The Economic and Environmental Effects of Border Tax Adjustments for Climate Policy

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Abstract

For the foreseeable future, climate change policy will be considerably more stringent in some countries than in others. Indeed, the United Nations Framework Convention on Climate Change explicitly states that developed countries must take meaningful action before any obligations are to be placed on developing countries. However, differences in climate policy will lead to differences in energy costs, and to concerns about competitive advantage. In high-cost countries, there will be political pressure to impose border adjustments, or “green tariffs”, on imports from countries with little or no climate policy and low energy costs. The adjustments would be based on the carbon emissions associated with production of each imported product, and would be intended to match the cost increase that would have occurred had the exporting country adopted a climate policy similar to that of the importing country. In this paper, we estimate how large such tariffs would be in practice, and then examine their economic and environmental effects using G-Cubed, a detailed multi-sector, multi-country model of the world economy. We find that the tariffs would be small on most traded goods, would reduce leakage of emissions reduction very modestly, and would do little to protect import-competing industries. We conclude that the benefits produced by border adjustments would be too small to justify their administrative complexity or their deleterious effects on international trade.

1 Introduction

For the foreseeable future, climate change policy will be considerably more stringent in some countries than in others. Indeed, the United Nations Framework Convention on Climate Change explicitly states that developed countries must take meaningful action before any obligations are to be placed on developing countries.

However, differences in climate policy will lead to differences in energy costs, and to concerns about competitive advantage. In high-cost countries, there will be political pressure to impose border tax adjustments, or "green tariffs", on imports from countries with little or no climate policy and low energy costs. The adjustments would be based on the carbon emissions associated with production of each imported product, and would be intended to match the cost increase that would have occurred had the exporting country adopted a climate policy similar to that of the importing country.

Several justifications have been proposed for including border tax adjustments (BTAs) as a key component of climate policy. Some authors, including Stiglitz (2006), Kopp and Pizer (2007), and Ismer and Neuhoff (2007) argue that border tax adjustments are required for economic efficiency in carbon abatement. An alternative argument is that adjustments are needed to keep climate policy from being undermined by "leakage" of emissions through migration of carbon-intensive industries to low-tax countries and, as a corollary, to protect import-competing industries in high-tax countries; for example, see Goh (2004), Hoerner (1998) Demailly and Quirion (2008). There are also a number of papers that argue that the approach could be used to punish countries that did not participate in the Kyoto Protocol, or could be used as a threat to encourage recalcitrant countries to join a global regime; for example, see Brack et al (2000), Hontelez (2008) and the discussion in Charnovitz (2003). Finally, there is also a considerable literature debating the legality of border tax adjustments for climate polices under WTO rules; see Biermann and Brohm (2005), Brewer (1998), Frankel (2005), Goh (2004), or Hoerner(1998).

These arguments are reflected in the political debate in Europe and the US. In 2006 then-French Prime Minister Dominique de Villepin suggested that countries that do not join a post-2012 international treaty on climate change should face additional tariffs on their industrial exports. The European Parliament's (2005/2049) resolution was focused on penalizing countries such as United States for non-participation in the Kyoto Protocol. In the United States, both the Bingaman-Specter bill (Senate 1766) and the Leiberman-Warner bill (Senate 2191) include mechanisms that would, in effect, impose border tax adjustments under some circumstances for imported goods from countries deemed to be making insufficient effort to reduce their greenhouse gas emissions[1].

Most of the arguments in the literature, however, have been theoretical. Little empirical work has been done to determine either the magnitude that border adjustments would take in practice, or on the economic and environmental consequences they would cause. This gap leads to range of important questions. Would border tax adjustments actually improve global carbon abatement? How much would they help or hurt the economic of the country imposing them? How much would they help or hurt the global economy? Are the gains, if any, large enough to justify the administrative costs involved?[2] In this paper, we address several of these questions. We estimate how large such tariffs would be in practice[3], and then examine their economic and environmental effects using G-Cubed, a detailed multi-sector, multi-country model of the world

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[1] See the discussion in Brewer (2008).

[2] Other studies (e.g. Levinson and Taylor (2008)) have examined the "pollution haven hypothesis" for more general environmental regulation econometrically however because carbon policy is relatively new, we use an empirical structural model and simulation analysis to uncover the relationships.

economy. We find that the tariffs would be small on most traded goods, would reduce leakage of emissions reduction very modestly, and would do little to protect import-competing industries. We conclude that the benefits produced by border adjustments would be too small to justify their administrative complexity or their deleterious effects on international trade and the potentially damaging consequences for the robustness of the global trading system.

In a sense, these results are not surprising[4] since most carbon emissions are from domestic activities such as electricity generation and local and regional transportation, which are largely non-traded and are little affected by international trade[5]. In practice, the most important mechanism through which leakage could occur would be world oil markets, not trade in manufactured goods. A sufficiently large carbon tax imposed in a major economy would lower global oil prices and lead to higher consumption in countries with little or no carbon tax. However, border tax adjustments would be neither appropriate nor effective at reducing that form of leakage. We conclude that it is an unnecessary distraction for the global community to focus much attention on negotiations over border tax adjustments as a component of climate policy: they wouldn’t matter much in practice and, as also argued by Lockwood and Whalley (2008), they may lead to greater distortions to the global trading system.

2 An Overview of the G-Cubed Model

G-Cubed is an econometric intertemporal general equilibrium model of the world economy with regional disaggregation and sectoral detail. Prior to this project, it divided the world economy into the ten regions shown in Table 1. Each region is further decomposed into a

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[3] This paper focuses only on import adjustment. For a discussion of the problems that arise with adjustment to exports in order to maintain competitiveness see Pearce and McKibbin (2007)

[4] These results of the damaging effect on trade are also found in Droge and Kemfert (2005).

[5] This point on the scale of leakage was made in McKibbin and Wilcoxen (1997).

household sector, a government sector, a financial sector, the twelve industries shown in Table 2, and a capital-goods producing sector. To facilitate analysis of energy and environmental policy, five of the industries are used to represent segments of the energy industry: electric utilities, natural gas utilities, petroleum refining, coal mining, and crude oil and gas extraction. All regions are linked through bilateral trade and financial markets. All relevant budget constraints are imposed on households, governments and nations (the latter through accumulations of foreign debt). Households and firms have forward-looking expectations and use these projections when planning consumption and investment decisions. However, a portion of the households and firms are assumed to be liquidity constrained. G-Cubed's theoretical and empirical structure is described in more detail in McKibbin and Wilcoxen (1998). In the remainder of this section we present an overview of its key features.

