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Comparison of the Environmental Impacts of Trade and Domestic Distortions in the United States

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Abstract: There is a great deal of concern, both among environmental activists and the general public, about the affects of globalization on the environment. One particularly contentious issue is that of trade liberalization. However, is all the concern being shown for the effect of increased trade on the environment misplaced? Should we instead be focusing our efforts on the distortions created by domestic policies as a greater source of potentially adverse environmental effects? This paper compares the environmental impacts of different types of subsidies/restrictions on the US economy. The paper presents the results of several scenarios surrounding the removal of two types of restrictions: trade and domestic subsidies. The Global Trade Analysis Project (GTAP) model and database will be used to derive economic changes while the environmental effects will be assessed using the Trade and Environment Assessment Model (TEAM). TEAM converts national level economic outcomes into environmental. Aggregate measures of pollution indicate greater increases in the US from trade liberalization, mostly through changes in the agricultural sector.

Key Words: Trade, Environmental Impacts, General Equilibrium
Subject Matter Categories: 47 International trade, 59 Economic Impacts, 61 Modeling

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Introduction

Beginning with NAFTA, continuing through Chile and Australia and more recently, the proposed Central American Free Trade Agreement (CAFTA), there has been growing interest in the United States over the possible environmental effects of increasing trade. This concern was explicitly addressed first in 1999 when President Clinton signed Executive Order 13141 committing the United States to undertake formal environmental reviews of all future trade agreements, and more formally in the 2002 Trade Promotion Authority Act. Since the Order was signed, there have been five final environmental reviews (for free trade agreements with Jordan, Chile, Singapore, Australia and Morocco) and there are currently four interim reviews (CAFTA, Panama, Andean and Bahrain).

The effect of trade on the environment is the subject of a growing literature. Trade-induced environmental effects can be traced through various channels including changes in transportation (affecting invasive species), in income and growth (affecting consumption and development), and in industry location and composition (affecting pollution levels and intensities). The sovereignty of domestic policy with respect to international agreements and commitments has been of particular concern to policy makers. The environmental impact of these issues and how they ultimately play out, either within a country or between countries, is an intensely debated topic.

There are a number of empirical studies of the effect of trade on the environment. Many of these studies investigate the Environmental Kuznets Curve; the idea that economic growth and environmental quality are linked in a predictable way (for a recent survey see Dinda 2004). Others study the incidence of pollution havens (see for example

Ederington, Levinson and Minier 2004). Most studies take the approach of dividing potential effects of trade on the environment into three categories: scale, composition and technique (Grossman and Krueger, 1993). The scale effect predicts any economic expansion due to an increase in trade will increase pollution because, all things equal, more output means more pollution. Thus increased trade will increase output and levels of pollution in a country. However, effects of trade vary across industries; some will experience a rise in output, others a fall. This compositional effect reduces pollution if the output from 'dirty' industries falls while the output from 'clean' industries expands. Finally, increases in output that come from advances in technique are usually associated with decreases in pollution, as 'modern' methods of production tend to be cleaner. However, technique can also have a negative impact on pollution. Capital-intensive industries are often associated with large pollution emissions, so that increases in capital-intensive industries will raise pollution level. Which effect ultimately dominates is an empirical question.

Antweiler, Copeland and Taylor (ACT 2001), investigate the relative contribution of each of these effects by modeling how openness to international trade affects sulfur dioxide (SO_2) concentrations. They conclude that freer trade is overall good for the environment. ACT (2001) find little change in SO_2 emissions from changes in the composition of national output and estimates of trade-induced technique and scale effects imply a net reduction in pollution. The authors estimate that for every 1 percent increase in national income resulting from trade liberalization, there is a 0.8 to 0.9 percent reduction in concentrations of SO_2. They also find that income gains brought about by further trade or neutral technical progress tends to lower pollution, whereas income gains from capital accumulation raise pollution levels. The authors attribute this to the fact that capital accumulation favors the production of pollution intensive goods whereas neutral technical progress does not.

Tsigas, Gray and Hertel (2002) examine the environmental effects of a Western Hemisphere trade liberalization scenario. They argue that there are 4 mechanisms linking trade policy and the environment: 1) international mobility of industry; 2) the changing composition of national output, 3) the intensity of production and 4) changes in consumer demand for environmental goods. Thus, they apply the same basic rationale as ACT (2001) with the added dimension of measuring consumer behaviour. Tsigas, et al. find that liberalization leads to a increase in pollution and therefore an initial decline in US environmental quality. This comes through the composition effect, principally from an increase in grain production, as well as from the chemicals and metal manufacturing sectors. The paper finds that increases in pollution abatement expenditures offset this increase in emissions, however, leading to an overall improvement in environmental quality.

Frankel and Rose (2003) use the gravity model to estimate the effects of openness (defined as the ratio of exports and imports to GDP) on several environmental measures, including particulate matter (PM), sulfur dioxide (SO_2), nitrogen dioxide (NO_2) as well as estimates of carbon dioxide (CO_2), deforestation, energy depletion and access to clean water. For three air measures (PM, NO_2, and SO_2) the results show that openness reduces pollution. Openness is also shown to be beneficial for clean water access and energy depletion, but of 'borderline' significance. Outcomes for CO_2 are the exception, showing an increase in emissions associated with openness.

Cooper, Johansson and Peters (2003) look specifically at trade liberalization in agricultural markets. They use a series of models to capture a multilateral trade liberalization scenario where all tariffs and domestic support programs in the agricultural sector are removed. They examine how world market changes affect US production and how changes in production impact environmental outcomes. Specifically, they examine changes in nitrogen, phosphorous and pesticides loss to water; sheet, rill and wind related soil erosion, and manure nutrient production. Unlike previous studies, the authors then examine how these impacts play out geographically within the United States.

The results of Cooper et al's work shows small changes in US output as a result of worldwide agricultural trade liberalization, with the exceptions of corn and dairy. These changes however lead to small overall changes in environmental outcomes. The authors note that important regional variations appear in their model. For example, the northern plains and northeast experience an increase in sheet and rill erosion while other parts of the country see a reduction.

The work presented here picks up on the Cooper, et al. paper by examining how a complete removal of trade barriers would affect environmental outcomes regionally across the US. It also extends Frankel and Rose's work by examining outcomes on a variety of emission types. We attempt to provide some context for a trade liberalization scenario by contrasting those results with outcomes obtained removing domestic distortions.

There are two important environmental affects resulting from shifting trade patterns not addressed in this paper. One is the changing geographic pattern of trade and different technologies used to produce the same output. The other is the effect from pollution embodied in the commodities themselves. Changes in regulation that change the geographic pattern of production can also affect the geographic pattern of pollution. Thus while production of highly polluting commodities may decline in the United States, that does not mean consumption declines as well. Indeed, consumption may remain the same, or even increase, through imports. If the source of these imports uses a "dirtier" production technology, there will be an increase in overall pollution due to trade.

A related issue is the pollution embodied in the products themselves. The shifting of production to other sources, using different technologies, may impact the materials used in the products (e.g., lead in batteries, certain dyes in textile products or pesticides in fruit production). Thus it is possible to export so-called dirty production only to import dirty products whose use and disposal can become an environmental concern.

The paper proceeds as follows; we first outline the two simulations and describe the models and data involved. We then present the results from the economic run for two scenarios and follow with a discussion of environmental outcomes. We conclude the paper with a summary of findings and a discussion of future research work.

The Simulations

The first simulation removes domestic distortions (primary and intermediate input subsidies/taxes and output subsidies/taxes), across all 57 sectors and 78 international regions reported in the GTAP database V5.4. In the second simulation, we remove all trade distortions, again for all sectors and regions reported in GTAP's database. We then take the changes in US output from each scenario and use this as an input to the EPA's

Trade and Environmental Assessment Model (TEAM). Environmental outcomes are then compared.

The TEAM model, which will be described in more detail below, is designed to estimate a wide range of environmental impacts resulting from national economic changes. The primary inputs to the model are changes in domestic production. effects for nine pollutant categories at the 6-digit NAICS level, covering over 1,200 sectors and 1,100 chemicals at the county level. The model uses static emissions baseline data to calculate emission factors and generate the projected emissions/resource use changes for each sector and/or facility by US county (Abt Associates, 2004). The two main types of baseline data used in TEAM are (1) economic output by sector and county or by individual facility and (2) emissions by sector and county or by facility (depending on data availability), all based on 1997 data. TEAM combines the economic and emission baseline to determine emission factors for each facility or each economic sector by county and estimate changes in emissions or resource use. TEAM can generate results at the four or six digit NAICS level. The results presented in this paper are at the level of 6 digit NAICS sectors.[1]

GTAP model and data

The GTAP model and dataset are used to run two simulations.[2] The model (version 6.1) used to generate the changes in economic output, is a comparative-static computable general equilibrium model with price taking behaviour for all economic

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[1] A concordance between the 57 GTAP sectors and the 6 digit NAICS was developed. Details are available from authors upon request.
[2] See Hertel, ed (1997) for details concerning the GTAP model specifications and http://www.gtap.agecon.purdue.edu/databases/v5/default.asp for details on the GTAP database.

agents. Commodity supplies are based on single-output production functions. Substitutions between inputs are modeled with two-level nested production functions. Demands for land, labor, and capital are based on constant elasticity of substitution (CES) functions, while intermediate demands are based on a fixed, or Leontief structure. International trade is determined by commodity market demands with commodities differentiated by place of origin. Trade policies operate as *ad valorem* distortions.

