Renewable or Clean Electricity Standards*. Washington, D.C., July 2011.

[15] Refer to the "American Clean Energy Leadership Act of 2009," S. 1462, 111th Congress, Section 132; the "Practical Energy and Climate Plan Act of 2010," S. 3464, 111th Congress, Section 301; and the 2011 State of the Union Address by President Obama.

despite the fact that a natural gas combined cycle power plant typically produces a unit of generation with half the CO_2 emissions of a conventional coal power plant, and a nuclear plant produces zero-emission power, as do wind, solar, and geothermal. Thus, mandating power from a limited portfolio of technologies can result in higher costs by providing no incentive to switch from emission-intensive coal to emission-lean gas or emission-free nuclear.

A more cost-effective approach to a clean energy standard would employ a technology-neutral performance standard, such as tons of CO_2 per megawatt hour of generation. All power sources, from fossil fuels to renewables, could be eligible under such a performance standard. This has the advantage over the portfolio approach of providing better innovation incentives and of enabling all possible ways of reducing the emissions intensity of power generation. The province of Alberta has employed such a tradable carbon performance standard for most large sources of CO_2 emissions and has required a 12% improvement in the emission intensity of these sources since 2007.

Power plants would be awarded credits for generating cleaner (less emissions-intensive) electricity than the standard. These clean power plants could sell credits to other power plants or save them for future use. Tradable credits promote cost-effectiveness by encouraging the greatest deployment of clean energy from those plants that can lower their emission intensity at lowest cost. Those power plants could then sell their extra credits to other power plants that face higher costs for deploying clean energy. The creation and sale of clean energy credits would provide a revenue stream that could conceivably enable the financing of low- and zero-emission power plant projects.

Eligible technologies for the standard could extend beyond generation technologies and also permit improvements in energy efficiency, or a broad set of emission offset activities, to create tradable credits. Extending the price on carbon to a broader set of activities could improve cost-effectiveness, but allowing for energy efficiency and other offsets poses risks. In both cases, estimating the offset is complex, requires extensive review and monitoring by third parties or regulatory agencies, and risks undermining the objective of a clean energy standard to the extent that some projects do not, in practice, deliver meaningful emission reductions. Offsets (emission-reduction-credits) aim to grant credits for what is not observed; since the counterfactual cannot be observed, there is uncertainty about the actual environmental integrity of an offset.

Monitoring and enforcement would be relatively straightforward under either a portfolio or performance standard approach. Electricity generation, generating technology type, and CO_2 emissions are already tracked at U.S. power plants by state and Federal regulators. A power plant could demonstrate compliance with a clean energy standard through a combination of the following approaches: (1) the power plant has lesser or equal emissions per megawatt hour than the standard set to drive clean energy deployment (or a share of clean energy power in excess of the minimum required); (2) the power plant purchases clean energy credits from other power plants such that the combination of clean energy credits and the power plant's own performance satisfies the standard; or (3) the power plant purchases additional clean energy credits from the Federal government at a preset price that, in combination with its own generation profile and purchased clean energy credits, would satisfy the standard. This is similar to the "alternative compliance payments" in a number of state electricity portfolio standards and akin to the hybrid safety valve approach under a cap-and-trade program. This could provide more certainty about compliance cost under a clean energy standard.

A clean energy standard represents a *de facto* free allocation of the right to emit greenhouse gases to the power sector. Suppose that the Federal government created a clean energy performance standard of 0.5 tons of CO_2 per megawatt hour (the 2010 U.S. power sector emission intensity was 0.56 tons of CO_2/MWh); this is comparable to a 50% clean energy standard that allows all technologies with lower emission intensity than conventional coal to qualify (with partial crediting for low- but non-zero emitting facilities). Every power plant implicitly receives the right to emit half a ton of CO_2 per megawatt hour of generation under such a standard, similar to an output-based allocation of emission allowances under cap-and-trade. Despite this free allocation, a clean energy standard could generate revenues though the alternative compliance payment mechanism that allows power plants to purchase additional clean energy credits at a preset price. These revenues could finance clean energy R&D and demonstration projects, as several states do through their renewable electricity and alternative energy portfolio standards, or provide for some modest deficit reduction.