2.1 Producer Behavior

Each producing sector in each region is modeled by a representative firm which chooses its inputs and its level of investment in order to maximize its stock market value subject to a multiple-input production function and a vector of prices it takes to be exogenous. We assume that output can be represented by a constant elasticity of substitution (CES) function of inputs of capital (K), labor (L), energy (E) and materials (M). Omitting industry and country subscripts the production has the following form:

(1) $$Q = A_O \left(\sum_{j=K,L,E,M} \delta_j^{1/\sigma_O} X_j^{(\sigma_O - 1)/\sigma_O} \right)^{\frac{\sigma_O}{(\sigma_O - 1)}}$$

where Q is the industry's output, X_j is the quantity of input j, and A_O, δ_j and σ_O are estimated parameters which vary across industries. In addition, the A_O and δ parameters vary across countries. Without loss of generality we constrain the δ's to sum to one.

Energy and materials, in turn, are CES aggregates of inputs of intermediate goods and services. The form of the function is the same as for the output tier but the inputs and estimated parameters are different. For energy:

$$X_E = A_E \left(\sum_{j=1}^{5} \delta_j^{1/\sigma_E} X_j^{(\sigma_E - 1)/\sigma_E} \right)^{\frac{\sigma_E}{(\sigma_E - 1)}} \tag{2}$$

where X_E is the industry's input of energy, X_j is the quantity of input j, and A_E, δ_j and σ_E are estimated parameters which vary across industries. As before, A_E and the δ parameters also vary across countries. The materials aggregation is defined in a similar manner.

The parameters in these equations were estimated using a time-series data set on prices, industry outputs, value-added, and commodity inputs to industries for the United States. A detailed discussion of the dataset can be found in McKibbin and Wilcoxen (1998). To parameterize the other regions we imposed the restriction that substitution elasticities are equal throughout the world. In other words, we assumed that each industry has the same energy, materials and KLEM substitution elasticities no matter where it is located. This is consistent with the econometric evidence of Kim and Lau in a number of papers (see, for example, Kim and Lau 1994).

However, the share parameters for other regions corresponding to individual countries (Japan, Australia, China, India and approximately the Eastern Europe and Former Soviet Union region) were derived from input-output data for those regions and are not set equal to their U.S.

counterparts. The share parameters for the remaining regions, which are aggregates of individual countries, were calculated by adjusting U.S. share parameters to account for actual final demand components from the aggregate national accounts data for each of the regions.

Although the substitution elasticities are identical across countries, the overall production models are not identical because we obtain the other production parameters (the δ's above) from the latest available input-output data for each country or region.[6] Thus, the durable goods sectors in the United States and Japan, for example, have identical substitution elasticities but different sets of δ parameters. The consequence of this is that the cost shares of inputs to a given industry are based on data for the country in which the industry operates, but the industry's response to price changes is identical across countries.

In effect, we assumed that all regions share production methods that differ in first-order properties but have identical second-order characteristics. This is intermediate between the extremes of assuming that the regions share common technologies and of allowing the technologies to differ across regions in arbitrary ways. Finally, the regions also differ in their endowments of primary factors and patterns of final demands. The main limitation of this approach is that there are very few benchmark input-output tables so our data set contains few observations. The problem is severe outside OECD countries.

Maximizing the firm's short run profit subject to its capital stock and the production functions above gives the firm's factor demand equations. At this point we add two further levels of detail: we assume that domestic and imported inputs of a given commodity are imperfect substitutes, and that imported products from different countries are imperfect substitutes for each

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[6] Input-output tables were not available for the regions in the model larger than individual countries. The δ parameters for those regions were calculated by adjusting U.S. share parameters to account for actual final demand components from the aggregate national accounts data for each of the regions.

other. Thus, the final decision the firm must make is the fraction of each of its inputs to buy from each region in the model (including the firm's home country). We represent this decision using a two-tier CES function, although in this version of the model the substitution elasticities have been set to unity due to data limitations. We assume that all agents in the economy have identical preferences over foreign and domestic varieties of each particular commodity.[7] We parameterize this decision using trade shares based on aggregations of the 4-digit level of the United Nations SITC data for 1987. We also develop a synthetic matrix for bilateral service flows that are consistent with the trade data and the National Accounts data for each country on the total trade in goods and non-factor services. The result is a system of demand equations for domestic output and imports from each other region.

In addition to buying inputs and producing output, each sector must also choose its level of investment. We assume that capital is specific to each sector, that investment is subject to adjustment costs, and that firms choose their investment paths in order to maximize their market value. In addition, each industry faces the usual constraint on its accumulation of capital that the change in the capital stock is equal to gross investment less depreciation.

Following the cost of adjustment models of Lucas (1967), Treadway (1969) and Uzawa (1969) we assume that the investment process is subject to rising marginal costs of installation. To formalize this we adopt Uzawa's approach by assuming that in order to install J units of capital the firm must buy a larger quantity, I. The difference between J and I may be interpreted many ways; we will view it as installation services provided by the capital vendor.

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[7] Anything else would require time-series data on imports of products from each country of origin to each industry, which is not only unavailable but difficult to imagine collecting.

Setting up and solving the firm's investment problem yields an investment decision that depends on production parameters, taxes, the current capital stock, and marginal q (the ratio of the marginal value of a unit of capital to its purchase price).

Following Hayashi (1979), the investment function above is modified to improve its empirical properties by writing J as a function not only of q, but also of its current capital income. This improves the empirical behavior of the specification and is consistent with the existence of firms that are unable to borrow and therefore invest purely out of retained earnings. The weight on optimizing behavior, α, was taken to be 0.3 based on a range of empirical estimates reported by McKibbin and Sachs (1991).

In addition to the twelve industries discussed above, the model also includes a special sector that produces capital goods. This sector supplies the new investment goods demanded by other industries. Like other industries, the investment sector demands labor and capital services as well as intermediate inputs. We represent its behavior using a nested CES production function with the same structure as that used for the other sectors. However, we estimate the parameters of this function from price and quantity data for the final demand column for investment.