The government demand system in GTAP is based on a Cobb-Douglas per capita utility function. Thus, government demand is a function of total income, and not related to tax revenues. This assumes that despite changes in government revenues (taxes and tariffs) and expenditures (subsidies) existing policies, notably existing environmental programs, remain in place. Thus, the analysis of simulation results focuses on relative price changes and industry output. Potential follow-on effects of government policy (such as changes in government spending programs) are not investigated. This is, as stated above, a static analysis, thus we are also assuming no changes in production technology. The 78 regions in the database are aggregated to 11: ANZAC, US, China, Rest of North America (NAF), EU, Non-EU Europe, East Asia (Hong Kong, Japan, Korea and Taiwan), Rest of East Asia, South Asia, South America, Rest of the Word.[3]

It is difficult to say, *a priori*, how the removal of domestic distortions will impact US environmental outcomes. Removing domestic support reduces the competitiveness of domestic production where subsidies are present, by raising prices, all else equal. When each region's domestic supports are removed, the ultimate outcome depends on the relative size of the subsides and/or taxes imposed and the level of price responsiveness within, and across, each region and sector.

[3] A list of the countries included in each region can be found in Appendix A.

The same type of scenario plays out with the removal of trade distortions. The removal of import tariffs decreases the price of imported goods and, again, all else equal, leads to reduced production from domestic competitors. But depending on the tariff structure of other regions, this may lead to an increase or a decrease in pollution producing industries. Removing export subsidies also increases prices, leading to a decrease in the competitiveness of these goods overseas. Again, depending on the structure of the change, the ultimate economic effect on the environment is an empirical question.[4]

Figure 1 shows the relative distribution of intermediate input subsidies for the US, NAF, ANZAC and the EU. Given the focus of the paper on the changes in emission for the United States, the sectors shown are based on the existence of a subsidy in the US. The highest subsidies are in the wheat, grains and oilseeds sectors in the EU. The US has relatively high subsides in paddy rice, wheat and sugar production. The pattern shown in Figure 1 holds for subsides in land and capital inputs as well, except that the US has higher subsides for these two inputs in wool than ANZAC and the EU has higher land subsides than the US and ANZAC in sugar.

Figure 2 shows the output taxes and subsides for the same regions for all sectors affected. The figure is meant to provide an indication of the pattern of output taxes/subsidies, rather than analyze any particular program, region or sector. The various GTAP sectors are represented along the horizontal axis. Values above the horizontal axis are taxes and those below are subsidies. The US has taxes on outputs in the agriculture

[4] Tying changes in pollution outcomes to the removal of regulation implicitly assumes that regulations are in terms of units of polluting outputs per dollar of good produced. As stated above, TEAM is a linear model and assumes the last unit of dollar out contains the same level of pollution as the first (the average level). To the extent this is not true (either through a changing relationship, or discontinuous relationship) the results will be biased.

sectors. However, these output taxes are much smaller than the input subsidies applied to these sectors, resulting in net support for these industry groupings. The other regions apply output taxes to the agriculture sectors as well, and output subsidies to the majority of sectors. The EU does apply output taxes on office equipment, motor vehicles output, as well as land transport and public sector services such as health and education.

Figures 3 and 4 illustrate selected export taxes/subsidies and import tariffs, respectively, for the same regions. Again, we concentrate on the overall pattern. For the regions shown here, there are few large export subsidies with the exception of Australian wool, petroleum, and recreation sectors. The EU has the largest number of export taxes, focusing mainly in the agriculture and food sectors.

Figure 4 shows the various import tariffs imposed by these regions. These values are clustered around the agriculture, food and textile sectors.[5] The EU imposes some of the largest import tariffs, particularly on sugar cane and beet imports. High tariffs on wheat and other meat products imports are found in NAF, on wearing apparel in ANZAC, and sugar and other crop imports by the US.

Based on the domestic subsidy/tax pattern picture provided by Figures 1 and 2, we would expect the US to do relatively worse in paddy rice and sugar output, but see improvement in some manufacturing sectors, where its competitors have large subsidies. On the foreign distortions side, the US has relatively few export subsidies, so we would expect to see an improvement in some of its traditional export markets, especially in sectors in which other regions do have export subsidies, such as agriculture. The removal of tariffs should further benefit some US agriculture markets such as rice, and many of the manufacturing sectors such as food production.

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[5] GTAP data has a base year of 1997 and is thus prior to the expiration of the MFA.

TEAM model and data

TEAM estimates the environmental impacts of a trade or other economic event by applying the total change in the value of domestic production to TEAM's emission factors. These emission factors are based on environmental release and resource use inventories compiled by EPA, the US Department of Agriculture and the US Geological Survey, coupled with economic activity data compiled from the US Economic Census, the US Agricultural Census, the US Department of Energy, and certain private sources of economic data, in particular, Dun & Bradstreet (Abt Associates 2004).

TEAM uses the estimated changes in economic activity in 1997 dollars to calculate changes in emissions/resource use by specific pollutant/resource media, economic sector, and location (county). TEAM calculates the change in emissions/resource use based on emission factors for each of nine pollutant emissions or resource use types: hazardous waste, water use, land use, agricultural chemicals, direct water discharges, indirect water discharges, point source, area source and mobile source air emissions. Direct water discharges are those discharges from point source (such as utilities) into surface water. Indirect discharges refer to wastewater which is first treated before it is released. Where point source air emissions refer to a single identifiable source of emissions (e.g., smokestacks) areas source emission are any source of air pollution that is related over a relatively small areas but can't be classified. Finally, mobile source emissions are a moving source of air pollution such as an automobile.

Each emission factor is defined as the value of baseline emissions/resource use – for a given pollutant/resource, and entity (or sector and county) – divided by the value of baseline economic activity measured as value of shipments in 1997 dollars. Emissions calculations E_{ij} are of the form

$$E_{ijk} = a_{ijk} \times N_{jk}$$

Where $\mathbf{a_{i,j,k}}$ is the quantity (generally mass) of pollutant *i* per dollar of commodity output *j* in region *k*; $\mathbf{N_{j,k}}$ is the change in dollars of commodity *j* output in region *k* due to a policy change; and $\mathbf{E_{i,j,k}}$ is the change in emission of pollutant *i* due to the impact of the policy change on the output of commodity *j* in region *k.*

The TEAM framework uses the concept of the direct requirements coefficient as the basis for its emission coefficient or emissions factors. However, TEAM's emission factors differ from the more common approach of measuring emission factors based on environmental engineering analyses. TEAM's emissions are defined in relation to the economic value of output - that is, quantity of pollutant emission or resource use per dollar value of output – instead of in relation to a physical unit of operation or production. Applying this approach implies that the change in value of output is a real change and not one based solely on changes in price.[6]

For point source air emissions and water discharges, the TEAM Entity is based on individual facilities, as identified in the National Emissions Inventory, Permit Control System and/or Toxic Release Inventory facility datasets. Although TEAM is configured to analyze all emissions/resource use categories on the basis of individual facilities, data are not currently available and/or present in TEAM to support a true facility analysis for

[6] Thus, prices are assumed to be fixed, or experiencing very small changes.

all emissions/resource use categories (Abt Associates, 2004). TEAM analyzes the other categories (area and mobile air emissions, hazardous wastes, agricultural chemicals, land use and water use) on the basis of so-called *pseudo*-facilities. Pseudo-facilities are defined based on the total value of economic activity and associated emissions/resource use in a given 6-digit NAICS sector by county.[7]

In most cases analyzed in TEAM, disaggregation and assignment of an economic change to specific individual counties and/or facilities is based on the national change in economic activity by sector. This change is distributed over all locations in proportion to the baseline distribution of economic activity for that sector. Given that each TEAM entity's emission factors remain fixed at the baseline, static emission factor value, the percent change in emissions/resource use for each TEAM entity is thus equal to the percent change in national level economic activity for the entity's economic sector.

TEAM generates estimates of the change in emissions/ resource use for all TEAM entities, where a TEAM entity may be defined as an individual facilities or county-level *pseudo*-facility. Table 1 lists the number of individual reporting elements by pollutant/resource media category for which TEAM calculates and reports changes in emissions/resource use. Elements here refer to chemicals, compounds, or indicators of resource use. For the air and water pollution categories, in addition to calculating the change in emission/discharge for individual pollutants, TEAM calculates and reports *toxicity-normalized* aggregates for specific pollutant subsets in these pollutant categories. The toxicity-normalized estimates are calculated by use of toxic-weighting factors currently incorporated in EPA's Risk Screening Environmental Indicators model.[8]

[7] Details are available from authors upon request.
[8] More information on this model can be found at http://www.epa.gov/opptintr/rsei/whats_rsei.html.

Table 1 also indicates the number of individual pollutants/chemicals for which toxic weights are currently incorporated in TEAM and for which toxicity normalized aggregates of the change in pollutant emission/discharge are available. We report only information available for all media types.

Results from GTAP

The discussion of results focuses on changes in US output that will drive the environmental changes. Table 2 outlines some summary results for the two scenarios: domestic distortions removal and foreign trade distortions removal. Table 3 examines the welfare effects of each scenario (excluding environmental welfare considerations). Table 4 presents the top five sector results in terms of percentage change for the US for the two scenarios. In the following discussion, scenarios referring to the removal of domestic distortions is referred to as 'domestic', while the removal of trade distortions is called 'foreign.'

Summary statistics and welfare changes

Changes in GDP are, as expected, quite small for all regions for both scenarios. China, under the foreign scenario, experiences the largest increase, at 1.34 percent. Looking at imports, the US has the largest change in the domestic scenario, falling almost 10 percent, while experiencing one of the smallest changes in the foreign simulation, 5.8 percent. Only the EU had a smaller increase in imports in the foreign simulation.