5. Normative Criteria and Issues in Designing a Market-Based Climate Policies

5.1 Cost-Effectiveness

Market-based policies can provide for *cost-effective* attainment of policy goals. A carbon tax and cap-and-trade establish a common price for emitting a ton of CO_2 into the atmosphere, and the private sector has the flexibility to identify and exploit the least costly ways of reducing emissions. This approach is vastly superior to command-and-control regulatory mandates, and can result in lower costs per ton of CO_2 abated than a clean energy standard. Even a CES designed as a tradable carbon performance standard would be less cost-effective than cap-and-trade or a tax, because it does not provide a comparable incentive for efficiency and conservation. The implicit free allocation of the right to emit (equal to 0.5 tons of CO_2/MWh in the above example) is functionally an output-based subsidy that will result in more electricity generated and consumed than under cap-and-trade or a tax.

A renewable electricity standard is even less cost-effective, because it proscribes some low- and zero- emission technologies from the set of compliance options. In theory, an RES could mandate so much renewable power that it spurs a socially excessive amount of total generating capacity, lowers the price of electricity (at least in the short run), and causes a net increase in electricity consumption, contrary to the efficiency and conservation incentives under cost-effective approaches.

5.2 Efficiency

Cost-effective implementation is necessary but not sufficient for a climate policy to maximize net social benefits. A socially *efficient* policy would result in marginal costs equal to marginal benefits of emission reduction. To accomplish this the carbon price must be set equal to the estimated social cost of carbon (at the efficient level of control). Alternatively, a policymaker could set an emission cap that would deliver an expected allowance price equal to the estimated social cost of carbon. Under a clean energy standard, the stringency of the performance standard could be set to yield expected credit prices on par with the social cost of carbon, although there would still remain some efficiency losses due to the weaker incentive for efficiency and conservation.

A market-based policy may *raise revenue* to finance reductions in taxes that discourage the supply of labor and capital. Lowering payroll, income, or capital gains tax rates could offset some of the costs of a climate policy. A well-designed market-based policy with a modest carbon price and efficiently targeted reduction in tax rates could – in principle – cause a net increase in GDP, although in practice the more likely outcome is some savings in the policy's cost.[16] In general, recycling revenue back into the economy by lowering existing distortionary taxes can allow for a more aggressive greenhouse gas mitigation policy that maximizes net social benefits.

5.3 Uncertainty and Investment

In a world without uncertainty, a carbon tax and a cap-and-trade program could be designed and implemented to yield the exact same carbon price and emission reductions. But the choice of policy instrument can affect the net social benefits, given the real-world *uncertainty* that characterizes emission mitigation.[17] The government must implement a climate policy before uncertainty about the cost of emission mitigation can be resolved. If mitigation costs are higher than the government

[16] Lawrence H. Goulder and Ian W.H. Parry. "Instrument Choice in Environmental Policy." *Review of Environmental Economics and Policy*, 2008, volume 2, number 2, pp. 152-174.

[17] See: Martin L. Weitzman. "Prices vs. Quantities." *Review of Economic Studies 41*(1974): 477–491.

expected, then the climate policy will yield either: (a) fewer emission reductions if the government implemented a carbon tax; or (b) higher costs if the government implemented cap-and-trade. If the foregone economic benefits from fewer emission reductions under the tax are less than the higher costs under the cap-and-trade program, then a tax would be the preferred policy instrument so long as uncertainty about mitigation costs persists. In not, then cap-and-trade would likely maximize net social benefits relative to a carbon tax.