2.2 Households and Governments

Households consume a basket of composite goods and services in every period and also demand labor and capital services. Household capital services consist of the service flows of consumer durables and residential housing. Households receive income by providing labor services to firms and the government, and from holding financial assets. In addition, they receive imputed income from ownership of durables and housing, and they also receive transfers from their region’s government.

Within each region we assume household behavior can be modeled by a representative agent who maximizes an intertemporal utility function subject to the constraint that the present value of consumption be equal to the sum of human wealth and initial financial assets. Human wealth is the present value of the future stream of after-tax labor income and transfer payments received by households. Financial wealth is the sum of real money balances, real government bonds in the hands of the public,[8] net holdings of claims against foreign residents and the value of capital in each sector.

There has, however, been considerable debate about whether the actual behavior of aggregate consumption is consistent with the permanent income model.[9] Based on the evidence cited in Campbell and Mankiw (1990), we modify the basic household model described above to allow a portion of household consumption to depend entirely on current after-tax income (rather than on wealth). This could be interpreted in various ways, including the presence of liquidity-constrained households or households with myopic expectations. For the purposes of this paper we will not adopt any particular explanation and will simply take the income-driven share of consumption to be an exogenous constant. Following McKibbin and Sachs (1991) we take the share to be 0.7 in all regions.[10]

Within each period, the household allocates expenditure among goods and services in order to its intratemporal utility. In this version of the model we assume that intratemporal utility may be represented by a Cobb-Douglas function of goods and services.[11]

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[8] Ricardian neutrality does not hold in this model because some consumers are liquidity-constrained.

[9] Some of the key papers in this debate are Hall (1978), Flavin (1981), Hayashi (1982), and Cambell and Mankiw (1990).

[10] Our value is somewhat lower than Campbell and Mankiw's estimate of 0.5.

[11] This specification has the undesirable effect of imposing unitary income and price elasticities.

Finally, the supply of household capital services is determined by consumers themselves who invest in household capital. We assume households choose their level of investment to maximize the present value of future household capital service flows (taken to be proportional to the household capital stock), and that investment in household capital is subject to adjustment costs. In other words, the household investment decision is symmetrical with that of the firms.

2.3 Government

We take each region's real government spending on goods and services to be exogenous and assume that it is allocated among final goods, services and labor in fixed proportions according to the base year input-output table for each region. Total government spending includes purchases of goods and services plus interest payments on government debt, investment tax credits and transfers to households. Government revenue comes from sales, corporate, and personal income taxes, and by issuing government debt. In addition, there can be taxes on externalities such as carbon dioxide emissions. We assume that agents will not hold government bonds unless they expect the bonds to be serviced, and accordingly impose a transversality condition on the accumulation of public debt in each region that has the effect of causing the stock of debt at each point in time to be equal to the present value of all future budget surpluses from that time forward. This condition alone, however, is insufficient to determine the time path of future surpluses: the government could pay off the debt by briefly raising taxes a lot; it could permanently raise taxes a small amount; or it could use some other policy. We assume that the government levies a lump sum tax in each period equal to the value of interest payments on the outstanding debt. In effect, therefore, any increase in government debt is financed by consols, and future taxes are raised enough to accommodate the increased interest costs. Thus, any increase in the debt will be matched by an equal present value increase in future budget surpluses.

2.4 Macroeconomic Features: Labor Market Equilibrium and Money Demand

We assume that labor is perfectly mobile among sectors within each region but is immobile between regions. Thus, within each region wages will be equal across sectors. The nominal wage is assumed to adjust slowly according to an overlapping contracts model where nominal wages are set based on current and expected inflation and on labor demand relative to labor supply. In the long run labor supply is given by the exogenous rate of population growth, but in the short run the hours worked can fluctuate depending on the demand for labor. For a given nominal wage, the demand for labor will determine short-run unemployment.

Relative to other general equilibrium models, this specification is unusual in allowing for involuntary unemployment. We adopted this approach because we are particularly interested in the transition dynamics of the world economy. The alternative of assuming that all economies are always at full employment, which might be fine for a long-run model, is clearly inappropriate during the first few years after a shock.

Finally, because we our wage equation depends on the rate of expected inflation, we need to include money demand and supply in the model. We assume that money demand arises from the need to carry out transactions and depends positively on aggregate output and negatively on the interest rate. The supply of money is determined by the balance sheet of the central bank and is exogenous.

2.5 International Trade and Asset Flows

The regions in the model are linked by flows of goods and assets. Each country's exports are differentiated from those of other countries; exports of durables from Japan, for example, are not perfect substitutes for exports of durables from Europe. Each region may import each of the twelve goods from potentially all of the other regions. In terms of the way international trade data is often expressed, our model endogenously generates a set of twelve bilateral trade matrices, one for each good. The values in these matrices are determined by the import demands generated within each region.

Trade imbalances are financed by flows of assets between countries. We assume that asset markets are perfectly integrated across the regions and that financial capital is freely mobile.[12] Under this assumption, expected returns on loans denominated in the currencies of the various regions must be equalized period to period according to a set of interest arbitrage relations of the following form:

$$i_k = i_j + \frac{dE_k^j / dt}{E_k^j} \tag{3}$$

where E_k^j is the exchange rate between currencies of countries k and j. In generating the baseline of the model we allow for risk premiums on the assets of alternative currencies, although in counterfactual simulations of the model, these risk premiums are generally assumed to be constant and unaffected by the shocks we consider.

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[12] The mobility of international capital is a subject of considerable debate; see Gordon and Bovenberg (1994) or Feldstein and Horioka (1980). Also, this assumption should not be confused with our treatment of *physical* capital, which we assume to be specific to sectors and regions and hence completely immobile. The consequence of assuming mobile financial capital and immobile physical capital is that there can be windfall gains and losses to owners of physical capital. For example, if a shock adversely affects profits in a particular industry, the physical

For all regions other than China, we assume that exchange rates are free to float and that financial capital is freely mobile. This may appear less plausible for developing countries than it does for the OECD since many developing countries have restrictions on short-term flows of financial capital. However, the capital flows in our model are the sum of short-term portfolio investment and foreign direct investment, and the latter is usually subject to fewer restrictions. In many countries with constraints on financial instruments there are large flows of direct foreign investment responding to changes in expected rates of return. We assume that China pegs its exchange rate to the dollar, which is closer to the recent historical record than the assumption of floating exchange rates.

