The Impact of U.S. Climate Legislation on Trade with China

Client: Energy Information Administration, Department of Energy

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Table of Contents

1. INTRODUCTION

Climate change is a growing concern for U.S. policymakers. H.R. 2454, or the American Clean Energy and Security Act of 2009 (ACESA), was passed by the U.S. House of Representatives in June 2009. Rep. Henry Waxman (D-CA) and Rep. Edward Markey (D-MA) sponsored this bill which includes a national cap-and-trade program designed to reduce the annual output of greenhouse gas emissions in the United States. The authors claim an environmental program akin to ACESA is important for mitigating the effects of climate change, although such a program has domestic producers worried about the impact it will have on the competitiveness of their goods in both domestic and foreign markets. It is not clear if policies in this bill which attempt to level the playing field in global markets actually achieve their goal and reduce emissions in the long run. Our goal is to model the trade impacts of a U.S. output-based carbon tax with the adjustment policies set forth in ACESA. We also model scenarios in which other countries adopt similar climate legislation. Accompanying our results is a full analysis of policy scenarios with a specific focus on how Chinese producers and policymakers will react to U.S. actions.

There is a great deal of fear that the cap-and-trade provisions embodied in ACESA will have adverse impacts on the competitiveness of U.S. manufacturing. Concerns over a "race to the bottom," where different regions attempt to attract businesses by lowering emissions standards, are generally unfounded (Engel 1997; Potoski 2001). However, some analysts believe the adoption of a domestic cap-and-trade program will shift manufacturing and its associated emissions to countries that do not yet have comparable greenhouse gas regulations, such as China (Fischer and Morgenstern 2009**;** Fischer 2007; Ishikawa and Kiyono 2006). This scenario poses environmental concerns because the resulting emission leakage,[1] increased foreign emissions divided by the decrease in domestic emissions, can undermine the environmental effectiveness of a domestic emissions cap. In ACESA, stopping leakage is achieved through output-based domestic rebates and import taxes on the embodied emissions of imports. Policy objectives written in ACESA are thus intended to reduce CO_2 emissions in the United States while allowing American producers to compete on a level playing field in markets at home and abroad.

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[1] The Intergovernmental Panel on Climate Change (IPCC, 2001), Third Assessment Report, describes leakages as follows:

> Leakage refers to the situation in which a carbon sequestration activity (e.g., tree planting) on one piece of land inadvertently, directly or indirectly, triggers an activity which, in whole or part, counteracts the carbon effects of the initial activity. It can be shown that most of these types of problems arise from differential treatment of carbon in different regions and circumstances, and the problem is not unique to carbon sequestration activities but pervades carbon mitigation activities in the energy sector as well.

Under the U.S. H.R. 2454, the term "Emission Leakage" can be defined as a potential shift of some manufacturing activity and their associated emissions to countries that do not yet have greenhouse gas regulations comparable to the domestic cap-and-trade program of the U.S. Mathematically, this boils down to the total increase in foreign emissions divided by the total decrease in domestic emissions. The IPCC report suggests that national caps on total emissions would help alleviate the problem of leakage within national boundaries. In order to resolve the problem of leakage between nations, however, global caps would have to be implemented; hence the agreements at the Kyoto Protocol on climate change.

Fischer and Morgenstern determine that "rigorous assessment of [policy] alternatives is not possible without detailed information on the relative responses of domestic and foreign producers to carbon price changes and on the relative emissions intensity of production at home and abroad" (Fisher and Morgenstern 2009). This paper attempts to accurately model and interpret the trade and emission impacts of multiple climate policy scenarios using computable general equilibrium (CGE) software.

Using a CGE model to assess shifts in trade has several advantages over econometric approaches. CGE models have the capability of showing impacts on specified goods and sectors and also allow for easy pre- and post-shock comparisons of the economies involved. New equilibriums are found by taking a base data set and running it through a system of equations that determine the interworking of the economy. Once shocks are applied to specified variables, economic indicators can be examined for pre- and post-shock values. Because its goal is to shift the economy to a new equilibrium, the CGE model traditionally static. However, by running sequential simulations, updating the base data each time a simulation is run, we can simulate dynamic climate change scenarios, such as the reduction of rebates over time. CGE modeling also allows us to easily model technology change by adjusting the emission content of each sector. Econometric modeling, on the other hand, reveals historical relationships between many independent variables and one dependant variable. While econometric approaches are generally preferred, there is no precedent for using econometric modeling for climate change because data on this type of legislation does not exist. CGE models allow an analyst to apply shocks to an economy in equilibrium and identify how all aspects of that economy will react to reach a new Walrasian equilibrium.

Policy concerns are most pronounced among energy-intensive trade-exposed (EITE) industries. Of the qualifying industries,[2] pulp and paper, non-metallic minerals, chemicals, iron and steel, and non-ferrous metals have been identified by the Energy Information Agency as those that will be most impacted by climate legislation. Our work focuses on these sectors with the addition of several others that are integral to the model.[3]

Our approach to modeling climate legislation is unique in that it goes beyond previous work in three main areas. First, accurate representations of embodied emissions are obtained from scholars in the field of environmental science and industry publications; the data obtained was verified by engineering consultants[4] for both the U.S. and China. Second, adjustments for technology changes likely to occur over the course of the policy will be made to the final equilibrium. This problem has been avoided in the past for two reasons. First, it is difficult to know the course technology change will take in the future. Therefore, our model assumes

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[2] EITE industries meet the following qualifications:

- Energy Intensity = [energy expenditures / domestic production]
    - Eligible if ≥ 5%
- Greenhouse Gas Intensity = [total greenhouse gas emissions (including indirect emissions from electricity consumption)] * [emissions price / domestic production]
    - Eligible if ≥ 5%
- Trade Intensity = [(exports + imports) / (domestic production + imports]
    - Eligible if ≥ 15%

[3] Other sectors include: commodities, manufacturing, services, over-land transport, air transport, water transport, and capital goods.

[4] Dr. Mahmoud El-Halwagi and Dr. Renee Elms of the Texas A&M University Chemical Engineering Department

producers will invest is the most readily available emissions reducing alternatives soon after the implementation of ACESA, such as the adoption of electric arc furnaces in steel production in China. Thus, no unforeseeable technologies are adopted. Second, rarely is CGE modeling used to asses dynamic issues. We overcome this obstacle as described in the modeling section of this paper. Lastly, we go beyond our modeling results to provide policy analysis for each scenario. We suggest possible responses from China and how a case would be handled if brought to the World Trade Organization. Thus, we hope to provide the most economically efficient and politically viable policies available to U.S. lawmakers.

Our goal in this paper is to assess the trade impacts of U.S. climate legislation on trade, focusing on China. The model translates several carbon allowance prices under a cap-and-trade system into a tax on output based on emissions per sector. Import taxes, home rebates, and full border adjustments are assessed as well as several scenarios that are not directly in line with ACESA. These additional scenarios provide alternate perspectives on climate legislation to paint a full picture of the impacts it will have on the U.S., China, the European Union, and the rest of the world. The paper progresses with a comprehensive literature review of previous authors who have used CGE software to model climate policy scenarios. Following this, the derivation of embodied emission coefficients will be explained, leading into a breakdown of our model, the various policy simulations, and the impacts technology change will have on each sector as these policies are implemented. Lastly, we provide a legal and political analysis of the international impacts of U.S. policy decisions with a strong focus on China's potential reactions.