Uncertainty about the price of carbon inhibits private sector investment. In recent years, uncertainty about the type, design, and stringency of climate policy has adversely affected new energy and climate-related technology investment. Uncertainty about future modifications to a climate policy may also deter investment, especially for long-lived energy-related capital. For example, a future government could relax policy stringency (for example, a lower carbon tax or higher emission cap) that would lower the economic return to low- and zero-carbon technology investments. Alternatively, under a cap-and-trade regime, a future government could wipe out the value of an emission allowance bank (the allowances set aside and banked for future use), increasing the stringency of the cap-and-trade program, not unlike recent experience with the effect of regulatory changes on the U.S. SO_2 cap-and-trade program.

While the business community would prefer cost certainty, the environmental community prefers certainty over greenhouse gas emission levels. This reflects a much greater weight for emission reductions. It also reflects the concern of some in the environmental community that business will simply “buy its way out” under a carbon tax and fail to undertake emission mitigation, even though it may be in businesses’ economic interests to do so.

Real-world experience has addressed uncertainty by pursuing hybrid price-quantity approaches, such as state renewable energy standards that establish quantity renewable goals and include alternative compliance payments that serve as a price ceiling on tradable renewable energy credits.

Such hybrid approaches can provide insurance against the costs of a cap-and-trade or clean energy standard going unexpectedly high. They may also represent a way of imposing an implicit carbon tax if the safety valve mechanism for the climate policy is set at a level that has a very high probability of being triggered.

5.4 Policy Interactions

Although public policies are frequently proposed and analyzed in isolation, they in fact interact with one another in a number of very important ways, which can affect the environmental effectiveness of a policy as well as its costs. It is well known that policies of all kinds – both market-based instruments and conventional policies – act as implicit taxes and interact with pre-existing taxes in ways that drive up the costs of the policies. This is the so-called tax-interaction effect.[18] Those policy instruments that produce revenues for government, including carbon taxes and cap-and-trade with auctioned allowances, can dedicate part or all of their revenue to cutting existing, distortionary taxes, thereby offsetting some or – in principle – all of the tax-interaction effect. These interactions can have profound effects on the costs of a climate policy.[19]

In addition, quantity-based policies that provide flexibility, such as cap-and-trade systems and tradable clean energy standards, introduce another set of issues due to their interaction with other climate policies. In general, once a flexible, averaging type of policy instrument is in place, then any attempt to elicit greater reductions from some specific source or sector under the cap will essentially be undone by some other covered source or sector under the cap, because of allowed trading. However, by increasing marginal abatement costs at the specific source or sector, the overall flexible (cap-and-trade) regime is no longer cost-effective. This is a major issue for cap-and-trade systems, renewable

[18] See: Lawrence H. Goulder. "Environmental Taxation and the 'Double Dividend': A Reader's Guide." *International Tax and Public Finance* 2(2), August 1995.

[19] See: Goulder and Parry (2008).

electricity standards, clean energy standards, and motor-vehicle fuel efficiency standards. These problematic interactions can occur when one policy instrument is nested within another, as with sub-national policies and national policies,[20] and can also occur when two policy instruments co-exist within the same political jurisdiction.[21] These perverse interactions are potentially less severe with a carbon tax than with quantity-based policies because the multiple policies could yield a lower emission level than the carbon tax in isolation, but at the expense of cost-effectiveness.

5.5 International Coordination

Given the global commons nature of climate change, it is important that any U.S. policy actions be carefully coordinated with the actions or anticipated actions of other countries. Otherwise, U.S. policies may have no more than trivial environmental impacts (despite their cost) and can even have the effect of increasing the emissions of other countries, due to induced leakage of carbon-intensive economic activity.