3 Calculating the Carbon Content of Traded Goods

In general, border adjustments are used to compensate for differences between countries in the taxes levied on goods, such as excise taxes or value added taxes. Exporting countries may exempt traded goods from such taxes, or rebate taxes already collected, and importing countries may impose taxes equivalent to what would have been charged had the product been produced domestically. In this paper, we examine only adjustments on imports and assume that carbon taxes are not rebated on exports. However, our methodology could be applied to export rebates as well.

The first step in computing a carbon-tax border adjustment on a given import would be to determine the total amount of fossil energy that was used directly or indirectly in production of the good. Measuring direct energy consumption is relatively straightforward: a Boeing 777 aircraft, for example, requires direct use of energy when it is assembled. However, energy is

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capital stock in that sector will initially be unaffected. Its value, however, will immediately drop by enough to bring also used indirectly through production of all the parts and materials from which the plane is made. Computing total indirect energy consumption requires following the value added chain back through intermediate products at every stage: energy is used to produce sheet metal from aluminum; to produce aluminum from bauxite; and to mine the bauxite itself.

Tracing energy consumption all the way back to raw materials is possible using input-output tables. An input-output "use" is a matrix showing the flow of each good to each industry in a particular year. Using that information, it is possible to determine the amount of each input needed to make a single unit of output. If A is a matrix of such coefficients, with one row for each input and one column for each output, the market equilibria corresponding to each of the inputs can be summarized in the equation below, where X is a vector of gross outputs by commodity, and F is a vector of final demands:

$$AX + F = X \tag{4}$$

The left side is total demand for each product: AX is the demand for intermediate goods and F is final demand. The right side, X, is the supply of each good. Solving for X gives the total inputs needed to produce any given vector of final demands:

$$X = (I-A)^{-1}F \tag{5}$$

Matrix $(I-A)^{-1}$ is known as a "total requirements" table. Each row corresponds to an input and each column to an output, and each element shows the amount of the input used directly or indirectly in the production of one unit of the output. For example, the total amount of coal use that can be attributed to production of a durable good would appear as an element in the coal row and durable goods column of $(I-A)^{-1}$.

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the rate of return in that sector back to into equilibrium with that in the rest of the economy.

Computing the implicit carbon content of each product requires two additional steps: the inputs of each fossil fuel are multiplied by appropriate emissions coefficients to convert fuel consumption to carbon emissions, and then carbon emissions are summed across fuels. The result is a single coefficient for each good indicating the total carbon emissions that can be attributed to the good's production.

Since input-output tables are used in the construction of G-Cubed, the information needed to compute a total requirements table for each of the regions in the model was readily available. In addition, the model's database includes emissions coefficients for each fuel, with emissions in millions of metric tons of carbon for each of the model's units of fuel, so the final steps were straightforward as well. Carrying out the calculation produced the results are shown in Table 3. For convenience, the results are shown as thousands of metric tons. As indicated in the lower rows of the table, production of non-fuel traded goods generally involves emissions of 0.1 to 1.1 thousand metric tons per model unit of output. (The model's output units are large, corresponding to billions of dollars of output in a base year.) For example, one unit of durable goods produced in the United States is associated with 0.13 thousand metric tons of carbon. Implicit emissions very strongly across regions: emissions associated with durables are only 0.7 thousand metric tons per unit in Japan, but are 1.01 thousand tons per unit in China. As expected, Japan and Europe are most efficient in terms of carbon and have the lowest coefficients; the highest coefficients are associated with China, India and Eastern Europe and the Former Soviet Union.

4 Carbon Taxes With and Without Border Adjustments

This section describes simulations we ran using the G-Cubed model to explore the effects of border adjustments. We began by constructing a hypothetical carbon tax beginning at $20 per metric ton of carbon and rising by $0.50 per year to $40. The tax was intended to illustrate the effect of border adjustments over a range of carbon prices but was not designed to achieve any specific emissions target. Our results would apply to a tradable permit policy as well if the policy had similar equilibrium permit prices. However, administering the border adjustments would be much more difficult under a permit system since frequents revisions in the adjustments might be needed to follow fluctuations in the permit price.

We then examined the effects of the carbon tax under four scenarios about the its implementation: (1) it is adopted in Europe without border adjustments (referred to in tables below as "EU-Tax"); (2) it is adopted in Europe and border adjustments are imposed on imports to Europe assuming that the carbon embodied in the imports matched the energy intensity of the United States ("EU-TaxAdj"); (3) the tax is adopted in the United States without border adjustments ("US-Tax"); and (4) it is adopted in the United States and border adjustments are imposed based on the energy intensity of China ("US-TaxAdj"). These simulations were chosen to contrast the effects of border adjustments between countries with similar and relatively efficient technology, Europe and the United States, with the effects of border adjustments between countries with more heterogeneous technology, the United States and China.

In all four simulations, additional government revenue generated by the border adjustments and the carbon tax itself was used to finance additional government spending in the corresponding region (that is, each region's fiscal deficit was held constant). Other fiscal closures could be used instead; for example, the revenue could be used to lower the deficit or it could be returned to households via a lump-sum rebate.

The border adjustments were computed by multiplying the embodied carbon per unit of output by the carbon tax prevailing in each year, and then converting the result to an ad valorem rate.[13] No adjustments were applied to imports of coal and crude petroleum, which are already subject to the carbon tax, which was applied to imports as well as domestic production. The results are shown in Tables 5 and 6 for two carbon tax rates: $20 and $40 per ton. For the European tariffs shown in Table 5, the rates for the $20 tax are small: less than one percent for tradable goods other than fuels. The rates for the $40 tax are twice as large, but still small: the largest are the tax on nondurables, at 0.92 percent, and on transportation, at 0.88 percent. For the US tariffs shown in Table 6, the rates are considerably higher. When the carbon tax is $20 per ton, the effective tariffs on durable and nondurable manufactured goods are almost two percent. At the $40 per ton rate, the tariffs double to slightly less than four percent. The rates in Table 6 reflect the higher energy intensity of Chinese manufacturing, as was shown in Table 3.