The US experiences the largest change in exports in the domestic scenario, rising over 17 percent. The next largest change is the 16 percent decline in Southeast Asian exports. Under the foreign scenario, South Asia sees the largest change in both imports (rising almost 40 percent) and exports (rising over 37 percent). The US changes are among the smallest. Again, only the EU experiences smaller changes in trade variables in the foreign simulation.

While there are both gains and declines in output, exports and imports in the domestic simulation, all three statistics increase for all regions in the foreign scenario. These overall gains in the foreign simulation, and mixed results in the domestic simulation, are apparent in the welfare statistics presented in Table 3. This table presents changes in total welfare for each region as well as the relative contribution due to changes in the terms of trade, resources allocation and the relative price of investment and saving goods.

In the domestic simulation, the US, Rest of East Asia, South America and the Rest of the World, all experience welfare declines. For the US, this comes overwhelmingly from a decline in the terms of trade. This is true of the rest of East Asia as well. For South America and the Rest of the World, the main effects are losses due to changes in allocation. The EU also experiences a decline in welfare from the terms of trade effect, however the gains from increased allocative efficiency more than compensate for the decline, leading to an overall increase in welfare.[9]

Looking at the results for the foreign scenario, all regions gain in overall measures of welfare. Also, all have positive contributions from the allocative effect, the largest coming in the EU. The US gains across the board, with the largest contribution coming from an improvement in the terms of trade.

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[9] Allocative efficiency refers to the gains made from the movement of resources from a low value sue into a relatively high social marginal value usage (see Huff and Hertel 2000).

Changes in US Sector Output

Table 4 shows the top five sectoral changes from both scenarios for the US. Many of the same sectors are affected in each, however the direction of the change differs. For example, manufacture of luggage, handbags, etc (listed in the table as 'leather') experiences the largest increase in output for the US, 13 percent, in the domestic simulation. This stems from an expansion in exports and a reduction in imports once domestic distortions are removed. When trade distortions are removed however, domestic output falls and imports rise, leading to an 8.6 percent fall in output for that sector.

Another reversal is the beverage and tobacco sector. When domestic distortions are removed, this sector's US output falls by over 3 percent. However, output increase by 8.7 percent when foreign trade distortions are removed. Relatively speaking, US price declines from the universal removal of domestic support are less than in other regions, leading to an overall decline in exports of over 35 percent and rise in imports of almost 18 percent. However, the US fares better when trade distortions are removed. Here, imports rise, but not by as much as exports.

In the domestic scenario, wheat experiences the largest sector declines. As shown earlier, this is one of the most highly subsidized sectors in the US. Construction declines come mainly from a decline in demand for these services from an overall decline in economic activity. While the US and EU, in particular, experience a reduction in input subsidies related to the wood manufacturing industry, at the same time other regions such as Asia remove taxes and increase exports. This leads to the overall decline in wood manufacturing in the US. For the majority of GTAP sectors in the US, the price of domestic output falls, relative to import prices. Only six sectors see an increase in the ratio of domestic to imported prices in the domestic simulation.

Transport equipment experiences one of the largest increases in exports, rising almost 27 percent for the US, leading to an increase in sector output of over 12 percent. Leather also experiences an increase in domestic sales of over 8 percent. The increases in office equipment, fisheries and gas extraction sectors all come from increases in domestic sales as prices drop relative to import prices.

In the foreign simulation, the rice sectors, milled and paddy, experience the largest increases in output. Processed rice has no real export subsidies in the US and its import tariffs are relatively low. However, big import tariffs come off this sector in the EU and Southeast Asia, leading to large export gains for the US to these regions.

While the US applies export subsidies to its wheat production, these are small relative to those applied by Southeast Asia, the EU and the rest of Europe. Thus US exports increase to these regions, especially to Southeast Asia, causing wheat to be one of the largest gaining sectors for the US in a trade liberalization scenario. Oilseeds are a similar story, although they do not see the same increases as wheat.

The US sectors experiencing the largest declines in a foreign scenario are those that have some of the highest rates of protection associated with them, namely sugar and textiles.

We apply the changes in output from the GTAP model run to TEAM and discuss the results below.

Results of the TEAM Run

We report the top five sectors for each of the major pollutant/resource use category for each simulation. In order to determine the true harm done by changes in economic activity, it would be ideal to rank sectors by toxicity weighted emissions factors. However, as stated above, toxicity weighted factors are not available for all chemicals so we used the simple emissions factors. These rankings are shown in tables 5 and 6. Tables 5A-5E and 6A–6E present the results of the TEAM runs for the domestic and foreign simulations, respectively. We attempt to present here a general overview of the results and point out some interesting trends and sector results. [10]

General trends

The total change (and percentage change) for each pollutant category is presented at the top of each panel in tables 5 and 6. The domestic simulation sees a net reduction in three emission types (agricultural chemicals, area and mobile source air emissions) while reductions are only observed for two emission types (hazardous waste and mobile source air emissions) in the foreign simulation. Among the individual emissions/resource uses, hazardous waste experiences a small net reduction in the foreign simulation and a much larger increase in the domestic. This is attributable to the larger increase in emissions from the semiconductor industry in the domestic simulation. Water use increases under

[10] The results presented here are for broad media categories (eg mobile source air emission, hazardous waste emission, etc.). Each media type captures a wide number of chemicals that have vastly different impacts on the environment such that small changes in one type of chemical implies very different outcomes in terms of human health and ecosystem damage than large changes in a different chemical might. The purpose of this paper is to provide an overview of outcomes. Future work will focus on a more detailed analysis.

both simulations, but the increase in the domestic simulation is more than the foreign simulation. This is due to both larger increases and smaller declines in the domestic scenario compared with the foreign.

The differences in outcomes for land use and agricultural chemicals can be traced to the large expansion in some agriculture sectors (e.g. wheat) in the foreign simulation and their contraction in the domestic. Land use changes are almost three times larger in the foreign simulation increasing use by 17 million acres (Table 6B). This is due almost entirely to the expansion of wheat and soybean production. Agricultural chemical use increases in the foreign simulation and decreases in the domestic scenario. This again, can be traced to the large expansion in agriculture in the foreign simulation. Both measures of water discharges increase in both scenarios. However, indirect discharges are much larger in the domestic and, as with hazardous waste, related to changes in the semiconductor industry.

Looking at changes in air emission, there is a net increase in point source air emissions in the domestic scenario and a decline in the foreign. However, these numbers are small, both less than one percent. Area source emissions, on the other hand, increase by over 2.2 billion tons in the foreign simulation and decline over 867 million tons in the domestic (Tables 6D and 5D, respectively). This is due, again, to the changing fortunes of agriculture. All top five expanding sectors in the foreign simulation are agriculture and all expand by amounts greater than the largest change (increase or decrease) in the domestic simulation for area source emissions from agriculture. Finally, the decline in mobile source air emissions seen in the domestic simulation is about twice as much as the net increase in the foreign scenario. The reduction comes mainly from the decline in the construction industry while expansion comes, again, from agriculture.

The tables discussed below present the top five sectors for each emission category in TEAM, for both simulations. The sectors are ranked by total change, as opposed to percent change. While percent changes often makes intuitive sense, as they mirror the changes in output presented in the GTAP runs discussed above, they do not always provide an accurate picture of emission output changes. Consider two examples from the domestic distortions scenario. Sectors experiencing the largest change in indirect water discharges, ranked by percentage change, are various wood manufacturing sectors (wood preservation, other millwork, etc). The largest declines in hazardous waste output, again ranked by percentage change, are seen in the wheat and various construction related industries. If we rank these emissions by absolute changes in the actual pounds of waste or tons of indirect water discharges, we see that the largest declines in indirect water discharges (Table 5C) are actually experienced by various food manufacturing industries, and for hazardous waste (Table 5A), by the petroleum refineries industry. Both of these latter sectors experience declines as a result of the shocks applied from the GTAP runs, but they are not among the top industries affected by the change in policy.

It is outcomes like this that drive home the sometimes counter-intuitive nature of environmental impacts from economic policy changes. The environmental impacts from a changes in a sector often have more to do with the type of pollutant and location than changes in its economic activity. The domestic simulation results are discussed below in terms of broad patterns and trends while the foreign simulation outcomes are addressed in more detail.

Domestic Scenario

There are several broad trends worth noting in Tables 5A-5E. The first, as noted above, is that the correspondence of changes in economic output and changes in environmental outcomes varies by emission type. For example, the only sectors appearing in both Table 4 (sector output changes) and Table 5A are electronic equipment, wood manufacturing and three construction related industries. While the construction sector experience the second largest decline in output in the GTAP simulation, this decline does not translate into a significant source of reduction in hazardous waste. It does however, come up in the results for area and mobile source air emissions. Also, the increase in electronic equipment in the GTAP run figures prominently in TEAM results with two industries topping hazardous waste expansion. Conversely, petroleum refineries (which experience a less than 1 percent decline in output in the GTAP simulation) experience large declines in almost all emission categories. The reduction of hazardous waste emissions from petroleum refineries, for example, dwarfs the declines observed in the other more ‘economically’ affected sectors such as construction.

Another broad trend is the net change for each emission type. Overall, the US experiences a decline in the quantity of output, i.e., GDP, in the domestic scenario. However, this decline in overall economic activity only leads to a reduction in area and mobile source air emissions (Tables 5D and 5E), agricultural chemical (Table 5B)use (driven by a reductions in construction and wheat farming). All other environmental indicators worsen. Hazardous waste and water use (Table 5A), land use (Table 5B), both direct and indirect water discharges (Table 5C) and point source air emissions (Table 5D) all see net increases in their emissions/resource use.