Cap-and-trade systems seem to have emerged as the preferred national and regional instrument for reducing emissions of greenhouse gases throughout much of the industrialized world, and the Clean Development Mechanism (CDM) — an international emission-reduction-credit system — has developed a substantial constituency, despite some concerns about its performance. Because linkage between tradable permit systems (that is, unilateral or bilateral recognition of allowances from one system for use in another) can reduce compliance costs and improve market liquidity, there is great

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[20] See: Lawrence H. Goulder and Robert N. Stavins. "Challenges from State-Federal Interactions in U.S. Climate Change Policy." *American Economic Review Papers and Proceedings* 101:3, 2011, pp. 253-257; and Meghan McGuinness and A. Denny Ellerman. "The Effects of Interactions between Federal and State Climate Policies." Massachusetts Institute of Technology Center for Energy and Environmental Policy Research Working Paper WP-2008-004, 2008.

[21] See: Carolyn Fischer and Louis Preonas. "Combining Policies for Renewable Energy: Is the Whole Less than the Sum of Its Parts?" *International Review of Environmental and Resource Economics*, 4(1), 2010, pp. 51-92; Arik Levinson. "Interactions Among Climate Policy Regulations." *NBER Working Paper 16109*, National Bureau of Economic Research, 2010; and Organization for Economic Cooperation and Development. *Interactions Between Emission Trading Systems and Other Overlapping Policy Instruments*. Environment Directorate, OECD, Paris, 2011.

interest in linking cap-and-trade systems with each other, as well as to the CDM and other credit systems. There are not only benefits but also concerns associated with various types of linkages,[22] but it is safe to say that such linkage may play one of three possible roles: as an independent bottom-up international climate policy architecture; as a step in the evolution of a top-down architecture; or as an ongoing element of a larger climate policy agreement.

A parallel set of issues arise with national or sub-national carbon taxes, namely, they can be linked in ways that are productive. For purposes of overall cost-effectiveness, the various taxes would need to be set at the same level, that is, harmonized.[23] The prospect of harmonization is complicated by equity issues (Would developing countries harmonize taxes without some form of side payments?) and related tax issues (How might carbon tax harmonization account for pre-existing energy subsidies in developing countries and high pre-existing energy taxes in some developed countries?).

In reality, there are a variety of policy instruments – both market-based and conventional command-and-control – that countries can employ to reduce their GHG emissions. Hence, it is important to ask whether a diverse set of heterogeneous national, sub-national, or regional climate policy instruments can be linked in productive ways. The basic answer is that such a set of instruments can be linked, but the linkage is considerably more difficult than it is with a set of more homogeneous tradable permit systems.[24] In fact, the basic approach behind emission reduction credit systems such as

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[22] See: Judson Jaffe, Matthew Ranson, and Robert Stavins. "Linking Tradable Permit Systems: A Key Element of Emerging International Climate Policy Architecture." *Ecology Law Quarterly* 36(2010):789-808.

[23] See: Richard N. Cooper. "The Case for Charges on Greenhouse Gas Emissions." Joseph E. Aldy and Robert N. Stavins, eds., *Post-Kyoto International Climate Policy: Implementing Architectures for Agreement*, pp. 151-178. New York: Cambridge University Press, 2010.

[24] See: Robert W. Hahn and Robert N. Stavins. *What Has the Kyoto Protocol Wrought? The Real Architecture of International Tradeable Permit Markets*. Washington, D.C.: The AEI Press, 1999.

the CDM and Joint Implementation (JI) can be extended to foster linkage opportunities among diverse policy instruments, including cap-and-trade, taxes, and certain regulatory systems.[25]

Another form of coordination can be unilateral instruments of economic protection, that is, border adjustments. In the case of a national carbon tax, this would take the form of a tax on imports that was equivalent to the implicit tax on the same domestically produced goods. In the case of a cap-and-trade system, this would take the form of an import-allowance-requirement, as it did in H.R. 2454, the climate cap-and-trade legislation passed by the U.S. House of Representatives in June, 2009. In that case, only a limited set of manufactured bulk products were covered, namely those that were judged to be both carbon-intensive in their production and subject to significant international competition.