2. LITERATURE REVIEW

In many of the industrialized countries, the issues arising from the energy production, consumption and greenhouse gases (GHG) emission have been among the top public policy priorities. Policy-makers in these countries have been striving to strike a balance between production and the likely impacts of the policies for emission mitigation on the international competitiveness of domestic EITE industries.

Approaches to Modeling

Many scholars have tried to unravel the different ramifications of the global emissions problem. The analytical model of choice is the CGE model. There are two main approaches used by researchers. "Top-down" models have a macro-perspective, which separates the world into regions and sectors for the simulation of policy changes of interest. They are highly favored by economic researchers. "Bottom-up" models concentrate on the computation of technical, input-output coefficients in a production system. They are, therefore, micro-oriented and are used primarily in engineering research. Within top-down and bottom-up models are two variants: the static and dynamic approaches. While the static models take one period snapshots of the issues under investigation, the dynamic models are multi-period simulations. The model used in the current study is a top-down approach in which we incorporated both static and dynamic simulations.

The choice of a CGE approach is predicated on the fact that "an econometric approach seems handicapped by the absence of past events, and the inability to construct experiments which are comparable with the policy changes of greatest interest…therefore a multi-country, multi-sector CGE model is used to derive quantitative estimates in situations of simultaneous climate and trade policy changes of the kind in which there could be significant interaction among the policies of different countries, and where the interest is in quantifying the effects of policy change on output and trade in different sectors of the economy"(Kehoe, Srinivasan, and Whalley, 2005).

Fatai, Oxley and Scrimgeour (2003) applied dynamic concepts to CGE modeling in their study of energy efficiency improvements in the New Zealand economy. The authors use a technological bundle approach and a bottom-up framework to simulate alternative energy efficient policies and energy shocks. Their model structure evolves over time in a sequence of connected single period (static) equilibria, giving it a recursive dynamic dimension. The model has twenty-three commodities and industries linked by a constant elasticity of substitution (CES) production function format. The authors examine three sets of simple scenarios:

1. Industries are temporarily more energy efficient;
2. Industries are permanently more energy efficient; and,
3. Industries and households are more energy efficient and forecasts of economic variables are incorporated.

Their results indicate that given a government policy that increases energy efficiency by 1.5% in the energy intensive sectors and by 1.5% in the household sector, the real GDP increases from zero to about 2.5% and real wages for households increase by about 2%.

In relation to the work of Fatai et al (2003), our study adopts a top-down orientation to dynamically simulate the impacts of the imposition of a carbon tax of $31.70/per ton of CO_2. The model incorporates this tax incrementally each year into the shocks until the full tax is imposed over a ten-year horizon.

The work of Al-Amin and Hamid (2009) reflects the role of well defined equation systems in the effectiveness of CGE models. Their top-down, static model uses the Malaysian Social Accounting Matrix for the year 2000 to investigate the impact of the carbon tax policies on economic growth. The model consists of ten industries, one representative household, three production factors and rest of the world. The equation systems of the model are grouped into five blocks: (i) the price block, (ii) the production block, (iii) the institutions block, (iv) the system constraints block, and (v) the carbon emission block.

Their carbon tax policy results show that a 3.40% reduction of carbon emission reduced the nominal GDP by 3.17% and exports by 5.71%. In addition, the researchers are of the opinion that policymakers should always strike a balance between achieving reasonably good environmental impacts without losing the overall competitiveness of the various actors in the macro-economy.

Our model adopts similar a format in classifying the equation systems. Primary among these are groups of equations to define the regions of the world, traded commodities representing the five energy-intensive, trade-exposed industries (EITE), and classes of commodities (such as capital goods, endowment, produced and demanded commodities) among other variables.

One of the highlights of CGE modeling is to ability to incorporate different policy scenarios. Liang, Fan and Wei (2009) explore the general equilibrium effect of energy end-use efficiency improvement on China's economy through a bottom-up, static, multi-sector approach. The model is calibrated into a 16-sector Chinese Social Accounting Matrix for the year 2002. The authors establish seven scenarios: business as usual, sole efficiency improvement, and five policy scenarios (taxing carbon, subsidized hydropower, subsidized nuclear power, combination of taxing carbon and subsidized hydropower, combination of taxing carbon and subsidized nuclear power). Energy efficiency is constructed within a constant elasticity of substitution model. Their results show that if the energy efficiencies of the iron and steel, building materials, and construction sectors improve by 2–6%, when those in the other sectors improve by 1%, the total CO_2 emissions reduce by 17.8–86.6% from the baseline level. Also, if the efficiency improvements in these three sectors all arrive at 7%, the increment of total CO_2 emissions could be completely removed.

In line with the contemporary approach of Liang et. al,, we develop four main scenarios which will be discussed further in our modeling section. They are:

1. Simulation 0 – A production tax in the U.S. with no accompanying import taxes. No other region imposes a production tax.
2. Simulation 1 – A production tax in the U.S. with import taxes on goods from China, the E.U., and the ROW at the border of the United States. China, the E.U., and the ROW still do not have a production tax
3. Simulation 2 – A production tax in the U.S., the E.U., and the ROW with accompanying import taxes in all three regions on goods from China.
4. Simulation 3 – Each region imposes a production tax with no accompanying import taxes.

Li, Huang and Hsu (2001) adopted a technology bundle approach in their analysis of GHG emission abatement scenarios. Their work is based on the TAIGEM, (Taiwan General Equilibrium Model), a top-down (economy-focused), dynamic, multi-sector, applied general equilibrium model of Taiwan's economy, developed specifically to analyze climate change response issues. Their data was from the 1994 input-output database compiled from the Use Table of the Taiwan economy. TAIGEM distinguishes 160 sectors, 6 types of labor, 8 types of margins and 170 commodities. The authors implemented a carbon tax in 2011 and analyze different simulation results with and without the technology bundle specification. For the CO_2 baseline forecasting, they considered the period from 1995 to 2020. In order to reach the year 2000 emission target, they adopted two policy measures namely: raising energy usage efficiency from 0.3% (baseline) to 5.3% and implementing the carbon tax at year 2011. With the technology bundle, the US$41.4 per ton of carbon is solved to bring CO_2 emission level at year 2020 (231 million tons) back very close to its year 2000 emission target (230 million tons). However, without the technology bundle, the US$41.4 per ton of carbon is not enough to get the target; carbon tax should be raised to US$55.8 per ton of carbon at a cost of lower GDP growth rates.

Emissions Mitigation

Prior to the passing of ACESA, one of the earliest studies on the issue of emission mitigation with a U.S. focus was undertaken by Fischer and Fox (2009). Fischer and Fox do not use a full CGE model, but rather use a simple two-country, two-good, partial equilibrium model. They consider two countries(Home and Foreign) and examine four policies that could be combined with unilateral emissions pricing to counter effects on international competitiveness: a border tax on imports, a border rebate for exports, full border adjustment, and a domestic production rebate (as might be implemented with output-based allocation of emissions allowances). With emissions price implemented either by a carbon tax, or a cap-and-trade program, some policy scenarios are possible:

> **Emissions Price Alone:** An emissions price is instituted in the home country without any adjustment mechanisms. Domestic producers become less competitive because of increased production costs. The emissions price remains in place for all scenarios.
>
> **Border Adjustment for Imports:** This policy attempts to level the playing field in domestic markets by ensuring that imports are equally penalized for the emissions associated with their production.
>
> **Border Rebate for Exports:** This policy attempts to level the playing field in foreign markets. Producers are rebated the value of the emissions embodied in exports.
>
> **Full Border Adjustment:** This policy **c**ombines the previous two, forgiving the value of the emissions embodied in exports and taxing the emissions embodied in imports. This adjustment essentially turns the emissions price into a destination-based tax, much like most revenue-raising consumption taxes.
>
> **Home Rebate:** This policy directs the full value of the emission rents to be rebated to producers of the home good, whether for domestic consumption or exports.