While some emission categories experience changes in a variety of sectors, other emissions outcomes are dominated by a single sector. For example, changes in indirect water discharges (Table 5C) are spread across many different types of industries from pulp mills to cheese manufacturing. On the other hand, increases in water used in hay farming (Table 5A) are more than three times larger than that used in the next sector, oilseed farming. This is true for direct water discharges (Table 5C) as well, for which declines in the other pressed and blown glass production sector are almost five times larger than those experienced in the next largest sector, petroleum refineries.

The distribution of regional changes follows similar lines. For example, all of the increases in hazardous waste from the photographic industry are experienced in New York (Table 5A). The same can be said for declines in direct water discharges from other pressed and blown glass and hardwoods and veneer manufacturing. The declines in direct water discharges (Table 5C) from these industries are enjoyed by Kentucky and Florida alone, respectively, despite the fact that other states have these manufacturing facilities. As a matter of fact, with the exception of dairy cattle, all of the sector declines in direct water discharges are heavily concentrated in one geographic area. Given that these industrial activities are located in several states, this outcome illustrates the difference in emission intensities across the US regions.

As noted above, most of the sectors experiencing large changes in environmental outcomes, such as the increase in water use in hay farming, or the decline in hazardous waste outputs from the petroleum industry, do not follow the pattern of economic changes as reported from the GTAP simulation. However, while this is true in general for the six non-air pollution types, it does not hold for declines in air emissions. Sources of declines for all three air pollution sources are dominated by changes in the construction industry. This finding has implications for previous studies linking trade and environmental outcomes that focus only on those sectors directly and significantly affected by changing trade policy and usually on air quality indices. The effects from trade are complex and multi-layered and looking at one media type (such as air) is not sufficient in determining the environmental impacts of large scale economic changes. Environmental outcomes depend not only on changes in output types, but also where the production is located and most importantly, how that output is produced.

Foreign Scenario

Tables 6A-6E show the TEAM results from removing trade distortions. As with the domestic simulation, most of the media categories in this scenario increase. Only hazardous waste (Table 6A) and point source air emissions (Table 6D) experience net declines, both less than one percent.

Table 6A shows the results for hazardous waste and water use. The semiconductor & related device manufacturing sector experiences the largest increase of 1.2 billion pounds in hazardous waste emissions. Most of this activity occurs in the western states, with Arizona (33 percent of the total), New Mexico (26 percent of the total), and California (18 percent of the total), accounting for most of the total change. Water use changes are dominated by agricultural sectors and show a general substitution away from cotton and sugar, and towards wheat, rice and oilseeds. The geographic distribution of changes in water use are much more dispersed than seen in hazardous waste where most effects are concentrated in one or two states.

Water use patterns are repeated in the results for land use (top panel of Table 6B) and agricultural chemicals (bottom panel of Table 6B), where we see movement out of sugar and cotton and into wheat and soybeans. Cotton is the only sector experiencing a decline in agricultural chemicals use in this scenario.

Table 6C shows the results for direct and indirect water discharges. With the removal of foreign trade distortions, pressed and blown glass is the sector that has the largest increase in direct water discharges at 31 million pounds. One hundred percent of this activity is in the state of Kentucky. However, this still represents only a small change in total water output for this sector, increasing by 0.35 percent. Compare these results to the next highest sector, Cattle feedlots, which emit 25.2 million additional pounds of discharges, a 7.6 percent increase. This illustrates how a small increase in a higher-emitting sector has a larger impact than a large increase in a lower emitting sector.

The other entries in Table 6C largely reflect the anticipated impacts of elimination of foreign trade distortions: less activity in footwear, textiles and apparel, and increases in animal agriculture and high tech sectors.

Table 6D shows the results for point source and area source air emissions. Three of the top five increasing sectors for point source air emissions are paper products manufacturing sectors. Area emissions are dominated by agriculture. The distribution of the changes for both is widespread. The exceptions are Kentucky (from distilleries) and Indiana (from petroleum and coal production) in point source.

Table 6E shows changes in mobile source air emissions. There are increases from couriers, animal slaughtering (corresponding to the increases in animal agriculture seen in Table 6D), and trucking as well as beef cattle ranching and farming, and wheat farming. The declines are mostly in building trades: plumbing, heating and air conditioning contractors, commercial and institutional building construction and single family housing construction and electrical contractors. These changes are all derived from a decrease in the GTAP construction sector under this scenario. The existence of these changes in this scenario, when construction did not rank highly in terms of economic effects, calls into question the rationale for their rankings in the domestic simulation, where construction output did fall by a relatively large amount. The declines in the foreign simulation are much smaller than in the domestic, especially when comparing percentage changes. However, the smaller percentage change in the foreign simulation still translated into large mobile source air emission increases, indicating these sectors are high relative polluters. These changes in mobile source emissions are widespread with most states experiencing less than five percent of the total change. The largest effects are increases from wheat farming in Nebraska and couriers in California and these account for only 15 and 13 percent, respectively, of their total change.

Conclusions

The paper began by introducing the concepts of scale, composition and technique effects in the context of the effects of changes in trade patterns on environmental outcomes These concepts, however, can be discussed in the context of domestic policy changes as well. Theoretically, changes in overall efficiency due to the removal of domestic policy distortions would affect overall output and produce a scale effect. In the case of the US, we saw output decline, albeit slightly, with the removal of domestic distortions. All things equal then, we would expect to see declines in pollution levels as well. This however, did not happen as only three of the nine media examined experienced reductions in output, and two of these three (the exception being agricultural chemicals) are less than one percent.

Given the disparity in US domestic support across sectors, we would except to see most of the pollution effects emanating from compositional changes. There was some evidence of this, especially within the agriculture sector as producers shifted out of wheat and corn and into cotton and soybean. Also, declines in the construction sector led to large decreases in hazardous waste output and led to the net decline in mobile source air emissions. Technique effects, given our static models are not specifically considered.

In the foreign scenario, total output increases, and scale effects are more prominent. Only two pollutant types decline in this scenario and both by very small amounts. Compositional changes are evident across the board, especially in the agriculture and textile sectors. Here, we see decreases in hazardous waste, direct and indirect water discharges from movement out of textiles and increases in mobile and area source air emissions from the expansion of agriculture sectors.

Examining trends in sector output changes and attributing them to scale or compositional effects is really only indicatory of what the underlying forces are. Much of the scale effect is brought about by changes in income and thus should be observed over time. We are examining the results of a static simulation performed over one period. Changes in investment flows over time as a result of a any economic liberalization will effect income and the composition of output as well. Thus, the trends we present are only to provide a flavor for a possible break down of effects.

The overall results, however, show that, as far as air emissions go, changes resulting from the removal of domestic distortions cause emissions to decline while removal of foreign distortions are associated with increases. In that sense, it would appear that trade liberalization is bad, with respect to domestic distortions, for the environment. However, looking at the other measures of environmental outcomes, the results are mixed. Multilateral trade liberalization improves outcomes for hazardous waste, water use, land use and indirect water discharges. Domestic liberalization appears to have greater positive impacts on agricultural chemical and direct water discharge emissions.

This paper presents the outcomes of large scale policy changes on a number of environmental indicators as well as the varied geographic effects. The point is to illustrate the complexity of the interaction between economic changes and environmental outcomes. The relationship between economic sectors affected by the policy changes and the change in environmental media depended on the type of media examined (air versus water discharges for example) as well as where the industry was located. These outcomes are presented to highlight the need to 'drill down' beyond the national estimates of pollutant changes and examine the 'local' effects. TEAM is a step on the way to this more detailed analysis.

These results are preliminary in nature. Consideration has not been given to particular programs in place, or how these emission changes affect current permit standards or policies. In addition, as stated above, individual chemicals within each media type need to be examined to determine the true nature of the environmental effect. Geographic distribution is also of primary importance. Increases in emissions in an area which is already out of compliance with regulated limits is very different than increases in an area which is in attainment. One thing is certain; calls for greater empirical work to support environmental analysis of trade agreements are well placed.

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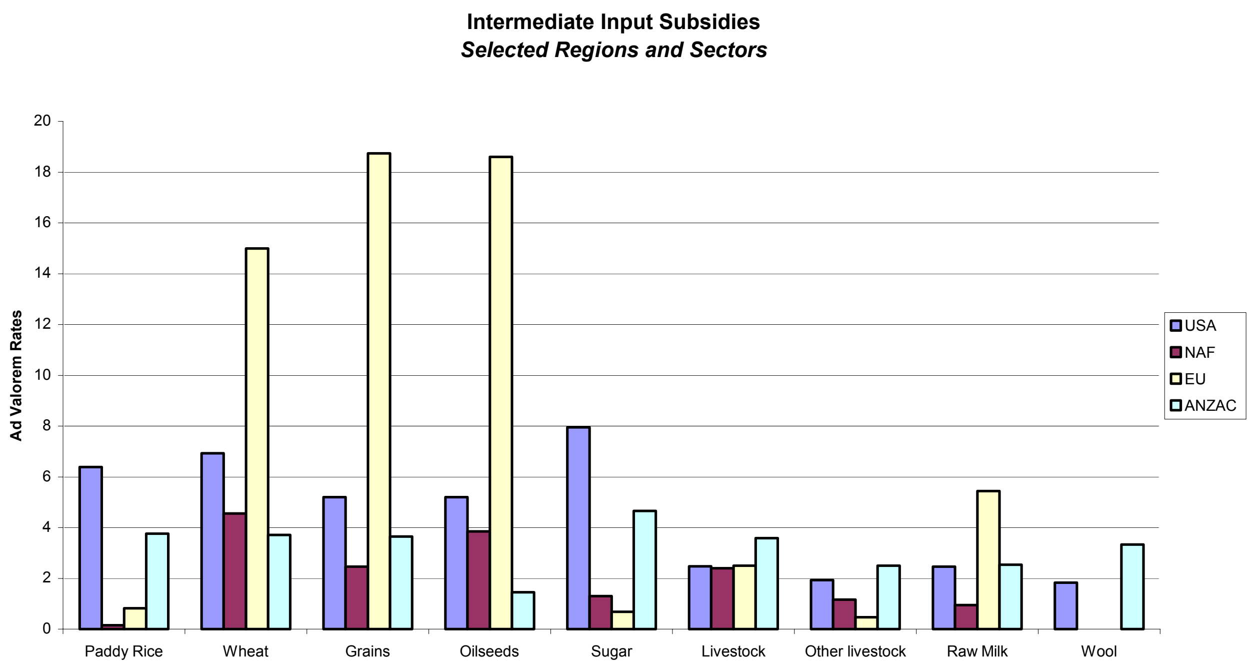
Appendix A