6. **Political Factors in Designing a Market-Based Climate Policy**

6.1 Allocation of Rents

Political factors are, of course, at the heart of policy feasibility in a democracy. In general, it may be necessary to elicit support from concentrated interests.[26] A key question is whether the process of developing such support leads to the reduction in a policy's effectiveness (such as through muting the price signals of a market-based instrument) or increases its cost. This is frequently the case. However, a key merit of one of the policy instruments we consider in this article – namely, cap-and-trade – is that under many circumstances the process of developing political support need not lead to the impairment of the policy. This is because of a very important property of such systems: the independence of the equilibrium allocation of allowances after trading from the initial allocation.[27] This means that the

[25] See: Gilbert E. Metcalf and David Weisbach. "Linking Policies When Tastes Differ: Global Climate Policy in a Heterogeneous World." Discussion Paper 2010-38, Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School, July 2010.

[26] See: Nathaniel Keohane, Richard Revesz, and Robert Stavins. "The Choice of Regulatory Instruments in Environmental Policy." *Harvard Environmental Law Review*, volume 22, number 2, pp. 313-367, 1998.

[27] See: David W. Montgomery. "Markets in Licenses and Efficient Pollution Control Programs". *Journal of Economic Theory* (1972): 395-418.

legislature can distribute the allowances in a way that builds a constituency of political support for enactment without jeopardizing the policy's environmental integrity or its cost-effectiveness.[28]

At the same time, it is important to recognize that those market-based policy instruments that raise revenues for government – including taxes and auctioned allowances – can have their own political attraction, particularly at a time of chronic government budgetary deficits.

6.2 Distributional Impacts and the Visibility of Costs

Any public policy – whether cost-effective or not – will inevitably have significant distributional consequences, even if it does no more than reinforce the status quo. In the case of U.S. climate change policy, the near-term distributional impacts will primarily reflect the cost of mitigating emissions. The climate benefits to any single nation of its emission-reduction efforts will be spread globally and over a number of generations. Any meaningful climate policy will have the effect of increasing energy prices, particularly increasing the cost of energy derived from coal combustion and, to a lesser extent, petroleum and natural gas combustion, but mitigation policies would also benefit firms (and some regions) with zero-carbon technologies, such as wind, solar, and energy efficiency. The economic incidence of such energy price increases will make up a considerable share of the distributional impacts. These impacts will vary across sectors of the economy, across regions of the nation, and across income groups, and are likely to have profound political impacts on the feasibility of climate policy and the choice among climate policy instruments.

Give the political economy implications of the costs with various policy instruments, there are strong incentives for public officials to identify and select policies and instruments that minimize at least

[28] There are, however, certain circumstances in which this independence axiom fails. On this, see: Robert W. Hahn and Robert N. Stavins. "The Effect of Allowance Allocations on Cap-and-Trade System Performance." *The Journal of Law and Economics*, forthcoming. In some cases, the tax-interaction and revenue recycling impacts of the choice of free allowance allocation could significantly undermine cost-effectiveness. On this, see: Lawrence H. Goulder, Ian W.H. Parry, Roberton C. Williams III, and Dallas Burtraw. "The Cost-Effectiveness of Alternative Instruments for Environmental Protection in a Second-Best Setting." *Journal of Public Economics* 72(1999): 329-360.

the perceived costs of policies. Of course, this can be accomplished – in some cases – by implementing policies and/or policy instruments that are indeed low-cost, either because they are essentially unambitious or because they are relatively cost-effective.