The simulation results indicate average leakage rates in the modeled scenario range from 64% for oil and 60% for steel to 8% for electricity. Additionally, the results indicate border adjustments for climate policy may not be very effective at improving overall emissions reductions net of foreign leakage. While it seems that full border adjustment would likely be the most effective policy for the United States for avoiding leakage, the home rebate scenario could achieve most of those gains if the home rebate option is not judged to be consistent with trade law.

Furthermore, following demands by the House Committee on Energy and Commerce, the EIA (2009) presents a top-down, dynamic study of the energy market and economic impacts of H.R. 2454. Their study projects what might happen given the assumptions and methodologies used. Here, the "reference case projections are business-as-usual trend forecasts, given known technology, technological and demographic trends, and current laws and regulations. Thus, they provide a policy-neutral starting point that can be used to analyze policy initiatives." The EIA based their current analysis on the agency's National Energy Modeling System (NEMS). Since the projection horizon for NEMS extends to only 2030, while the emissions policies in ACESA extend to 2050 and beyond, this analysis is limited to addressing the bill's impacts through 2030.

The major findings of the study are that cumulative compliance between 2012 and 2030, including reductions both in domestic emissions of covered gases and in domestic and international offsets, ranges from 24.4 BMT to 37.6 BMT CO_2 and CO_2-equivalent emissions in the main analysis cases, representing a 21-percent to 33-percent reduction from the level of cumulative covered emissions projected in the reference case. In addition, the discounted cumulative percent losses of energy-intensive industrial output range from -0.5 percent to -3.6 percent from 2012-2030 compared to manufacturing losses of -0.5 percent to -4.3 percent (ix-xiii).

Sequel to the request of the High Ranking Energy Committee members of the Senate, the U.S. Environmental Protection Agency (2009) coordinated a top-down, dynamic inter-agency study. This study adopted the Fischer-Fox Emissions and Trade (FFEAT) model, which is based on the GTAP 7 database of the global economy and domestic economy that existed in 2004. The researchers examine three levels of global action: United States and developed country action, unilateral United States action, and developed country action without the United States. The results show that at an allowance price of $20 per ton and absent ACESA's allocation provisions, the average increase in production costs experienced by each of five EITE industries would range from less than 0.5 percent to slightly more than 2.5 percent.

Mattoo et al (2009), at the World Bank, conducted work very similar to ours. They explored the real costs to developing countries of climate change mitigation. Using a top-down static CGE model, they decompose the impact of an agreement on emissions reductions into three components: the rise in the price of carbon due to each country's emission cuts per se; the further rise in this price in developing countries due to emissions tradability; and the changes due to any international transfers (private and public).

The researchers implemented the model with the World Bank's Environmental Impact and Sustainability Applied General Equilibrium (ENVISAGE) Model. The results reveal that emission limits with tradability create a painful dilemma for poor countries. China and India, for example, will experience a contraction of their manufacturing exports by 12-15 per cent and manufacturing output by 6-7 percent.

Our model goes beyond previous works by implementing a comprehensive list of climate legislation scenarios in all regions. The next section presents a breakdown of the data used in our model. For each of the EITE sectors, we will discuss the source of our emissions data and provide a background on the production process to illustrate the source of emissions.

3. EMISSIONS DATA

Our model was developed using the GTAP database along with the GEMPACK platform. Rather than developing an entirely new model of the global economy, we adjusted the GTAP version 6.1 model to incorporate a carbon tax on domestic output and imports. The first step in determining a tax rate on CO_2 based products in each of the EITE sectors is to find the ratio of tons of carbon dioxide produced per ton of product. Unfortunately, the CGE database uses an aggregate for each sector, which makes determining disaggregated ratios for some sectors impossible. We, therefore, use the most relevant goods in each sector to obtain the ratios given in **Table 1** below. The goods are: steel for iron and steel, aluminum for non-Ferrous metals, cement for non-metallic minerals, pulp and paper for pulp and paper, and ammonia for chemicals. These ratios include process emissions and energy emissions, but do not include CO_2 equivalents because they are largely marginal in these five goods/sectors.

Table 1: Ton CO_2/Ton Output

EITE Sectors	US	China
Steel	1.59	3.22
Aluminum	9.06	18.18
Cement	0.89	0.89
Pulp/paper	0.70	0.80
Chemicals	2.27	4.58

Process emissions are produced when raw and intermediate goods undergo the chemical processes involved in producing each good. For example, a key component in cement is clinker. Clinker is made by heating limestone in a kiln; during this pyro-processing, carbon and oxygen atoms break free from the limestone as CO_2. Nearly 40% of CO_2 from cement production comes from this process (Worrell, et al. 2001, 317). Process emissions are most notable in steel, cement, and ammonia production, and are negligible or non-existent in pulp and paper and aluminum. These emissions typically cannot be changed without extensive technology change that enables the use of less carbon rich input materials.

Energy emissions represents the heat and mechanical energy used to produce the good. These numbers are typically found by considering the amount of energy in joules needed for all the process steps involved, from crushing and grinding a material to heating it, and then applying the carbon intensity per joule of the power source used. Typically this is either based on the power grid in the region, or the combustible fuels consumed. As an example, aluminum production is very electricity intensive, with the vast majority of its emissions coming from the power used in its production. The difference in the energy-intensity of production methods between China and the United States is very large, which is primarily why China’s emission ratios are much higher. China’s power grid is generated mostly by CO_2 intensive coal, whereas the U.S.’ is generated by largely by natural gas.

Steel

These ratios are drawn from Price (2002). Price gives a ratio for China in its current state and also determines a hypothetical best practices ratio, which we use to proxy the U.S. Technology plays a major role in the difference between the U,S, and China in steel production. The most efficient technology for steel production is currently the electric arc furnace, used in the initial pyro-processing stages. Most steel in the US is produced using this technology, while China only used it in about 15% of steel production in 1999 (Price, et al. 2002, 7). A minority of steel emissions are process emissions, which come from heating ore (in the form of iron oxide), and breaking off the oxygen in combination with carbon.

Aluminum

Aluminum production requires a number of electricity-intensive processing steps, changing bauxite to alumina, and then alumina into aluminum. The U.S. figure for emissions was drawn from a report by the International Aluminum Institute's *Life Cycle Report,* updated in 2005. This is a world figure, but features a dominance of highly developed countries and so functions as a fair proxy for the U.S. figure. The Chinese emissions figure is drawn from Gao, et al. (2009)

Because aluminum is a commodity, aluminum producers are typically price takers based on the major international markets such as the London Metal Exchange (LME). Comparing prices from the LME to China's domestic price of aluminum based on their industrial yearbook shows that Chinese aluminum costs over 50% more than aluminum traded in the world. From this we can presume China lacks a comparative advantage in aluminum and trades little if any, keeping the industry running through government protection. Also, aluminum production in developed nations often takes advantage of on-site hydropower generation, or similar cost saving power sources, which make significant impacts on emissions as a side-effect.