The effects of the two European scenarios on real GDP are shown in Table 7. The carbon tax lowers European GDP by 0.6 to 0.7 percent. Lower European GDP, in turn, lowers GDP in Eastern Europe and the former Soviet Union (EEFSU) by 0.1 to 0.2 percent. OPEC GDP also falls slightly, but the remaining countries and regions are affected by less than 0.1 percent. Adding border adjustments has little additional effect on European GDP, which is still reduced by 0.6 to 0.7 percent. However, the GDP of the EEFSU region drops considerably more than under the carbon tax alone: 0.5 to 0.7 percent. In part this is due to the increase in trade barriers between Europe and EEFSU: even though the border adjustment rates are calculated based on US energy intensities, in this simulation they are applied to European imports.

The effects of the policies on annual carbon emissions from each region are shown in Table 8. The carbon tax alone lowers European emissions by 53 to 98 million metric tons (MMT) per year over the 2010-2030 period. Some of these emissions are offset by increases in

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[13] The conversion to an ad valorem rate was for convenience; in practice, it is likely that a unit tax would be used.

other regions, often referred to as “leakage”. In 2010, for example, European emissions fall by 53 MMT but world emissions only fall by 48 MMT. The difference is 5 MMT, or about 10% of the European decrease: 2 MMT in the US, 1 MMT in developing countries, and 2 MMT in EEFSU. Adding border adjustments causes a larger reduction in worldwide emissions: 69 to 127 MMT annually over the period. The larger cuts are the result of three interacting effects: European emissions do not fall as much (49 to 91 MMT), there is no leakage of emissions to the US or LDCs, and EEFSU emissions fall by much more due to the much larger drop in EEFSU GDP.

Table 9 shows the effects of the two policies on short run interest rates in each region. Both policies lower the return to capital in Europe, and to a lesser extent, EEFSU. The changes in interest rates in other regions are generally very small. Lower rates of return in Europe and EEFSU lead to capital outflows and shifts of the two regions’ trade and current account balances toward surplus, as shown in Tables 10 and 11. The capital flows to the remaining regions in the model, which generally see their trade and current accounts shift toward deficit. The two exchange rates weaken relative to the US dollar, as shown in Table 12. Exchange rates in the model are US dollars per unit of foreign currency. A depreciation of the Euro relative to the dollar, therefore, appears in the table as a percentage *increase* in the exchange rate.

The effects of the policies on European prices and domestic output are shown in Table 13. The carbon tax, shown in the top section of the table, raises coal prices sharply: by 23 percent in 2010 rising to 33 percent in 2030. Coal output drops by 8 percent in 2010 rising to 13 percent in 2030. Other energy prices rise as well, although by much smaller percentages: 5-6 percent for crude oil and refined petroleum, and 1-2 percent for electricity. The combined tax and border adjustment policy shown in the bottom of the table is very similar, but with slightly larger increases in most prices (due to the tariffs) and slightly smaller reductions in output (due to the shift away from imports to domestic production). However, the protective effect of the adjustments for European producers is very small: typically raising output by only 0.1 percent relative to the carbon tax alone.

Tables 14 through 20 show the effects of the two US policies on the same set of variables. In general, the effects of the carbon tax are similar in magnitude but with the US and the Other OECD region (which includes Canada and Mexico) filling the roles of Europe and EEFSU. Table 14 shows that the carbon tax reduces US GDP by 0.6 to 0.7 percent and Other OECD GDP by 0.3 to 0.4 percent. Adding border adjustments has negligible effect on US GDP but increases the effect on Other OECD GDP to reductions of 0.8 to 0.1 percent. Also, additional regions are affected as well, particularly developing countries.

As shown in Table 15, the carbon tax reduces US carbon emissions by much more than it reduced European emissions: 303 to 577 MMT per year over 2010-2030. As with the European case, the carbon tax alone leads to some leakage of emissions: world emissions fall by 293 to 554 MMT. Leakage, therefore, ranges from 10 to 23 MMT or 3 to 4 percent of the US reduction. As with the European simulations, adding border adjustments causes the US reduction to be smaller but causes larger drops in emissions outside the US and results in slightly larger global reductions: 297 to 558 MMT annually over 2010-2030.

The effects on short run interest rates are shown in Table 16, and the main effect is a small reduction in rates in the US. Under the carbon tax, the result is a small capital outflow, as reflected in the shift of the current account toward surplus in Table 18. Interestingly, the capital flow reverses under the border adjustment policy. When the US increases its tariffs, the reduction in trade reduces GDP in many regions (Table 14) and leaves the US economy in a relatively stronger position. The dollar weakens in both simulations, as shown in Table 19.

As shown in Table 20, the US carbon tax causes much larger percentage changes in fuel prices than did the European tax, reflecting the lower initial energy prices in the US. The price of coal rises by 50 to 94 percent, compared with the 23-33 percent increase under the European policy. Fuel consumption, in turn, falls by larger percentages: coal, for example, drops by 20 to 29 percent rather than the 8-13 percent in Europe. It is interesting to note that the border adjustments generally do no have the mild protective effect seen under the European case. The reduction in world GDP, and the consequent drop in demand for US exports, more than offsets the shift of domestic consumption from imports to domestic producers.

5 Conclusion

Border tax adjustments for primary energy (i.e. coal, oil, natural gas) trade is relatively straightforward and would likely be part of any domestic carbon tax or permit trading system. Computing border tax adjustments for the carbon content of all other traded goods and services is very complex in practice. In particular it would require calculations on a country of origin basis for all trading partners of a country. The complexities increase when a good that has been manufactured contains intermediate goods that have a number of different sources across countries. This calculation can be simplified in theory in a modeling framework because we could rely on information about the input-output structure of a country’s trade partners. However, our results show that when we do this in a model, the tariffs would be small for most goods at moderate carbon tax levels. At an aggregate level, the adjustments for most manufactured goods would be on the order of one or two percent. However, the rates within more narrowly defined and energy-intensive industries, such as aluminum refining, the rates would be considerably higher. Also, the adjustments are proportional to the carbon tax being imposed, so very high carbon taxes could lead to more significant border adjustments.

We find that the adjustments would be effective at reducing leakage of emissions, but leakage is very small even without the adjustments. Moreover, much of the emissions gain that does occur comes about because the tariffs reduce world GDP through the overall reduction in international trade. Finally, because the adjustments are small, they have little effect on import-competing industries. We conclude that the benefits produced by border adjustments of trade goods and services would be small, and are unlikely to justify their administrative complexity or their deleterious effects on international trade.