This can also be accomplished by identifying policy instruments that hide or at least partially obscure their costs. Indeed, this appears to be one of the major reasons why ordinary performance and technology standards have for so long been favored over market-based instruments.[29] A prime example is the apparent political attraction of Corporate Average Fuel Economy standards as a means of increasing the fuel efficiency of American automobiles, in contrast with the political aversion to gasoline taxes, even though the latter would accomplish more at lower cost (but in a highly visible manner).[30]

6.3 Threat of Higher Costs

Public and political interest in a market-based policy instrument may respond positively to the threat of a high-cost regulatory alternative. The business community may prefer a more cost-effective (and hence potentially lower cost) market-based policy to traditional command-and-control regulation. Some in the environmental community may also support a cost-effective policy if it enables a more ambitious environmental goal than possible under a conventional regulatory mandate.

During the policy debate over the 1990 Clean Air Act Amendments, the prospect of a costly regulatory standard for power plant SO_2 emissions prompted interest in a cap-and-trade regime that became the centerpiece of the law's approach to combat acid rain. Building on the successful experience with SO_2 cap-and-trade, the Environmental Protection Agency worked with Northeastern, Mid-Atlantic, and Midwestern states to design a nitrogen oxide emissions cap-and-trade program to reduce ground-level ozone pollution (smog). While states had the option to implement a conventional

[29] See: Keohane, Revesz, and Stavins 1998.

[30] See: Robert Crandall. "Policy Watch: Corporate Average Fuel Economy Standards." *Journal of Economic Perspectives* 6(1992): 171-180 and Mark R. Jacobsen. "Evaluating U.S. Fuel Economy Standards in a Model with Producer and Household Heterogeneity." UC – San Diego Department of Economics Working Paper, September 2010.

command-and-control regulation in lieu of joining the cap-and-trade regime, every state chose to pursue the more cost-effective trading approach.

The threat of a high-cost regulatory alternative for greenhouse gas emissions could influence the potential interest in a market-based policy approach. First, EPA could design regulations under the existing Clean Air Act that include some form of cap-and-trade or a variant of a clean energy standard. While existing law would circumscribe some potentially appealing attributes of a market-based climate policy (including revenue generation and cost containment through a safety valve) as well as prohibit a carbon tax outright, it could allow for a more cost-effective approach than conventional regulatory mandates. Second, the risk of a politically (and potentially economically) unpalatable regulatory scheme under the Clean Air Act may also mobilize interest in a legislative alternative.

6.4 Navigating the Federal Government

Pursuing a legislative option through Congress could involve a variety of legislative committees that would engage a variety of special interests. Consider the example of the Senate. A carbon tax bill would likely start in the Finance Committee, a cap-and-trade bill would likely start in the Environment and Public Works (EPW) Committee, and a clean energy standard bill would likely start in the Energy and Natural Resources Committee. If a cap-and-trade or clean energy standard bill raises significant revenue, it would likely be referred to the Finance Committee, while any bill that modifies the Clean Air Act (for example, by substituting a market-based policy for existing statutory authority) would likely be referred to the Environment and Public Works Committee. The committee that starts drafting a bill will shape it in line with its priorities – for example, revenue-raising for Finance, ambitious environmental goals for EPW – and the persistence of policy design as a bill moves through the legislative process would result in a final law reflecting those initial efforts.

6.5 Gradual Ramp-Up of Stringency

A successful effort in designing and implementing a market-based policy would also benefit from the positive experiences on other policy fronts related to the gradual ramp-up in policy stringency. British Columbia implemented a carbon tax in 2008 at C$10 per ton of carbon dioxide (tCO_2) and increasing annually until reaching C$30/$tCO_2$ in 2012. To complement this gradual implementation of the policy, in the month before tax collection began, the provincial government provided checks to households representing the revenue expected to be raised by the tax in the first year. As the carbon tax revenue has increased, households and businesses have enjoyed larger reductions in their income taxes.

The SO_2 cap-and-trade program was phased in over two time periods, with the largest power plants covered by the program starting in 1995, and the balance of the covered facilities entering the program in 2000. The EU CO_2 Emission Trading Scheme began with a pilot phase in 2005 that imposed a relatively lax emission cap to enable time for covered facilities and government regulators to gain experience with the trading regime before moving into a more stringent second phase in 2008. State renewable electricity and alternative energy standards have likewise started with relatively modest goals – the average renewable target for the 24 operational state programs in 2010 was about 4.7% – but will ramp-up by a factor of three by 2020.