Cement

Cement emissions ratios are determined using data from Worrell, et al. (2009). These figures are the same for the U.S. and China for four reasons. First, process emissions are largely fixed and come from clinker production. Cement consumed in the U.S. tends to have a higher percentage of clinker than cement from China, 88% and 83% respectively. This means that process emissions are higher in the US (Worrell, et al. 2001, 320-321). Second, U.S. clinker is processed into a finer material, requiring more energy use in the grinding process. Third, China's production techniques involve wide scale use of small batch kilns heated by a combustible material rather than the CO_2 intensive Chinese power grid (shaft kilns). The CO_2 from these small kilns can vary wildly based on the material used, but average relatively even with US figures for the same process (Worrell, et al. 2001, 310). The high carbon intensity of China's power grid evens out the difference caused by the clinker differences.

Pulp and Paper

The pulp and paper ratios for the U.S. and China are an aggregate of the sector as a whole, factoring in board, fine paper, newsprint, and pulp manufacture. Szabo, et al. (2009) contains current industry data for OECD and developing countries, which are used as proxies for the U.S. and China, respectively. The two dominant processes in this industry are chemical pulping and mechanical pulping. Chemical pulping uses more raw materials, but tends to produce fewer emissions due to repurposing production byproducts for use as energy. Chemical pulping is the dominant method in the U.S. and is growing in China.

Chemicals

The chemicals industry encompasses a wide range of goods, including plastics and pharmaceuticals. Because of this, determining the emission content of production in this industry is extremely difficult. To solve this problem, we use ammonia as a proxy because it composes about 20% of production in the U.S. chemical industry and 50% in China (International Energy Agency 2009). However, ammonia's emissions are higher than most chemicals produced, which leads to overstated results for this industry in the model.

Ammonia emissions data for the U.S. is from Rafiqul, et al. (2005), and Chinese data is from Zhou, et al. (2010). The ratios are different in part because of the difference in power grids, but also because the U.S. uses a cleaner feedstock than China, natural gas and coal respectively. These hydrocarbons are broken down for the hydrogen used in ammonia, and free carbon is emitted as CO_2.

Ad Valorem Taxes

This carbon coefficient data and the carbon price were used to create an ad valorem tax rate on the appropriate sectors. To do this, a market price for these goods had to be determined. **Table 2** provides the market prices used on U.S. and Chinese goods. These data points are from the U.S. Economic Census 2002, the Chinese Industrial Yearbook 2005, the London Metal Exchange, the Chicago Exchange, and the ICIS. While accurate prices are difficult to acquire for many of these products, given regional differences and product differentials within a given good, these prices provide a very reasonable estimate for tax calculation.

Given these three points of data, **Table 3** can be assembled by taking the product of the carbon price and the coefficients from **Table 1** and dividing it by the market prices on **Table 2**. Some of these tax rates are quite dramatic, which is intuitive based on the interchange between CO_2 coefficients and prices involved.

Table 2: $ Price / Ton Output

EITE Sectors	US	China-X
Steel	$700.00	$379.25
Aluminum	$2,154.00	$2,154.00
Cement	$75.27	$30.91
Pulp/paper	$570.52	$799.50
Chemicals	$578.72	$578.72

Table 3: Ad Valorem Tax (Emissions Price: $31.70/ton CO_2)

EITE Sectors	U.S. (%)	China (%)
Steel	7.21	26.93
Aluminum	13.33	26.76
Cement	37.44	91.16
Pulp/Paper	3.89	3.17
Ammonia	12.43	25.09

Technology

Table 4 displays the technology improvement percentages proposed by our engineering consultant. There are three routes of improvement behind these figures and assumptions have been made about each of these. The timeframe on these technology changes is approximately ten years. The first is some change in inputs or technology that might alter the process emissions involved. This is assumed to be unchanging in the timeframe of the model.

Second are the technology changes and upgrades, looking at current technology that is well within reach. For China this is typically adopting current U.S. technology, while in the U.S. this includes new technology improvements already on the horizon. While these improvements focus on improving energy emissions, there is no change in the power grid.

The last part of technology improvement is the use of process integration. This is a series of upgrades and improvements in the organization of a plant that improve the efficiency in how energy is used without actually changing or adding significant equipment. An example would be reusing residual heat from one batch to begin the next batch, reducing the total energy needed. These integrations have been underway in the U.S. for decades due to the cost reduction benefits they provide, but are still working their way into Chinese industry. Integration is the most significant element in the technology improvement numbers on **Table 4**.

Table 4: Technology Change

EITE Sectors	U.S. (%)	China (%)
Steel	10	15
Aluminum	10	15
Cement	15	10
Pulp/Paper	2.5	7.5
Ammonia	2.5	2.5

4. MODEL

GTAP and GTAP-E

GTAP version 6.1 is a theoretical model of the global economy. Based on the idea of Walras' Law, the overarching goal of GTAP61 is to model the most efficient, market clearing equilibrium that can be obtained after the inception of an economic shock. This shock can come in many forms, such as changes in the domestic capital stock or a new tax. Though the model is traditionally a static model that determines annual changes, we simulate dynamic results by stringing subsequent tests together, updating the base data for each progressive test with the previous test's final equilibrium. We added several equations to the GTAP61 model which incorporate the change in emissions following the implementation of import and domestic output taxes based on the embedded emissions in the production of our five target industries. Our baseline year is 2005, the most recent year that the GTAP database was updated. The regions used in the model comprised the U.S., China, the EU-27, and the ROW. [5]

An alternative to the GTAP61 model is the GTAP-E (Energy and Environment) model. The goal of the GTAP-E model is to determine the environmental effect of the burning of fossil fuels for global production and also the substitutability of fossil fuels within these production processes. This model is of vital importance to the study of trade linkages in the energy market; however, our model adds a new facet to field of trade in emissions.

Though the GTAP-E model has been successful in calculating the trade effects on energy inputs, it falls short in determining the overall environmental impact of the industrial production process. Our model takes into account both the emissions from the energy inputs as well as the emissions from the production process itself. The embedded emissions coefficients, given in **Table 1**, allow for more accurate taxing of imports and domestic production as well as a means to determine the technological advances across borders within domestic production processes.

Technological Change

We model technological change by reducing our emissions ratios from **Table 1**. The E.U. and the ROW were given the same embedded emissions coefficients as the United States. We do this because the more technologically advanced countries (such as those in western Europe within the E.U. and Japan, Singapore, South Korea and Hong Kong within the ROW) make up the majority of production within their respective regions. Without technological change, there will be little to no reduction in real worldwide emissions. Our initial baseline simulations reveal that much of the emissions in the U.S. will shift to other regions, harming U.S. producers, but resulting in no change in global emissions.

As a country becomes more developed, its production processes become more efficient and it produces less emissions. Though this occurs naturally over time, the emissions tax is intended to speed up the process. Its goal is to force each country, in both private and public sectors, to invest in cleaner technologies as a means to reduce the embedded emissions in their production processes thereby lowering the tax burden and improving their terms of trade.

New Equations and the Determination of the Tax Rate

Rather than calculating a new tax variable based on embedded emissions within the GTAP model, our base tax rates were calculated outside of the model and implemented through the “to” (domestic output tax) and the “tms” (import tax) variables. These variables are both tax power variables meaning that instead of a basic percentage tax on the production or import of a good, it is added to the basic supply price and existing tax levies. An additional formula is used to calculate the shock value needed to change the tax power the proper amount. This formula along with the formulas used to calculate the base tax rate can also be found in the Appendix.