Regional aggregation mapping

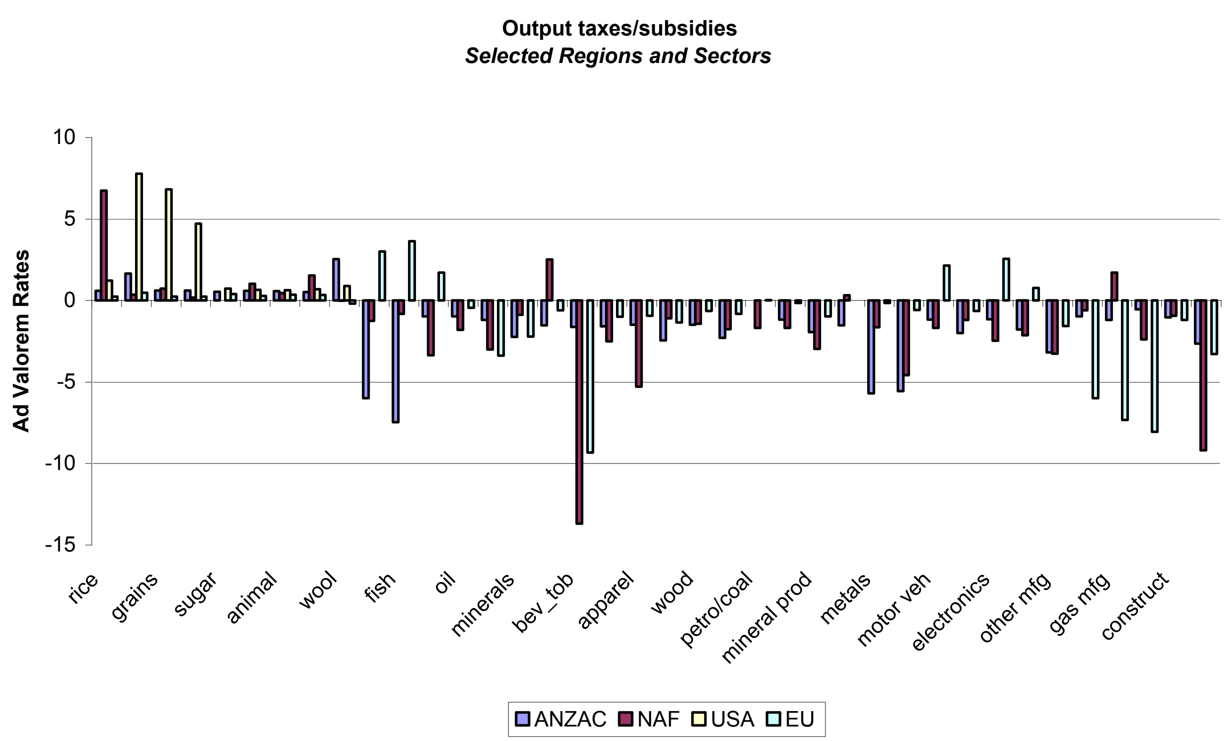
Simulation Sector	**Components**
Anzac	Australia, New Zealand
China	China
USA	United States
East Asia	Hong Kong, Japan, Korea, Taiwan
Rest of East Asia	Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam
South Asia	Bangladesh, India, Sri Lanka, rest of South Asia
South America	Colombia, Peru, Venezuela, Argentina, Brazil, Chile, Uruguay, rest of Andean Pact, rest of South America
European Union	Austria, Belgium, Denmark, Finland, France, Germany, United Kingdom, Greece, Ireland, Italy, Luxemburg, Netherlands, Portugal, Spain, Sweden
Rest of North America	Canada, Mexico, Central America and the Caribbean
Non-EU Europe	Switzerland, rest, of EFTA, Albania, Bulgaria, Croatia, Czech Republic, Hungary, Malta, Poland, Romania, Slovakia, Slovenia, Estonia, Latvia, Lithuania, Russian Federation, former Soviet Union
Rest of World	Turkey, Cyprus, rest of Middle East, Morocco, rest of North Africa, Botswana, rest of SACU, Malawi, Mozambique, Tanzania, Zambia, Zimbabwe, rest of southern Africa, Uganda, rest of sub-Saharan Africa, rest of World