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Table 1: Regions in the G-Cubed Model

	Region
1	United States
2	Japan
3	Australia
4	Europe
5	Other OECD
6	China
7	India
8	Other Developing Countries (LDC)
9	Eastern Europe and the Former USSR (EEFSU)
10	Oil Exporting Developing Countries (OPEC)

Table 2: Sectors in the G-Cubed Model

Num.	**Name**
1	Electric utilities
2	Gas utilities
3	Petroleum refining
4	Coal mining
5	Crude oil and gas extraction
6	Other mining
7	Agriculture
8	Forestry and Wood Products
9	Durable Goods
10	Nondurables
11	Transportation
12	Services

Table 3: Carbon Content of Non-Fuel Exports by Country of Origin

(Thousands of metric tons of carbon per model unit)

		USA	Japan	Australia	Europe	Other OECD	China	India	LDCs	Former USSR	OPEC
1	**Electric Utilities**	2.65	0.38	2.76	0.60	1.45	7.63	4.98	2.07	4.27	1.05
2	**Gas Utilities**	0.41	0.65	1.07	0.13	0.70	11.68	0.37	1.55	1.25	0.17
3	**Petroleum Refining**	6.59	1.75	3.53	1.75	4.37	7.38	4.94	5.30	6.82	2.45
4	**Coal**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	**Crude Oil**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	**Mining**	0.27	0.10	0.35	0.21	0.87	0.81	1.20	0.41	0.98	0.15
7	**Agriculture**	0.17	0.10	0.16	0.13	0.25	0.47	0.36	0.20	0.84	0.07
8	**Forestry and Wood**	0.13	0.05	0.21	0.08	0.18	0.61	0.24	0.16	1.01	0.08
9	**Durables**	0.13	0.07	0.43	0.09	0.23	0.97	1.01	0.33	1.10	0.21
10	**Nondurables**	0.23	0.13	0.23	0.15	0.33	0.92	0.81	0.37	1.06	0.21
11	**Transportation**	0.22	0.08	0.25	0.18	0.32	0.87	0.59	0.35	1.08	0.20
12	**Services**	0.05	0.04	0.09	0.03	0.11	0.59	0.30	0.13	0.71	0.08

Table 4: Carbon Tax and Border Adjustment Simulations

Name	Description
EU-Tax	European carbon tax without border adjustments.
EU-TaxAdj	European integrated carbon tax and border adjustment policy.
US-Tax	US carbon tax without border adjustments.
US-TaxAdj	US integrated carbon tax and border adjustment policy.

Table 5: European Border Adjustments Based on US Energy Intensity

(Percentage point change in ad valorem tariff.)

Sector	**$20 per Ton Carbon Tax**	**$40 per Ton Carbon Tax**
Electric Utilities	5.30	10.60
Gas Utilities	0.82	1.64
Petroleum Refining	13.18	26.36
Coal	NA	NA
Crude Oil	NA	NA
Mining	0.54	1.08
Agriculture	0.34	0.68
Forestry and Wood	0.26	0.52
Durables	0.26	0.52
Nondurables	0.46	0.92
Transportation	0.44	0.88
Services	0.10	0.20

Table 6: US Border Adjustments Based on China's Energy Intensity

(Carbon tax equal to $20 per ton)

Sector	**$20 per Ton Carbon Tax**	**$40 per Ton Carbon Tax**
Electric Utilities	15.26	30.52
Gas Utilities	23.36	46.72
Petroleum Refining	14.76	29.52
Coal	NA	NA
Crude Oil	NA	NA
Mining	1.62	3.24
Agriculture	0.94	1.88
Forestry and Wood	1.22	2.44
Durables	1.94	3.88
Nondurables	1.84	3.68
Transportation	1.74	3.48
Services	1.18	2.36

Table 7: Effects of European Policies on Real GDP

(Percentage changes from business as usual values)

	EU-Tax			EU-TaxAdj		
Region	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
US	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Japan	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Australia	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Europe	-0.7%	-0.6%	-0.7%	-0.7%	-0.6%	-0.7%
Other OECD	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
China	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
India	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
LDC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
EEFSU	-0.2%	-0.1%	-0.1%	-0.7%	-0.5%	-0.5%
OPEC	-0.1%	-0.1%	-0.1%	-0.2%	-0.2%	-0.2%

Table 8: Effects of European Policies on Carbon Emissions

(Millions of metric tons)

	EU-Tax			EU-TaxAdj		
Region	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
US	2	2	2	0	0	0
Japan	0	0	0	0	0	0
Australia	0	0	0	0	0	0
Europe	-53	-72	-98	-49	-66	-91
Other OECD	0	0	0	0	0	0
China	0	0	0	0	-1	-1
India	0	0	0	0	0	0
LDC	1	2	2	-1	-1	-1
EEFSU	2	3	5	-18	-24	-32
OPEC	0	0	0	-1	-2	-2
Total	**-48**	**-64**	**-88**	**-69**	**-93**	**-127**

Table 9: Effects of European Policies on Short Run Interest Rates

(Percentage point change)

	EU-Tax			EU-TaxAdj		
Region	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
US	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Japan	-0.01	-0.01	-0.01	-0.02	-0.01	-0.01
Australia	-0.01	-0.01	-0.01	-0.02	-0.01	-0.01
Europe	-0.04	-0.03	-0.04	-0.05	-0.04	-0.05
Other OECD	-0.01	-0.01	-0.01	-0.02	-0.01	-0.02
China	-0.02	-0.01	-0.01	-0.02	-0.01	-0.01
India	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
LDC	-0.02	-0.01	-0.01	-0.02	-0.01	-0.02
EEFSU	-0.03	-0.01	-0.02	-0.03	-0.02	-0.02
OPEC	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01

Table 10: Effects of European Policies on Trade Balances

(Billions of US dollars)

	EU-Tax			EU-TaxAdj		
Region	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
US	-2.1	-0.6	0.1	-2.1	-0.4	0.6
Japan	-1.0	-0.3	-0.1	-1.2	-0.4	-0.2
Australia	0.0	0.0	0.0	0.0	0.0	0.0
Europe	5.5	1.6	0.4	4.7	1.9	1.4
Other OECD	-0.1	0.0	0.0	-0.1	0.0	0.1
China	-0.5	-0.2	-0.1	-0.6	-0.2	-0.1
India	-0.2	-0.1	0.0	-0.2	-0.1	-0.1
LDC	-1.3	-0.2	0.0	-1.2	-0.3	0.0
EEFSU	0.0	0.1	0.0	1.3	0.5	-0.2
OPEC	0.0	0.0	0.1	0.1	0.0	0.1