Description of Simulations

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[5] A list of all countries included in each regional grouping can be found in the Appendix.

We performed three sets of simulations: 1) baseline simulations, 2) one-year simulations, and 3) dynamic simulations. Within each set we created four models that show how regional policies affect the ability of the tax to reduce: 1) global emissions, 2) unfair competition, and 3) emissions leakage. The four models are as follows:

1. Simulation 0 – A production tax in the United States with no accompanying import taxes. No other region imposes a production tax.
2. Simulation 1 – A production tax in the United States with import taxes on goods from China, the EU and the ROW at the border of the United States. China, the EU and the ROW still do not have a production tax
3. Simulation 2 – A production tax in the United States, the EU and the ROW with accompanying import taxes in all three regions on goods from China.
4. Simulation 3 – Each region imposes a production tax with no accompanying import taxes.

Baseline Simulations Results

This initial simulation determines the effects of an immediate implementation of a carbon tax of \$31.70/ton of CO_2. In this simulation, tax rates were calculated based on the total regional value of emissions as a percentage of nominal GDP. Sectoral differences in tax rates based on difference in market prices of the good and emissions coefficients will be implemented in later simulations. All tax rate calculations are listed in the Appendix.

Table 5: Percent Change in Domestic Output (Emissions)

	China				US			
	Base-0	Base-1	Base-2	Base-3	Base-0	Base-1	Base-2	Base-3
Paper	0.20	-0.22	-0.37	-3.57	-0.98	-0.73	-0.35	-0.27
Chem	0.38	-0.52	-1.69	-7.50	-2.42	-1.95	-0.35	-0.16
NonMetals	0.12	-0.33	-1.54	-2.08	-0.80	-0.21	0.03	-0.01
I&S	0.06	-0.03	-0.01	-1.75	-0.77	-0.22	0.40	0.44
NonFerrous	0.31	0.19	-0.80	-7.40	-2.98	-1.96	0.04	0.27

As we move from Base-0 to Base-3 in **Table 5**, output in China decreases because it has a much higher tax rate relative to the other regions and becomes less competitive. The decline in output for the U.S. lessens as more countries adopt carbon taxes. This shows how leakage can be prevented through a global tax initiative. This story is further exemplified in **Table 6**. China is no longer competitive in global markets and its exports suffer.

Table 6: Percent Change in Exports

	China				US			
	Base-0	Base-1	Base-2	Base-3	Base-0	Base-1	Base-2	Base-3
Paper	1.68	-4.70	-15.32	-13.97	-4.30	-4.92	0.98	2.27
Chem	1.59	-3.56	-16.81	-15.95	-4.92	-5.72	1.40	2.33
NonMetals	1.02	-2.90	-14.14	-7.40	-4.04	-4.58	1.82	2.19
I&S	0.89	-1.39	-12.01	-9.87	-4.74	-5.51	4.54	6.14
NonFerrous	1.45	-0.35	-18.48	-19.29	-8.22	-9.91	2.05	3.79

Baseline Simulation Discussion

Some important features of our tax calculations help explain the above results. First, although the U.S. and China are similar in total emissions, China's tax rates are much higher. This is because the U.S. economy is much larger and dominated by non-emitting service industries, while the Chinese economy consists of many emissions-intensive manufacturing industries. With taxes calculated as total emissions/nominal GDP, China's smaller economy and equal emissions results in a higher tax.

As Base-3 shows, if all regions begin to tax Chinese exports, this high tax effect would have a severe impact on China's output. Other developing countries would likely experience similar trauma, but our model aggregates them into either the E.U. or ROW regions which leads to an understating of the effect this scenario has on them. On their own, other developing countries may see similar impacts as shown in Mattoo et al (2009).

Additionally, the U.S. has more energy efficient technology than China. Thus, even if both economies consisted of the same industries, China's tax rate would still be somewhat higher due to this difference in technology.

One-Year Simulation Results

The tax rates for the one-year simulations are calculated using the embedded emissions coefficients discussed earlier and the market prices for the representative goods in the five EITE industries. The formula for the tax rate calculation can be found in the Appendix. Specific tax rate calculation for each industry results in changes that are more indicative of the actual changes one would expect from the implementation of a carbon tax. However, future legislation will likely implement a carbon tax gradually. This simulation shows that the immediate implementation of an industry specific carbon tax has a large impact on global production.

Table 7: Percent Change in Domestic Output (Emissions)

	China				USA			
	1 Year-0	1 Year-1	1 Year-2	1 Year-3	1 Year-0	1 Year-1	1 Year-2	1 Year-3
Paper	0.19	0.20	0.88	3.98	-0.97	-0.78	-1.02	-1.27
Chem	2.15	-0.03	2.34	-15.77	-13.40	-10.59	-0.65	-0.16
NonMetals	2.97	-1.08	-4.22	-30.54	-18.53	-8.39	-1.79	0.14
I&S	0.09	-0.20	-0.96	-9.72	-1.02	0.08	0.23	0.25
NonFerrous	1.70	1.39	6.12	-17.45	-17.81	-12.12	-3.43	-2.96

The most striking changes are in the U.S. In simulation 0 and 1, U.S. producers must pay the carbon tax, while Chinese producers are able to shift their exports to the regions that do not have import taxes. This is the leakage effect described by Fischer and Morgenstern (2009), Fischer (2007), and Ishikawa and Kiyono (2006). Simulations 2 and 3 address this problem by opening up climate legislation to all regions. China is no longer able to shift exports to avoid taxation, and U.S. producers are no longer at a cost disadvantage. In simulation 2, China must rely more heavily on domestic producers since foreign goods are more expensive after being taxed at the production stage, which increases output in several Chinese industries. However, by simulation 3, all Chinese production is taxed, making these industries uncompetitive relative to the rest of the world.

Table 8: Percent Change in Exports

	China				USA			
	1 Year-0	1 Year-1	1 Year-2	1 Year-3	1 Year-0	1 Year-1	1 Year-2	1 Year -3
Paper	1.31	1.27	1.62	41.94	-0.11	-2.64	0.50	-0.65
Chem	9.39	-3.37	-26.44	-25.89	-27.13	-31.01	15.32	18.72
NonMetals	24.08	-10.11	-54.84	-92.46	-68.76	-70.54	35.24	69.24
I&S	3.21	-3.82	-37.70	-45.94	-12.64	-16.06	13.04	21.61
NonFerrous	8.71	3.49	-29.53	-41.12	-44.96	-50.78	4.81	11.52

Changes in competitiveness are further illustrated in **Table 8**. As the tax regime becomes more restrictive, China is less able to shift their goods away from the tax and, because their tax rates are so much higher, they become less competitive. The opposite is true for the U.S. which sees the relative price level for its goods decrease as the tax regime expands to all four regions. This negates any comparative advantage China might have had prior to the implementation of the tax.

One-Year Simulation Discussion

Several messages are obtained from the results of our one-year simulations. First, when the U.S. goes alone in terms of regulating global emissions domestically, they are at an extreme disadvantage relative to the other regions. The similarity in results from one-year simulations 0 and 1, show that even if the U.S. imposes a carbon import tax to level the playing field domestically, it remains uncompetitive. This is because the U.S. taxes all domestic production in the EITE industries, whereas other regions only face taxes on their exports to the U.S. In China, the carbon tax only affects a small percent of production, allowing firms to spread the costs across all operations, making foreign goods cheaper relative to U.S. goods.