7. What Will the Future Hold for Market-Based Policy Instruments?

The U.S. political response to possible market-based approaches to climate policy has been and will continue to be largely a function of issues and structural factors that transcend the scope of environmental and climate policy. Because a truly meaningful climate policy – whether market-based or conventional in design – will have significant impacts on economic activity in a wide variety of sectors (because of the pervasiveness of energy use in a modern economy) and in every region of the country, it is not surprising that proposals for such policies bring forth significant opposition, particularly during difficult economic times.

In addition, U.S. political polarization – which began some four decades ago, and accelerated during the economic downturn – has decimated what had long been the key political constituency in the Congress for environmental (and energy) action, namely, the middle, including both moderate Republicans and moderate Democrats.[31] Whereas Congressional debates about environmental and energy policy had long featured regional politics, they are now fully and simply partisan. In this political maelstrom, the failure of cap-and-trade climate policy in the U.S. Senate in 2010 was essentially collateral damage in a much larger political war.

That said, it is possible that better economic times will reduce the pace – if not the direction – of political polarization. Furthermore, it is also possible that the ongoing challenge of large Federal budgetary deficits will at some point increase the political feasibility of new sources of revenue. When and if this happens, consumption taxes (as opposed to traditional taxes on income and investment) could receive heightened attention, and primary among these might be energy taxes, which can be significant climate policy instruments, depending upon their design.

Some would argue that a mobilizing event will soon precipitate U.S. climate policy action. But the nature of the climate change problem itself helps explain much of the relative apathy among the U.S. public and suggests that any such mobilizing event may come "too late." Nearly all of our major environmental laws have been passed in the wake of highly-publicized environmental events or "disasters," including the spontaneous combustion of the Cuyahoga River in Cleveland, Ohio, in 1969, and the discovery of toxic substances at Love Canal in Niagara Falls, New York, in the mid-1970s. But note that the day after Cleveland's Cuyahoga River caught on fire, no article in *The Cleveland Plain Dealer* commented that the cause was uncertain, because rivers periodically catch on fire from natural

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[31] See: Robert N. Stavins. "Polarized Politics Paralyze Policy." *The Environmental Forum,* Volume 28, Number 6, November/December 2011, p. 16.

causes. On the contrary, it was immediately apparent that the cause was waste dumped into the river by adjacent industries. A direct consequence of the observed "disaster" was, of course, the Clean Water Act of 1972.

Climate change is distinctly different. Unlike the environmental threats addressed successfully in past U.S. legislation, climate change is essentially unobservable. We all observe the weather, not the climate. Until there is an obvious and sudden event — such as a loss of part of the Antarctic ice sheet leading to a dramatic sea-level rise — it is unlikely that public opinion in the United States will provide the bottom-up demand for action that has inspired previous Congressional action on the environment over the past forty years.

Despite this somewhat bleak assessment of the politics of climate change policy in the United States, it is much too soon to speculate on what the future will hold for the use of market-based policy instruments, whether for climate change or for other environmental problems. On the one hand, it is conceivable that two decades (1988-2008) of high receptivity in U.S. politics to cap-and-trade and offset mechanisms will turn out to be no more than a relatively brief departure from a long-term trend of reliance on conventional means of regulation. On the other hand, it is also possible that the recent tarnishing of cap-and-trade in national political dialogue will itself turn out to be a temporary departure from a long-term trend of increasing reliance on market-based environmental policy instruments. Perhaps the ongoing interest in these policy mechanisms in California (Assembly Bill 32), the Northeast (Regional Greenhouse Gas Initiative), Europe, and other countries will form a bridge to a changed political climate in Washington.