Table 11: Effects of European Policies on Current Accounts

(Billions of US dollars)

	EU-Tax			EU-TaxAdj		
Region	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
US	-3.0	-2.7	-3.4	-3.1	-2.9	-3.7
Japan	-1.6	-1.3	-1.7	-1.9	-1.7	-2.2
Australia	0.0	0.0	0.0	0.0	0.0	0.0
Europe	7.9	6.7	8.6	6.5	6.1	8.5
Other OECD	-0.3	-0.3	-0.3	-0.3	-0.2	-0.3
China	-0.7	-0.6	-0.7	-0.9	-0.7	-1.0
India	-0.2	-0.2	-0.3	-0.3	-0.3	-0.4
LDC	-1.9	-1.4	-1.7	-1.7	-1.4	-1.8
EEFSU	0.0	0.2	0.1	1.9	1.9	2.0
OPEC	-0.1	-0.1	-0.1	0.1	0.1	0.0

Table 12: Effects of European Policies on Real Exchange Rates

(Exchange rates are measured as US dollars per unit of foreign currency.
Percentage changes from business as usual values)

	EU-Tax			EU-TaxAdj		
Region	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
US	--	--	--	--	--	--
Japan	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	0.0%
Australia	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
Europe	0.5%	0.7%	1.0%	0.9%	1.2%	1.5%
Other OECD	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
China	-0.1%	-0.1%	0.0%	-0.1%	-0.1%	0.0%
India	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
LDC	-0.1%	0.0%	0.0%	-0.1%	-0.1%	0.0%
EEFSU	-0.3%	-0.2%	-0.1%	-0.9%	-0.8%	-0.7%
OPEC	-0.2%	-0.2%	-0.2%	-0.3%	-0.3%	-0.3%

Table 13: Effects of European Policies on European Prices and Output

(Percentage changes from business as usual values)

	EU-Tax					
	Prices			**Quantities**		
Sector	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
Elect. Util.	1.6%	1.9%	2.2%	-1.0%	-1.1%	-1.3%
Gas Utilities	0.5%	0.4%	0.5%	-1.3%	-1.6%	-1.9%
Petrol. Ref.	4.5%	5.1%	6.1%	-2.8%	-3.0%	-3.4%
Coal	22.5%	27.8%	33.4%	-7.5%	-9.8%	-13.1%
Crude Oil	4.9%	5.6%	6.7%	-3.3%	-4.0%	-5.1%
Mining	0.5%	0.4%	0.5%	-1.0%	-0.8%	-0.9%
Agriculture	0.4%	0.3%	0.4%	-0.1%	-0.1%	-0.2%
For. & Wood	0.3%	0.2%	0.2%	-0.5%	-0.4%	-0.4%
Durables	0.3%	0.1%	0.2%	-1.1%	-0.6%	-0.7%
Nondurables	0.4%	0.4%	0.4%	-0.2%	-0.1%	-0.2%
Trans.	0.5%	0.5%	0.6%	-0.4%	-0.4%	-0.4%
Services	0.3%	0.2%	0.2%	0.0%	0.1%	0.1%
	EU-TaxAdj					
	Prices			**Quantities**		
Sector	**2010**	**2020**	**Sector**	**2010**	**2020**	**Sector**
Elect. Util.	1.6%	1.9%	2.2%	-0.9%	-1.0%	-1.2%
Gas Utilities	0.5%	0.4%	0.5%	-1.3%	-1.6%	-1.9%
Petrol. Ref.	4.8%	5.6%	6.6%	-2.4%	-2.6%	-3.0%
Coal	22.3%	27.5%	33.1%	-7.5%	-9.8%	-13.0%
Crude Oil	4.8%	5.5%	6.5%	-3.1%	-3.7%	-4.8%
Mining	0.5%	0.5%	0.6%	-1.2%	-0.9%	-1.0%
Agriculture	0.3%	0.3%	0.3%	-0.2%	-0.2%	-0.2%
For. & Wood	0.2%	0.1%	0.1%	-0.5%	-0.4%	-0.4%
Durables	0.2%	0.1%	0.1%	-1.2%	-0.7%	-0.8%
Nondurables	0.4%	0.4%	0.4%	-0.2%	-0.2%	-0.2%
Trans.	0.5%	0.5%	0.6%	-0.5%	-0.4%	-0.5%
Services	0.2%	0.1%	0.2%	0.1%	0.2%	0.2%

Table 14: Effects of US Policies on Real GDP

(Percentage changes from business as usual values)

	US-Tax			US-TaxAdj		
Region	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
US	-0.6%	-0.6%	-0.7%	-0.6%	-0.6%	-0.7%
Japan	0.0%	0.0%	0.0%	-0.1%	-0.1%	-0.1%
Australia	0.0%	0.0%	0.0%	-0.1%	-0.1%	0.0%
Europe	0.0%	0.0%	0.0%	-0.1%	-0.1%	-0.1%
Other OECD	-0.4%	-0.3%	-0.3%	-1.0%	-0.8%	-0.8%
China	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
India	0.0%	0.0%	0.0%	-0.1%	-0.1%	-0.1%
LDC	-0.2%	-0.1%	-0.1%	-0.5%	-0.2%	-0.2%
EEFSU	0.0%	0.0%	0.0%	-0.1%	-0.1%	-0.1%
OPEC	-0.4%	-0.3%	-0.3%	-0.5%	-0.4%	-0.3%

Table 15: Effects of US Policies on Carbon Emissions

(Millions of metric tons)

	US-Tax			US-TaxAdj		
Region	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
US	-303	-422	-577	-279	-390	-535
Japan	0	0	0	-1	-1	-1
Australia	0	0	0	0	0	0
Europe	1	2	2	-2	-3	-3
Other OECD	3	4	6	-4	-5	-6
China	0	0	0	-1	-2	-2
India	0	0	0	-1	-1	-1
LDC	5	8	11	-6	-4	-5
EEFSU	1	1	2	-2	-2	-2
OPEC	0	0	1	-1	-1	-2
Total	**-293**	**-405**	**-554**	**-297**	**-407**	**-558**

Table 16: Effects of US Policies on Short Run Interest Rates

(Percentage point change)