The results from one-year simulations 0 and 1 also depict emissions leakage. Though the carbon tax reduces emissions in the United States, much of these emissions are simply shifted to other regions in the form of increased foreign output. The United States is no longer competitive in these industries; therefore, the other regions increase production and emissions over the previous baseline.

The results from one-year simulations 2 and 3, however, eliminate this problem. They show that with the expansion of the production and import tax from the U.S. to the E.U. and ROW, leakage is minimized in all five industries.

Interestingly, Chinese production increases in some sectors throughout this simulation. This is because imports to China are now more expensive due to each region's domestic production tax. The domestic taxes in other regions make the goods produced in China more competitive relative to foreign imports in each industry.

Dynamic Simulation Results

Our final simulation models the impact of an incremental increase in the carbon tax over a ten year period. Though the tax rate was calculated the same as the one-year simulations, ten percent of the total tax is added each year to allow for industries to adapt to the legislation. For example, in Year 1 the model implements ten percent of the full value of the $31.70 tax. In Year 2, we increased the tax rate by an additional ten percent, making the total tax rate twenty percent of the full value of the tax. By Year 10, we have imposed one-hundred percent of the full value of the tax.

These simulations were also used to depict the impact of technological change on emissions reduction over a ten year period (**Figure 3 and Table 11**). Technological change was implemented similar to the dynamic tax rate. Taking the range of possible technological improvements discussed earlier, we reduced the emissions coefficients by ten percent each year. For example, in Year 1 we reduced the emissions coefficient by ten percent of the value of the possible technological improvement. In Year 2, we reduced the coefficient by an additional ten percent of the possible reduction, creating a twenty percent total reduction. By Year 10, we had reduced the coefficient by the total value of the possible reduction.

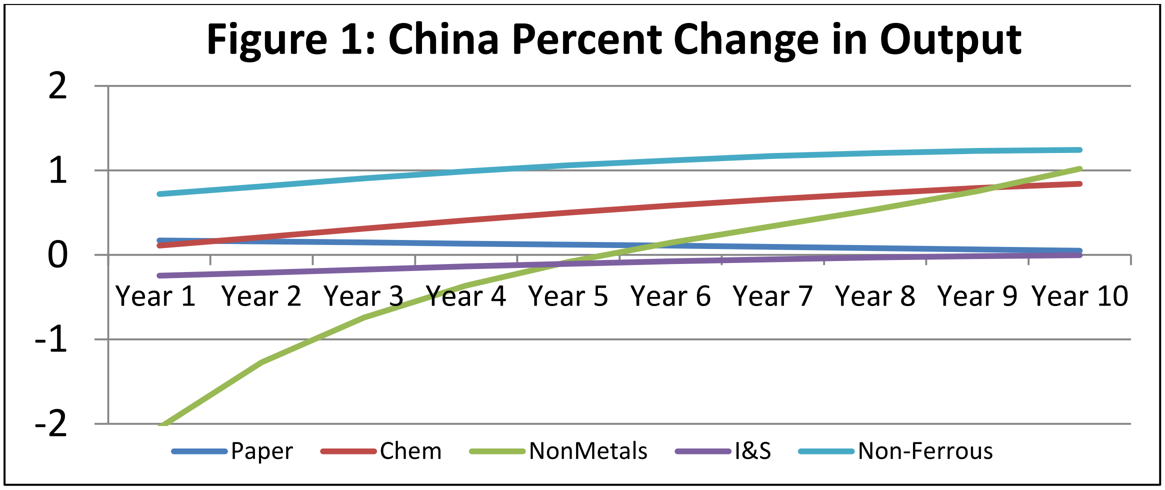
Figure 1: China Percent Change in Output

Table 9: China Percent Change in Output

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Paper	0.172	0.16	0.147	0.135	0.122	0.11	0.096	0.082	0.067	0.05
Chem	0.109	0.211	0.312	0.409	0.5	0.585	0.661	0.729	0.791	0.843
NonMetals	-2.045	-1.272	-0.741	-0.363	-0.082	0.144	0.343	0.538	0.754	1.021
I&S	-0.246	-0.21	-0.173	-0.137	-0.105	-0.076	-0.051	-0.029	-0.013	-0.001
Non-Ferrous	0.719	0.813	0.905	0.988	1.062	1.12	1.17	1.207	1.231	1.242

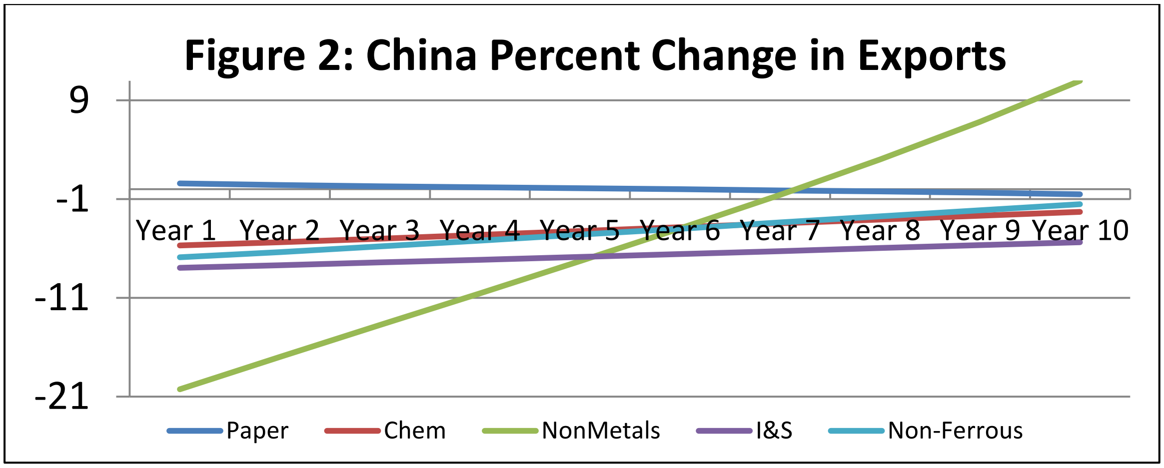
Figure 2: China Percent Change in Exports

Table 10: China Percent Change in Exports

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Paper	0.596	0.439	0.31	0.198	0.094	-0.005	-0.11	-0.224	-0.349	-0.498
Chem	-5.706	-5.366	-5.006	-4.629	-4.245	-3.852	-3.461	-3.071	-2.68	-2.301
NonMetals	-20.266	-16.999	-13.76	-10.536	-7.296	-3.984	-0.57	3.019	6.846	10.998
I&S	-7.949	-7.697	-7.424	-7.138	-6.849	-6.557	-6.26	-5.961	-5.671	-5.379
Non-Ferrous	-6.905	-6.371	-5.802	-5.217	-4.606	-3.998	-3.376	-2.749	-2.126	-1.509

The impact on China in dynamic simulation-2 is interesting in several respects. First, foreign goods are now much more expensive within Chinese borders (because of regional production taxes) and China is now forced to rely more heavily on domestic producers. The result is increasing domestic output despite steep losses in exports. Second, exports begin to pick up as the simulation progresses and import taxes on Chinese goods begin to increase. Each year, goods in the U.S., E.U. and ROW are being taxed at the production stage. China, however, is only taxed at the borders of these three regions, leaving domestically consumed goods untaxed. This allows the overall price level of these goods to rise much slower relative to goods from other regions. This increasing ratio of domestic prices to import prices seen in the U.S., E.U., and ROW allows for China's goods to become relatively more competitive as the years go by, allowing them to regain a foothold in their export markets.