Figure 1



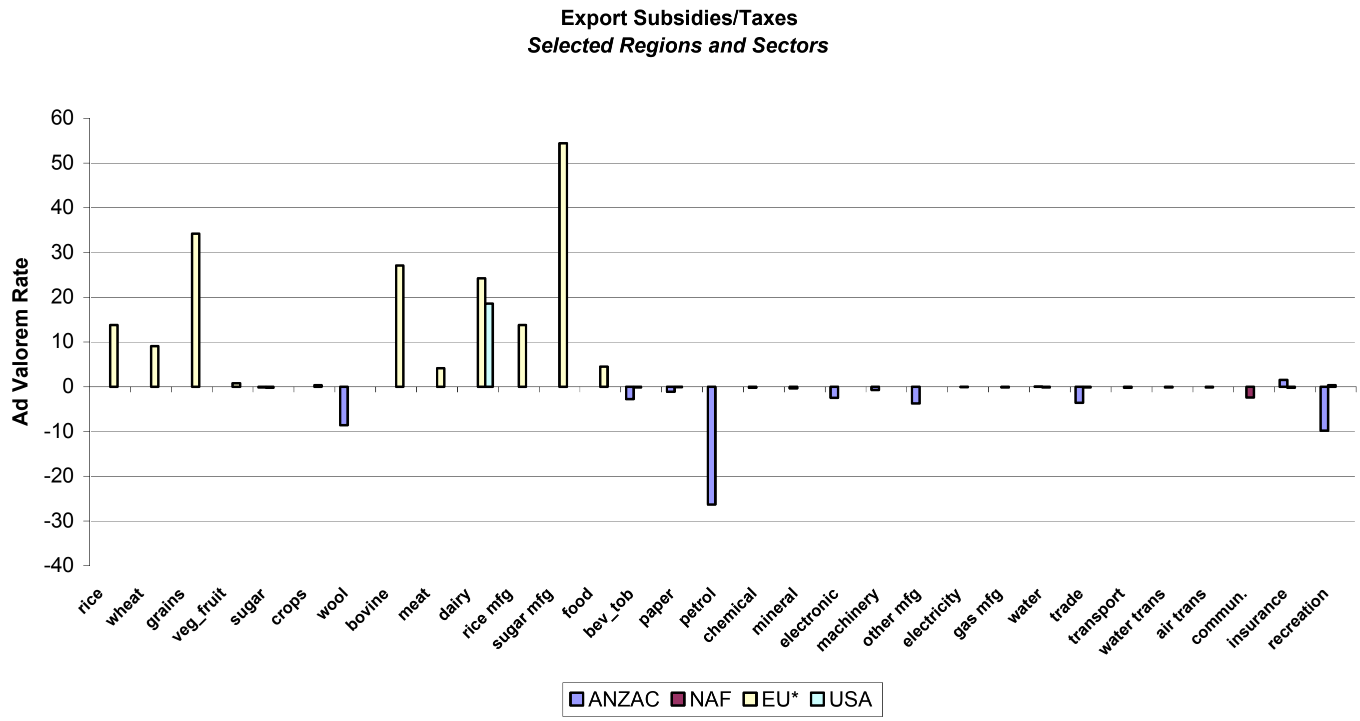
Source: GTAP Database 5.4

Figure 2



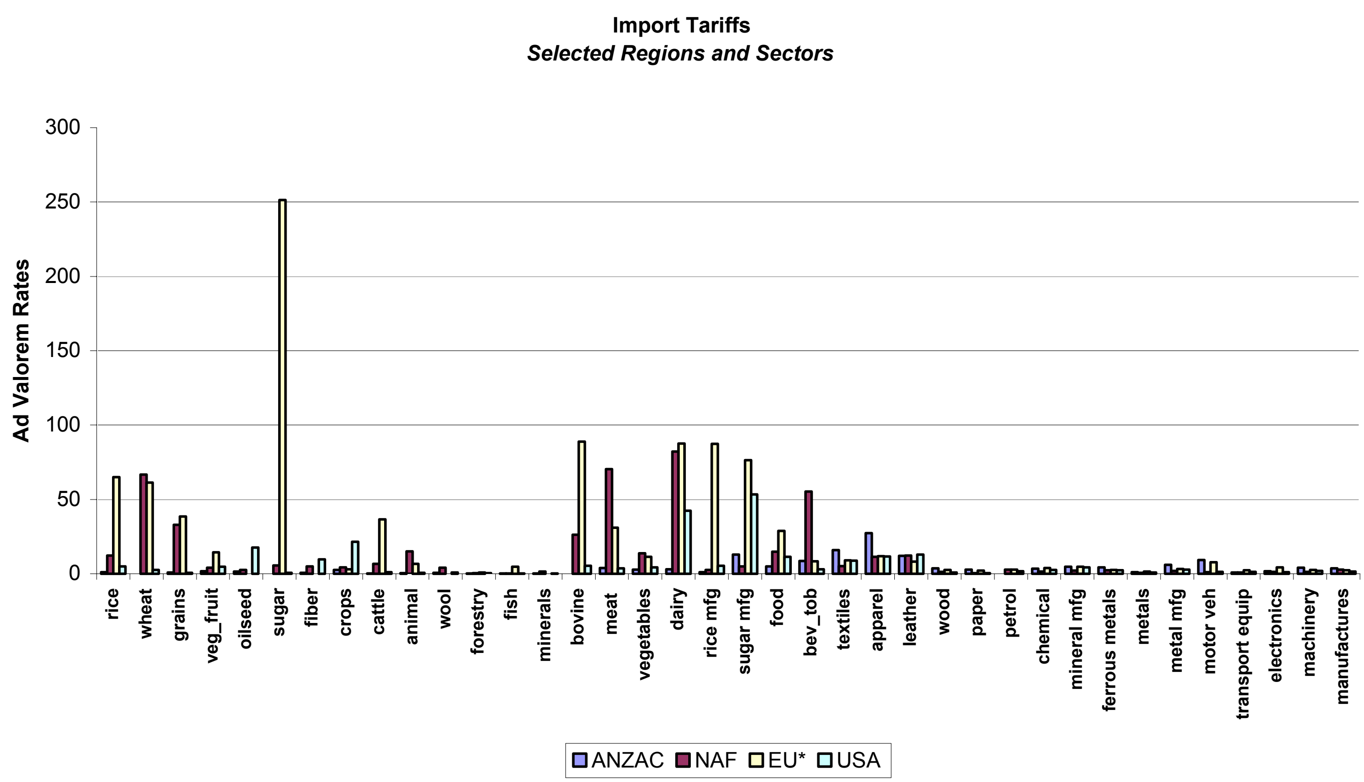
Source: GTAP Database 5.4

Figure 3



Source: GTAP Database 5.4
**Does not include intra-EU trade*

Figure 4



Source: GTAP Database 5.4
**Does not include intra-EU trade*

Table 1: Reporting Elements By Pollutant/Resource Category in TEAM

Pollutant/Resource Category	Reporting Elements	Reporting Elements (Chemicals) with Toxic Weighting Factors
Point Source Air Emissions	396	270
Area Source Air Emissions	149	127
Mobile Source Air Emissions	31	21
Indirect Water Discharges	244	206
Direct Water Discharges	233	157
Hazardous Waste Groups	10	10
Agricultural Chemicals*	215	NA
Land Use	1	NA
Water Use	6	NA

*54 agricultural chemicals have toxic weights. However, the health and environmental risk impact concepts underlying development of the toxic weights are not generally applicable to analyzing risks of agricultural chemical usage. As a result, TEAM does not apply toxic weighting factors to agricultural chemicals usage.
NA – not applicable.

Table 2 Summary Statistics (percentage change)

	Domestic distortions			Foreign trade distortions		
	Changes in GDP*	**Changes in Imports**	**Changes in Exports**	**Changes in GDP***	**Changes in Imports**	**Changes in Exports**
Anzac	-0.05	-1.00	-0.57	0.09	11.90	7.61
China	0.06	3.80	-10.65	1.34	35.25	29.08
USA	*-0.03*	*-9.81*	*17.31*	*0.025*	*5.83*	*9.84*
East Asia	0.25	6.30	-16.16	0.31	12.51	10.92
Rest of East Asia	-0.01	1.65	2.75	0.51	9.92	7.94
South Asia	0.14	2.27	-9.95	0.99	39.93	37.11
South America	-0.21	-7.17	13.38	0.53	28.96	26.04
European Union	0.12	-0.54	-1.70	0.27	2.72	3.95
Rest of North America	0.06	1.50	-0.37	0.24	5.91	7.23
Non_EU Europe	0.27	2.62	-4.87	1.09	16.92	13.36
Rest of World	-0.13	-2.48	0.43	0.97	19.32	18.27

*Quantity index

Table 3 Welfare Effects (1997 $US million)

Region	Aggregate Welfare Effect	Contribution of Terms of Trade	Contribution of Allocation	Contribution of Investment/Savings
Removal of domestic distortions				
Anzac	1,060	1,295	-240	5.6
China	4,842	4,803	534	-495
USA	-37,133	-33,965	-2,019	-1,148
East Asia	41,251	28,522	12,823	-95
Rest of East Asia	-714	-736	-36	58
South Asia	2,482	1,617	741	123
South America	-6,602	-2,735	-3,169	-697
European Union	6,193	-6,059	9,503	2,749
Rest of North America	3,949	3,172	618	158
Non-EU Europe	6,212	2,765	3,625	-178
Rest of World	-2,536	-110	-1,943	-482
Removal of foreign trade distortions				
Anzac	3,767	3,246	450	71
China	5,726	-5,529	11,405	-150
USA	5,387	3,306	2,055	25
East Asia	27,768	12,772	15,772	-776
Rest of East Asia	4,520	1,028	3,336	156
South Asia	2,181	-2,917	5,250	-152
South America	10,516	2,548	7,845	122
European Union	20,305	-2,182	21,147	1,340
Rest of North America	133	-2,881	2,687	327
Non-EU Europe	13,536	-910	14,311	136
Rest of World	4,845	-8,678	14,622	-1,098

Table 4 Changes in US sector output (percentage change)

Domestic				**Foreign trade**			
Top five gaining sectors		***Top five declining sectors***		***Top five gaining sectors***		***Top five declining sectors***	
Leather	13.02	Wheat	-12.55	Milled rice	158.0	Wearing apparel	-28.84
Manufacture transport equip	12.25	Construction	-9.58	Rice	29.30	Sugar	-17.40
Electronic equipment	10.81	Wood Manuf	-3.70	Wheat	20.23	Cane/beet	-17.08
Fisheries	7.95	Beverage & tobacco	-3.39	Beverage & tobacco	8.69	Textiles	-11.44
Gas	7.71	Grains	-1.26	Oilseeds	7.62	Leather	-8.62

Table 5A Emissions changes from removing domestic distortions

Emission Type	**Hazardous Waste** (pounds)		
Total Change 14,873,700,532 (1.6%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)***
Top five increasing sectors (ranked by total change)			
Semiconductor and related Industry	4,056,964,825	8.61	AZ(33),NM(26),CA(18), PA(6)
Photographic & photocopying equipment	1,415,230,370	4.19	NY(99)
Bare printed circuit board manufacturing	1,207,955,320	8.61	CA(40),VA(27),NH(6)
Iron and steel plants	986,237,041	3.99	PA(72),MI(8)
All other basic inorganic chemical manuf.	945,182,610	0.92	TN(64),TX(12),LA(6)
Top five declining sectors (ranked by total change)			
Petroleum refineries	-3,380,320,041	-1.42	PA(24),TX(23),CA(14),LA(13)
Wood preservation	-102,030,119	-5.91	GA(66),AL(10),MO(6)
Plumbing, heating & AC	-17,168,092	-10.85	NY(100)
Bridge & tunnel construction	-10,450,882	-10.85	MA(97)
All other heavy construction	-9,722,727	-10.85	NS

Emission Type	**Water use** (millions of gallons)		
Total Change 3,056,028 (1.87%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)***
Top five increasing sectors (ranked by total change)			
Hay Farming	1,176,510	10.63	CA(16),CO(16),ID(12),WY(11), MT(10),OR(10),WA(6)
Oilseed (except soybean) farming	316,870	5.41	MT(15),CO(13),WY(9),CA(7),NE(7)
Other vegetable and melon farming	271,101	9.81	CA(34),TX(10),ID(9),CO(8)
Nursery & Tree Production	220,162	10.63	CA(56),OR(9),ID(9),CO(7),HI(7),FL(7)
Fossil fuel electric power	208,895	0.43	TX(8),NY(8)
Top five declining sectors (ranked by total change)			
Wheat farming	-655,706	-17.68	ID(26),CA(15),WA(9),CO(9),TX(9)
Corn farming	-91,755	-2.27	NE(39),CO(14),KS(14),TX(11),CA(8)
All other grain farming	-41,749	-2.27	ID(25),TX(16),MT(11),CO(11),WY(10)
Petroleum refining	-6,176	-1.42	LA(42),TX(23),IN(8),CA(8)
Sawmills	-5,981	-5.91	WA(25),TX(16),OR(15),CA(13),MI(9)

*States shown where significant (i.e., greater than 5% of total) results are found, if none, NS shown.