	US-Tax			US-TaxAdj		
Region	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
US	-0.02	-0.03	-0.03	-0.05	-0.04	-0.04
Japan	-0.01	0.00	0.00	-0.01	0.01	0.01
Australia	-0.02	-0.01	-0.01	-0.03	-0.01	-0.01
Europe	-0.01	0.00	0.00	-0.02	0.00	0.00
Other OECD	-0.01	0.00	0.00	0.03	0.00	0.00
China	-0.01	0.00	0.00	0.00	0.01	0.01
India	0.00	0.00	0.00	0.01	0.01	0.01
LDC	-0.01	0.00	0.00	0.01	0.01	0.01
EEFSU	-0.01	0.00	0.00	-0.01	0.00	0.00
OPEC	0.01	0.01	0.01	0.02	0.01	0.01

Table 17: Effects of US Policies on Trade Balances

(Billions of US dollars)

	US-Tax			US-TaxAdj		
Region	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
US	-0.5	-0.9	0.4	-4.6	-1.2	4.3
Japan	-0.2	0.7	0.9	0.4	1.6	1.6
Australia	0.2	0.2	0.1	0.6	0.4	0.3
Europe	-1.0	-0.4	-0.8	0.5	-0.5	-2.7
Other OECD	1.2	0.9	0.5	2.9	1.9	1.0
China	-0.4	0.0	0.0	-0.8	0.0	-0.3
India	0.0	0.1	0.2	0.1	0.3	0.3
LDC	0.3	-0.1	-0.4	1.4	-0.8	-1.6
EEFSU	0.4	0.5	0.5	1.0	1.1	1.0
OPEC	0.5	-0.3	-0.7	-0.1	-1.0	-1.5

Table 18: Effects of US Policies on Current Accounts

(Billions of US dollars)

	US-Tax			US-TaxAdj		
Region	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
US	0.8	0.2	1.8	-5.1	-4.2	0.0
Japan	-1.4	-1.0	-1.5	-1.7	-1.4	-2.6
Australia	0.3	0.4	0.5	0.8	0.9	1.1
Europe	-2.1	-1.6	-2.4	-0.3	-0.5	-2.1
Other OECD	1.4	1.6	1.7	3.5	3.6	4.0
China	-0.6	-0.2	-0.4	-0.9	-0.2	-0.7
India	0.0	0.1	0.1	0.2	0.3	0.3
LDC	0.5	0.4	0.4	3.0	1.7	1.9
EEFSU	0.4	0.5	0.7	1.2	1.5	1.7
OPEC	0.8	0.4	0.4	0.3	-0.3	-0.4

Table 19: Effects of US Policies on Real Exchange Rates

(Exchange rates are measured as US dollars per unit of foreign currency.
Percentage changes from business as usual values)

	US-Tax			US-TaxAdj		
Region	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
US	--	--	--	--	--	--
Japan	-2.0%	-2.1%	-2.4%	-4.6%	-5.0%	-5.6%
Australia	-1.7%	-1.8%	-2.0%	-3.9%	-4.1%	-4.4%
Europe	-1.8%	-1.9%	-2.2%	-4.2%	-4.5%	-5.0%
Other OECD	-2.2%	-2.4%	-2.6%	-5.0%	-5.4%	-5.9%
China	-1.8%	-1.9%	-2.2%	-4.1%	-4.5%	-5.0%
India	-1.8%	-2.0%	-2.3%	-4.3%	-4.7%	-5.2%
LDC	-1.8%	-2.0%	-2.3%	-4.2%	-4.7%	-5.2%
EEFSU	-1.8%	-1.9%	-2.2%	-4.1%	-4.4%	-4.8%
OPEC	-2.2%	-2.5%	-2.8%	-4.1%	-4.7%	-5.2%

Table 20: Effects of US Policies on US Prices and Output

(Percentage changes from business as usual values)

	US-Tax					
	Prices			**Quantities**		
Sector	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
Elect. Util.	6.6%	7.9%	9.4%	-3.6%	-4.3%	-5.0%
Gas Utilities	1.1%	1.2%	1.4%	-3.7%	-4.4%	-5.3%
Petrol. Ref.	14.3%	17.2%	20.6%	-10.9%	-12.4%	-13.8%
Coal	59.7%	75.9%	94.3%	-19.4%	-23.7%	-28.3%
Crude Oil	18.6%	22.6%	27.2%	-13.2%	-15.3%	-19.0%
Mining	0.6%	0.6%	0.7%	-1.0%	-0.8%	-0.8%
Agriculture	0.3%	0.4%	0.4%	-0.3%	-0.3%	-0.4%
For. & Wood	0.0%	-0.1%	0.0%	-0.4%	-0.2%	-0.3%
Durables	-0.1%	-0.2%	-0.2%	-0.7%	-0.4%	-0.4%
Nondurables	0.3%	0.4%	0.5%	-0.2%	-0.2%	-0.3%
Trans.	0.5%	0.5%	0.6%	-0.4%	-0.3%	-0.4%
Services	0.2%	0.2%	0.2%	0.1%	0.1%	0.1%
	US-TaxAdj					
	Prices			**Quantities**		
Sector	**2010**	**2020**	**Sector**	**2010**	**2020**	**Sector**
Elect. Util.	6.6%	8.0%	9.5%	-3.5%	-4.2%	-4.9%
Gas Utilities	1.1%	1.1%	1.3%	-3.7%	-4.4%	-5.2%
Petrol. Ref.	14.9%	18.2%	22.0%	-9.1%	-10.4%	-11.7%
Coal	59.5%	75.8%	94.2%	-19.5%	-23.9%	-28.5%
Crude Oil	17.0%	20.8%	25.2%	-13.3%	-15.3%	-18.9%
Mining	0.5%	0.5%	0.7%	-1.6%	-1.4%	-1.4%
Agriculture	0.1%	0.2%	0.3%	-0.6%	-0.6%	-0.7%
For. & Wood	-0.3%	-0.3%	-0.3%	-0.2%	0.0%	-0.1%
Durables	-0.1%	-0.1%	0.0%	-1.1%	-0.7%	-0.8%
Nondurables	0.3%	0.3%	0.5%	-0.3%	-0.3%	-0.4%
Trans.	0.5%	0.5%	0.6%	-0.3%	-0.3%	-0.4%
Services	0.2%	0.1%	0.2%	0.2%	0.2%	0.2%