This slow adaptation to the taxes on Chinese goods raises a final point. If industries are allowed to adapt, any reductions in emissions early on will be negated in the long run by increases in production. This reveals that any climate legislation will be ineffective in reducing emissions unless it forces industries to invest in cleaner technology.

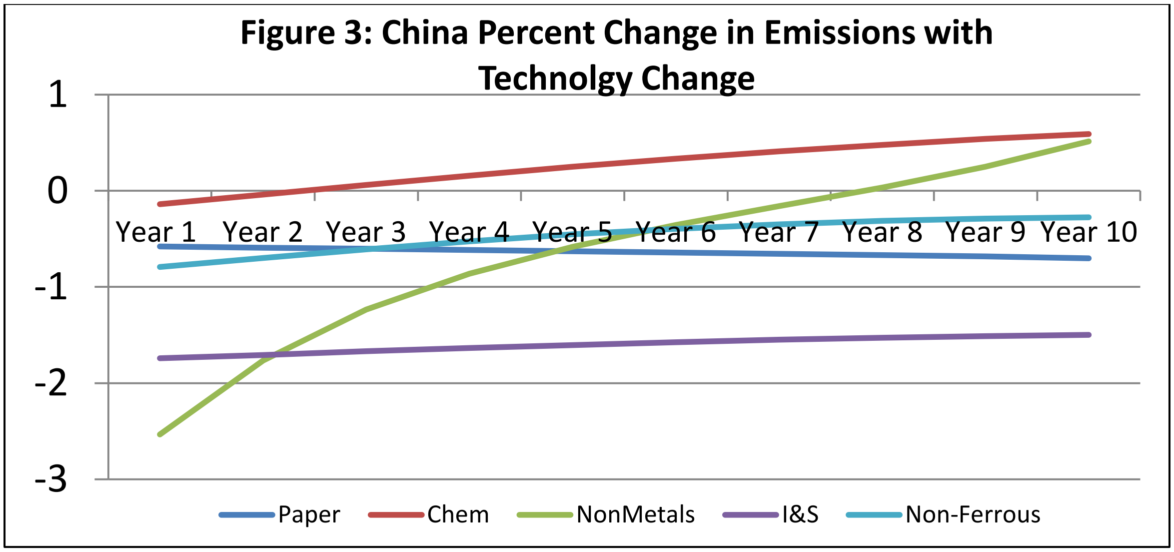

Table 11: China Percent change in Emissions with Technology Change

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Paper	-0.579	-0.592	-0.604	-0.616	-0.629	-0.641	-0.655	-0.669	-0.684	-0.701
Chem	-0.141	-0.039	0.062	0.158	0.249	0.334	0.41	0.478	0.539	0.591
NonMetals	-2.534	-1.765	-1.237	-0.862	-0.581	-0.356	-0.159	0.035	0.25	0.515
I&S	-1.742	-1.707	-1.67	-1.635	-1.604	-1.575	-1.55	-1.529	-1.513	-1.5
NonFerrous	-0.792	-0.699	-0.608	-0.527	-0.454	-0.396	-0.348	-0.311	-0.288	-0.277

Comparing **Figure 1**, in which percent changes in output equal percent changes in emissions, to **Figure 3**, we see that with technology change when production decreases, emissions are reduced further and if output increases emissions increase less than they would have otherwise. Any climate bill would need to include additional parameters to incentivize technology change.

Dynamic Simulation Discussion

Many of the results discussed in the previous section remain the same in the dynamic simulations. The U.S. is still uncompetitive when it is the only region with climate legislation in place, which creates high levels of leakage. Regional expansions of production and import taxes reduce the leakage problem and create a level playing field.

The dynamic simulation is important in that shows each industry's ability to adjust to the new tax. Though the outcome is not always the same, a general trend in most regions and industries is that over time, decreases in production and emissions become smaller. By the end of the simulation, some industries are already beginning to increase production. Therefore, any decrease in emissions early on is simply negated by increases in production in later years.

This finding reveals how important technology change is to climate legislation. The differences in emissions reduction between results with and without technological change have two implications: 1) when production decreases, emissions decrease more; and 2) when production increases, emissions increase less than they would without technology change.

From these results, it is evident that any implementation of a carbon tax would also require measures intended to induce technological change. If industries expect their production to resemble the results in **Figure 1 and Table 11**, there will be little incentive for these industries to invest in technological change to reduce their tax burden other than to avoid the initial harm to their bottom line.

5. CHINESE RESPONSE

Current US Legislation

While ACESA is not likely to pass the Senate as it is currently written, its progress signifies the inevitability of climate legislation in the coming years. ACESA is the most well-known and successful piece of legislation to date, therefore, we use it as a guide in analyzing the international policy implications of climate legislation.

The proposed date of implementation in ACESA is 2012. At that time, the national cap on greenhouse gas emissions will be put into effect and domestic producers will be given a set amount of carbon emissions allowances. Domestic producers in the EITE industries will receive relatively more allowances than other industries. Producers that still expect to exceed their allotted allowances may purchase excess carbon permits in the United States auction market or may use qualifying international permits.

One goal of ACESA is to encourage producers to invest in cleaner technology. A rebate program is included in the bill to help domestic producers cope with increases in production costs, to encourage them to invest in more energy efficient technologies, and to reduce the likelihood of carbon leakage into other countries. The Emission Allowance Rebate Program is designed to protect domestic competitiveness after the cap-and-trade program is put into effect, but will be phased out over time.

Foreign producers will inevitably be affected as well. If a multilateral environmental accord is not in place by 2018, ACESA gives the acting administration the right to notify international trade partners that the International Reserve Allowance Program will be put into effect. In this case, trade partners will need to purchase carbon allowances according to their U.S.-defined carbon intensity. International producers may purchase carbon allowances from the United States International Reserve Allowance Program or may substitute a qualifying international permit. This type of domestic protection will continue if more than 15% of production in one sector continues to be made in countries that are: 1) not members of an international treaty with the United States and do not have a nationally enforceable emissions program akin to the United States; 2) a party to an international agreement along with the United States for the sector in question; or 3) have a greenhouse gas intensity for that sector that is equal to or less than the United States (Fischer and Morgenstern, 12).

International Reactions

The main goal of ACESA is to reduce U.S. greenhouse gas emissions, but this legislation is also an attempt to reduce the likelihood of emissions leakage to developing countries. A particular country of interest in our study is China, which is a leader amongst developing countries and currently the third largest economy in the world (in terms of purchasing power parity). We focus on China because it is one of the United States' largest trading partners, the potential consequences of this climate change legislation on international trade between the United States and China could be severe.

A United States carbon-emissions reduction program which taxes the emissions content of imported goods should place significant pressure on China to implement greener production methods. However, Bordoff (2008, 5) finds the United States market share of Chinese goods in these EITE industries to be extremely small – less than one percent of Chinese steel is sold to the US, only three percent of aluminum, two percent of paper products, and less than one percent of the chemicals and cement industries. Since the U.S. is not a major player in the market for Chinese carbon-intensive products, Bordoff (2008) claims that ACESA is not likely to exert strong economic pressure on China to adopt cleaner technologies.