Table 5B Emissions changes from removing domestic distortions

Emission Type	Land Use (acres)		
Total Change 5,575,903 (1.5%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)**
Top five increasing sectors (ranked by total change)			
Hay farming	6,032,313	10.63	TX(8),MO(7),WI(6)
Nursery & tree production	4,375,381	10.63	PA(49), CA(28)
Soybean farming	3,525,802	5.41	IL(15),IA(15)MN(9),IN(8),M)(7)
Cotton farming	1,229,675	9.41	TX(40),GE(10),CA(8),AR(7),MO(7),MI(7)
Oilseed (except Soy) farming	828,517	5.41	IA(12),IL(10),ND(10),IN(7),OH(7)
Top five declining sectors (ranked by total change)			
Wheat farming	-10,313,959	-17.68	ND(19),KS(16),MT(10),OK(8),TX(6)
Corn farming	-1,587,907	-2.27	IA(17),IL(15),NE(12),MN(9),IN(8)
All other grain	-202,924	-2.27	KS(18),TX(18),ND(15),MT(7)
No other declining sectors			

Emission Type	Agricultural chemicals (pounds applied)		
Total Change –761,278,996 (-2.96%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)**
Top five increasing sectors (ranked by total change)			
Cotton farming	188,651,065	9.41	TX(22),GE(17),TN(16)MS(11),AR(9)CA(8)
Soybean farming	176,557,759	5.41	
Potato farming	54,755,481	9.18	ID(44),WA(22),WI(8),OR(8)
Other vegetable & melon farming	11,134,792	9.18	CA(51),FL(15),GE(6)
Dry pea & bean farming	2,568,886	9.18	WI(43),OR(27),MI(12)
Top five declining sectors (ranked by total change)			
Wheat farming	-861,313,019	-17.68	ND(23),KS(15),OK(8),MN(7),MT(7),TX(7)
Corn farming	-335,290,246	-2.27	IL(24),IA(19),IN(12),NY(11),MN(9),OH(8)
Dairy cattle & milk production	-4,214	-.095	KS(7)
All other grain farming	-79	-2.27	KS(49),MN(21),PA(15),WI(9),SD(7)
No other declining sectors			

*States shown where significant (i.e., greater than 5% of total) results are found, if none, NS shown.

Table 5C Emissions changes from removing domestic distortions

Emission Type	Direct Water Discharge (pounds)		
Total Change 63,027,337 (0.34%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)***
Top five increasing sectors (ranked by total change)			
Pulp mills	14,645,151	1.69	NC(32),FL(16),AR(11),GE(8)
Paper (except newspaper) mills	12,239,740	1.61	
Steel & Iron	11,400,266	3.99	WV(46),IN(18),OH(14),PA(8), MI(6)
Electric power generation	10,871,736	0.43	KY(79)
Broiler & other meat type chicken production	10,367,319	3.35	NC(19),AL(15),AR(15),MI(8)
Top five declining sectors (ranked by total change)			
Other pressed & blown glass	-29,746,753	-0.33	KY(100)
Petroleum refineries	-6,590,380	-1.42	CA(77),IL(8)
Hardwood & veneer	-3,456,751	-5.91	FL(100)
Dairy cattle & milk production	-2,721,022	-0.95	CA(19),WI(17),MN(7),NY(7)
Wood window & door manufacturing	-2,650,646	-5.91	KY(100)

Emission Type	Indirect Water Discharge (pounds)		
Total Change 6,685,386 (2.1%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)***
Top five increasing sectors (ranked by total change)			
Semiconductor and related devices	775,394	8.61	CA(22),AZ(20),TX(17),MO(12),OR(12)
Pulp mills	621,348	1.69	OR(24),TX(20),FL(19),MN(16),MI(11).PA(10)
Plastic material & resin manufacturing	407,407	0.92	TX(47),NJ(37),MA(7)
Electroplating, plating, etc	385,828	3.81	IL(15),OH(13),WI(12),MN(10),MA(8),OR(7)
Electronic capacitor manufacturing	381,978	8.42	AL(78),SC(19)
Top five declining sectors (ranked by total change)			
All other miscellaneous food manufacturing	-65,183	-5.68	AR(25),WI(20),TN(13),NJ(11),CA(8),IA(6)
Cheese manufacturing	-53,617	-0.77	CA(28),WI(22),MN(16),NY(7)
Petroleum refineries	-51.978	-1.42	CA(53),TX(29),PA(7)
Dry condensed & evaporated dairy	-37,846	-0.78	SD(69),WI(10)
Petroleum lubricating oil & grease manufacturing	-23,937	-1.42	CA(95)

*States shown where significant (i.e. greater than 5% of total) results are found, if none, NS shown.

Table 5D Emissions changes from removing domestic distortions

Emission Type	Point Source Air (tons)		
Total Change 187,270 (0.6%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)***
Top five increasing sectors (ranked by total change)			
Primary aluminum production	30,526	5.45	WA(27),TX(15),KY(12),MO(9)
Fossil fuel electric power generation	28,683	0.43	MD(27),IN(20),KY(14),NC(8)
Crude petroleum & natural gas extraction	16,953	3.68	TX(21),LA(15),ND(10),CO(10),AL(9)
Iron & Steel	16,879	3.99	OH(34),IL(16),PA(10),AL(9)
Paper(except newsprint) Mills	11,829	1.69	AL(19),WI(10),LA(8),NC(8),GE(7)
Top five declining sectors (ranked by total change)			
Petroleum refineries	-13,733	-1.42	TX(23),LA(14),IL(12),CA(8)
Sawmills	-7,047	-5.91	MS(17),CA(14),AL(10),OR(10),AR(7)
Reconstituted wood product manufacturing	-6,969	-5.91	TX(17),LA(9),MI(9),GE(8),OR(7),MN(7), MS(7)
All other petroleum & coal product manufacturing	-6,949	-1.42	IN(69),MD(14),LA(7)
Softwood veneer & plywood manufacturing	-6,508	-5.91	LA(16),TX(13),AR(12)AL(9),OR(8),MI(8)

Emission Type	Area Source Air (tons)		
Total Change -867,652,900 (-0.42%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)***
Top five increasing sectors (ranked by total change)			
Hay farming	203,527,919	10.63	OR(31),ID(17),CA(8)
Cotton farming	188,249,252	9.41	GA(29),TX(18),AL(12),MS(10)
Soybean farming	161,144,608	5.41	UL(17),IA(11),IN(8),MN(7),OH(7), MI(6)
Other vegetable (except potato) & melon farming	113,2713322	9.18	FL(17),GE(16),CA(16),OR(14)
Broiler & other meat-type manufacturing	100,657,952	3.35	GE(17),MS(17),AL(14),NC(12),AR(10)
Top five declining sectors (ranked by total change)			
Commercial & institutional building construction	-393,620,326	-10.85	TX(12),NY(8)
Wheat farming	-378,563,820	-17.68	ND(14),KS(13),ID(12),MT(10),OK(8)
Single family housing construction	-332,819,985	-10.85	TX(11),FL(8),CA(6)
Plumbing, heating & air conditioning	-187,961,199	-10.85	TX(12),NY(7)
Janitorial service	-170,528,574	-1.42	CA(14),TX(8),FL(6)

*States shown where significant (i.e. greater than 5% of total) results are found, if none, NS shown.

Table 5E Emissions changes from removing domestic distortions

Emission Type	**Mobile Source Air** (tons)		
Total Change –386,136,460 (-0.26%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)***
Top five increasing sectors (ranked by total change)			
General freight, long distance, truckload	88,627,456	2.66	NS
General freight, long distance, less than truckload	40,367,320	2.66	CA(9),OH(6),GE(6)
Specialized freight (except used goods) trucking, long distance	34,654,851	2.66	TX(7),OH(7),CA(6)
Specialized freight (except used goods) trucking, local	33,918,971	2.66	CA(11),OH(6),TX(6)
Couriers	30,173,296	1.45	CA(13)
Top five declining sectors (ranked by total change)			
Plumbing, heating & air conditioning	-123,380,442	-10.85	TX(12),FL(8),CA(7),OH(7),NY(6)
Commercial & institutional building construction	-105,999,174	-10.85	CA(12),TX(6),NY(6)
Single family housing construction	-92,886,801	-10.85	CA(14),FL(7),TX(6)
Electrical contractors	-89,846,366	-10.85	TX(11),FL(8),CA(7),NY(7),OH(6)
Concrete contractors	-37,237,862	-10.85	TX(12),OH(9),CA(9),FL(8),IL(6)

*States shown where significant (i.e. greater than 5% of total) results are found, if none, NS shown.

Table 6A Emissions changes from removing foreign trade distortions

Emission Type	**Hazardous Waste** (pounds)		
Total Change –404,591,807 (-0.04%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)***
Top five increasing sectors (ranked by total change)			
Semiconductor & related device manufacturing	1,200,883,700	2.55	AZ(33), NM(26), CA(18), PA(6)
Bare printed circuit board manufacturing	387,161,904	2.55	CA(40), VA(27), NHZ(6)
Paper board mills	369,571,078	0.80	LA(99)
Photographic & photocopying equipment manufacturing	354,201,068	1.05	NY(99)
Copper rolling, drawing & extruding	92,488,734	1.59	MI(80),PA(7)
Top five declining sectors (ranked by total change)			
Petroleum refineries	-3,788,032,183	-1.59	PA(24), TX(23),CA(14),LA(13)
Fastener, button, needle & pin manufacturing	-87,902,170	-18.86	GA(100)
Iron & steel	-35,125,406	-0.14	PA(79), MI(8)
Motor vehicle seating & interior trim manufacturing	-30,613,765	-12.26	MA(79), CO(20)
Motor vehicle steering & suspension components	-20,777,579	-1.18	NE(77), MI(8),IN(6)

Emission Type	**Water use** (millions of gallons)		
Total Change 1,981,928 (1.2%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)***
Top five increasing sectors (ranked by total change)			
Wheat farming	1,056,777	28.5	ID(26),CA(15),WA(9),CO(9),TX(9), KS(7),MO(7)
Oilseed (except soybean) farming	458,840	7.84	MT(15),CO(13),WY(9),ID(9),CA(7),NE(7),TX(6)
Rice farming	411,530	24.66	CA(41), AR(34),LA(9),TX(8),MI(6)
Other vegetables (except potato) & melon farming	290,672	9.85	CA(34),TX(10),ID(9),CO(8),WA(7), MO(6)
Potato farming	206,799	9.85	CA(22),ID(12),WA(11),TX(10)AR(7), FL(7)
Top five declining sectors (ranked by total change)			
Hay farming	-828,622	-7.49	CA(16), CO(16),ID(12),WY(11),OR(10), WA(10),MT(10)
Nursery & tree production	-155,061	-7.49	CA(56),OR(9),CO(7),FL(7),HI(7)
Sugar beet farming	-131,480	-19.02	ID(33), WY(20), CA(20),MT(11), CO(7)
Cotton farming	-84,203	-3.86	CA(45), TX(32),AR(9)
Floriculture	-38,790	-7.48	LA(26),CO(19),CA(19) TX(14),WY(12), ID(11), FL(11)

*States shown where significant (i.e. greater than 5% of total) results are found, if none, NS shown.

Table 6B Emissions changes from removing foreign trade distortions

Emission Type	Land Use (acres)		
Total Change 17,417,627 (4.86%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)***
Top five increasing sectors (ranked by total change)			
Wheat farming	16,622,630	28.5	ND(19),KS(16), MT(10),OK(8),TX(6)
Soybean farming	5,105,495	7.84	IL(15),IA(15) MN(9), IN(8), MO(7)
Oilseed (except soybean) farming	1,199,724	7.84	IA(12),IL(10),ND(10),IN(7) SD(6),MN(6)OH(6)
Rice farming	764,775	24.65	AR(45), CA(17), LA(19),TX(9),MI(8)
Oilseed & grain combination farming	701,480	7.86	TX(18),KS(18),ND(15),MO(6)
Top five declining sectors (ranked by total change)			
Hay farming	-4,248,589	-7.49	TX(7),WI(6),MO(6)
Nursery & tree production	-3,081,603	-7.48	PA(49), CA(28)
Cotton farming	-503,594	-3.85	TX(40),GE(10),CA(8),AR(7),MI(7)
Sugar beet farming	-273,316	-19.02	MN(35), ND(16), ID(13), MI(11),CA(7)
Sugar cane farming	-173,627	-19.03	FL(48), LA(46)

Emission Type	Agricultural chemicals (pounds applied)		
Total Change 1,645,119,051 (6.4%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)***
Top five increasing sectors (ranked by total change)			
Wheat farming	1,388,146,602	28.5	ND(23),KS(15),OK(8),MN(7), MT(7),TX(7),NC(6)
Soybean farming	255,662,338	7.84	IL(16),OH(12),IA(12),IN(10),MN(7)
Potato farming	58,708,321	9.85	ID(44),WA(22),WI(8),OR(8),ME(7)
Other vegetable (except potato) & melon farming	11,938,621	9.85	CA(51), FL(15)
Corn farming	3,090,952	0.02	IL(24),IA(19),IN(12),NE(11),MN(9),OH(8)
Top five declining sectors (ranked by total change)			
Cotton farming	-77,259,082	-3.85	TX(22),GE(17), MO(11%),AR(9), TN(8),AL(6),NC(6)
No other declining sectors			

*States shown where significant (i.e. greater than 5% of total) results are found, if none, NS shown.

Table 6C Emissions changes from removing foreign trade distortions

Emission Type	**Direct Water Discharge** (pounds)		
Total Change 102,606,047 (0.55%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)***
Top five increasing sectors (ranked by total change)			
Other pressed & blown glass and glassware manufacturing	31,243,505	0.35	KY(100)
Cattle feedlots	25,180,861	7.58	TX(23),NE(18),KS(17),CO(13),IA(7)
Hog & pig farming	16,419,597	7.58	IA(24),NC(19),MN(12),IL(8),IN(7),NE(6)
Broiler & other meat type chicken production	11,611,500	3.75	GE(15),AR(15),AL(13),CA(13), NC(9), MI(8),TX(6)
Pulp Mills	6,949,468	0.80	NC(32),FL(16),AR(11),GE(8),WA(6)
Top five declining sectors (ranked by total change)			
Beet sugar manufacturing	-18,974,368	-20.86	MN(99)
Petroleum refineries	-7,385,268	-1.59	CA(77), IL(8)
Other hosiery & sock mills	-2,006,306	-35.89	MS(97)
Broadwoven fabric finishing mills	-1,541,398	-12.87	SC(39), NC(28), AL(14), RI(11)
Sugarcane Mills	-1,182,619	-20.86	HI(52),NY(33),LA(15)

Emission Type	**Indirect Water Discharge** (pounds)		
Total Change 1,523,828 (0.48%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)***
Top five increasing sectors (ranked by total change)			
Animal (except poultry) slaughtering	460,895	7.27	VA(50), IA(26), MO(11)
Pulp mills	294,844	0.80	OR(24),TX(20),FL(19),MN(16),MI(11),PA(10)
Semiconductor & related devices manufacturing	235,441	2.54	AZ(20),CA(22),TX(17), MO(12), OR(12)
All other food miscellaneous manufacturing	205,928	17.95	AR(25), WI(20), TN(13), NJ(11),CA(8),IA(6)
Electronic Capacitor manufacturing	126,811	2.79	AL(78), SC(19)
Top five declining sectors (ranked by total change)			
Leather & hide tanning & finishing	-181,518	-19.17	MN(25), MO(21), TX(14), WI(13), ME(10)
Fabric coating mills	-174,066	-12.87	DE(97)
Textile & fabric (except broadwoven) finishing mills	-98,963	-12.87	SC(69), NC(20), NJ(9)
Broadwoven fabric finishing mills	-87,043	-12.87	SC(43), NC(26), RI(19),IL(6)
Broadwoven fabric mills	-59,348	-12.86	GA(44), VA(24), AL(12), SC(10)

*States shown where significant (i.e. greater than 5% of total) results are found, if none, NS shown.

Table 6D Emissions changes from removing foreign trade distortions

Emission Type	Point Source Air (tons)		
Total Change –19,816 (-0.06%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)***
Top five increasing sectors (ranked by total change)			
Primary Aluminum	8,891	1.58	WA(27),TX(15),KY(12),MO(9),MI(9)
Paper (exc. Newsprint) Mills	5,316	0.80	GA(27),AL(16),WI(10),LA(8),N(8),AR(6),PA(6)
Pulp Mills	5,304	0.80	GA(21),WA(10),SC(9),FL(9),VA(6),OH(6)TN(6)
PaperBoard Mills	3,390	0.80	GA(38),VA(0),LA(8), FL(7), WI (6)
Distilleries	3,376	16.73	KY(66), TN(15), IN(11)
Top five declining sectors (ranked by total change)			
Sugarcane Mills	-20,570	-20.86	FL(64) LA(23),HI(9)
Petroleum Refineries	-15,390	-1.59	TX(23),LA(14), IL(13),CA(8)
Beet Sugar Manufacturing	-9,090	-20.86	ND (34), MN(17),ID(22),OR(6)
AO Petroleum and Coal Prod.	-7,787	-1.59	IN(69),MD(14),LA(7)
Crude Petrol and Nat Gas Ext	-3,871	-0.84	LA(15),ND(10),CO(10),AL(9), CA(7),WY(7),MS(6)

Emission Type	Area Source Air (tons)		
Total Change 2,284,820,989 (1.11%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)***
Top five increasing sectors (ranked by total change)			
Beef Cattle Ranching & Farm'g	745,946,340	7.59	TX(13),OR(9),AL(6)
Wheat Farming	610,117,424	28.5	ND(14),KS(13),ID(12),MT(10),OK(8),OR(6)
Hog & Pig Farming	241,982,645	7.59	NC(21),IA(20),MN(9),IL(9),IN(7)
Soybean Farming	233,343,511	7.84	IL(17),IA(11),IN(8),MN(7),OH(7),MO(6),AR(6)
Cattle Feedlots	232,134,622	7.60	NE(15),KS(14),TX(12),IA(8),CO(7)
Top five declining sectors (ranked by total change)			
Janitorial services	-203,491,724	-1.70	TX(18),CA(14),FL(6)
Hay Farming	-143,345,763	-10.32	OR(31),ID(17),CA(8)
Cotton Farming	-77,094,527	-3.86	GA(29),TX(18),AL(12),MS(10),AR(6),CO(6)
Tobacco Farming	-69,173,183	-7.48	NC(36),GA(29),KY(11),SC(9),TN(6)
Extermination & pest control	-54,502,976	-1.70	CA(19),FL(18),TX(6)

*States shown where significant (i.e. greater than 5% of total) results are found, if none, NS shown.

Table 6E Emissions changes from removing foreign distortions

Emission Type	Mobile Source Air (tons)		
Total Change 177,311,384 (0.12%)			
Sector	**Total Change**	**Percent Change**	**State (% of total)***
Top five increasing sectors (ranked by total change)			
Couriers	59,523,912	2.86	CA(13)
Animal Slaughtering	56,015,040	7.27	CA(11),TX(7)
General Freight Trucking	32,139,399	0.97	NS
Beef Cattle Ranching & Farm.	24,663,251	7.59	TX(11),OK(10), CO(7)
Wheat Farming	20,543,919	28.5	ND(15),OK(10),KS(9),CO(9), MT(7),ID(7)
Top five declining sectors (ranked by total change)			
Plumbing, heating & air conditioning	-15,809,358	-7.48	TX(11), FL(7), CA(6), OH(6)
Commercial & institutional building construction	-13,582,209	-1.39	CA(11), TX(6)
Single family housing construction	-11,902,054	-1.39	CA(13), FL(6)
Electrical contractors	-11,512,468	-1.39	TX(10), CA(8), FL(7), NY(7)
Hay Farming	-10,797,455	-7.48	ID(7),GA(7),CO(6)

*States shown where significant (i.e. greater than 5% of total) results are found, if none, NS shown.