The passage of ACESA and the dialogue that occurred at the 2009 United Nations Climate Change Conference, however, has placed considerable pressure on Chinese officials. This pressure has sparked debates within the Chinese government and in the Chinese media ("Levying Carbon Tax, Promoting Low-Carbon Education Proposed"). At the Eleventh National People's Congress, members rallied the government to pass legislation advocating a low-carbon lifestyle. Members of the National People's Congress argued the adoption of a Chinese low-carbon economy would allow the government to reduce carbon emissions as well as reduce negative international trade impacts from developed countries. Rather than allowing the United

States to enjoy the rents of carbon taxation on Chinese goods, Chinese political officials propose adopting a domestic carbon-intensity tax. In this case, China would generate revenue to help the country transition towards greener production, which would reduce the likelihood of a U.S. tariff on Chinese imports.

Alternatively, China may turn to the World Trade Organization (WTO) for relief. U.S. international trade partners, especially China, have been critical of ACESA. International spectators are wary that it is not purely climate-conscious, but rather a protectionist policy for trade-vulnerable industries. This mentality has led some scholars to warn of a potential tit-for-tat trade war (Bordoff 2008; Fischer and Morgenstern 2009). If a trade partner believes the border adjustment program in ACESA violates the United States' WTO obligations, it may bring a case before the WTO's Dispute Settlement Body. Should this occur, the burden of proof of supplying evidence and preparing arguments will ultimately fall upon the United States government. If the United States is unable to justify ACESA as a WTO-consistent measure, trade partners could be authorized by the WTO to adopt retaliatory measures against the United States.

Proposed U.S. Cap-and-Trade Program & the WTO

A CO_2 reduction program, like other environmental protection policies, is theoretically compatible with the WTO. Some scholars argue there is no outright bias in the WTO against sovereign states enacting and enforcing purely environmental laws (Bernasconi-Osterwalder et. al. 2006; Jansen and Keck 2004). Still, climate legislation that includes border adjustment policies will likely face strong opposition from developing countries. Khalilian (2009) and Fischer and Morgenstern (2009) acknowledge that ACESA has already begun stirring international debates on whether or not ACESA 2009 is in violation of WTO law.

WTO compatibility of current United States legislation is difficult to determine. Trade disputes within the WTO system are treated on a case-by-case basis. The aims and effects of environmental legislation are scrutinized, as well the effects on domestic and international producers. The WTO dispute mechanism serves as a tool to ensure that national policies are not protectionist in nature and that environmental policies are specifically designed to reach its end goal. United States environmental legislation would be subject various WTO provisions, including provisions related to equal treatment between members, fair treatment of like products, etc.

As it currently stands, ACESA is likely to conflict with GATT Article I and GATT Article III. GATT Article I, known as the most favored nation (MFN) clause, requires that any special treatment or advantage afforded to products originating from one country must be applied automatically and unconditionally to like products from all other WTO members. In the GATT 1994, this principle is embodied in the Technical Barriers to Trade Agreement. GATT Article III, known as the national treatment clause, requires that member governments afford like products from foreign producers treatment as favorable as that afforded to domestic producers. This relates to the Subsidies and Countervailing Measures (SCM) Agreement in the updated version of GATT. The SCM agreement strikes a balance between member concerns that domestic industries should not be at a disadvantage by competition from imported goods that benefit from subsidies and the concern that measures taken to offset subsidies should not be obstacles to fair trade.

Current and future climate legislation may find relief in GATT Article XX, known as the general exceptions clause. Article XX(g) and (b) allow members to justify GATT-inconsistent measures provided they are not protectionist measures and either relate to the conservation of natural resources (subsection g) or are necessary to protect the life or health of humans, plants, or animals(subsection b). Should a trade dispute be brought to the WTO, the defendant must prove that an environmental policy is designed to protect life and/or preserve exhaustible resources. Additionally, the defendant must also prove the legislation is in line with the introductory clause of Article XX, known as the chapeau. The chapeau refers to the implementation of the general exception clause and states that GATT-inconsistent measures may not be applied in an arbitrary or discriminatory manner against countries where the same conditions prevail and that measures may not be disguised as a restriction on the flow of international trade.

Since the WTO dispute settlement procedure took over from GATT in 1995, only a handful of environmental and health-related proceedings have taken in the WTO system. Only one case, the 1996 United States gasoline case, can specifically be connected to trade-related measures aimed at reducing environmental pollution and increasing air quality. The *United States – Standards for Reformulated and Conventional Gasoline* case arose in 1990 after the United States passed an amendment to the Clean Air Act in 1990 to reduce the air pollution in the United States. Following this amendment, the Environmental Protection Agency instituted a gasoline rule, which established the baselines necessary to attain the emissions target under the Clean Air Act. Under this rule, the United States placed baselines for determining reformulated and conventional gasoline. Because of administrative problems (determination of verifying content in foreign gasoline), importers of gasoline were held to higher standards than domestic gasoline producers. As a result, Venezuela and Brazil appealed to the WTO's dispute settlement body arguing the gasoline rule was discriminatory. While the dispute settlement body acknowledged a WTO member's autonomy to determine domestic environmental policies, it reinforced the fact that members cannot use environmental justifications to discriminate against foreign importers. In this case, the WTO ruled that the US discriminated against WTO members because the environmental standards for gasoline were more stringent for importers than domestic producers. Because the United States did not treat domestic and foreign producers alike, it did not qualify for an Article XX exception. Though the United States lost the dispute, the WTO did not rule in such a way that curbed U.S. sovereignty to determine its own environmental measures. It merely held that the United States should provide foreign and domestic gasoline producers the same opportunities to comply with environmentally-driven regulations. In this sense, the WTO dispute panel used international law both to promote free trade and maintain high environmental standards.

If the border adjustment program created by ACESA is seen as equal for both domestic and foreign producers, then it would appear the legislation is on good grounds. As long as other nations are afforded the same treatment as domestic producers, the national treatment clause is satisfied. Bordoff (2008) cautions though that complexity in determining the carbon content of a good may create the same problem as in the US gasoline case. In that case, the United States was determined to be in violation of WTO law because of how domestic and foreign gasoline baselines were determined. Given that industrial goods vary in the amount of carbon emitted in the production process, Bordoff argues that "applying one baseline carbon content to every product regardless of how and where it was produced may well be considered discriminatory" (*International Trade Law and the Economics of Climate Policy*, 13).

As it is written, the border adjustment program set forth in ACESA 2009 may not even satisfy the MFN clause. MFN treatment requires that any privilege afforded to one WTO member must automatically be applied to all others. Since ACESA does not require all countries to adopt into the international reserve allowance program, its MFN clause compatibility is questionable. The legislation excludes:

1. Countries that are parties to an international agreement with which the US is also a party that includes an emissions reduction program equal to or better than the US program

2. Parties to a bilateral emission reduction agreement for a sector to which the US is also a party

3. Countries with annual greenhouse intensity for industrial sectors that is less than or equal to United States are exempt from participation in the US allowance program

Ultimately, this legislation would have a heavy impact on developing countries with high emissions (especially China). By establishing a border adjustment program that benefits only certain WTO member countries, it is likely the WTO would find the United States in violation of its WTO obligations. Bordoff (2008) supports the idea that the WTO would likely find the US in violation if it allows exceptions.

Even if the program setup by ACESA is seen as incompatible with GATT/WTO law, the United States government may seek an Article XX exception. Previous WTO rulings have found the language of subsection g ("relating to conservation") a lower standard than that of subsection b ("necessary to protect"), making an exemption for ACESA under Article XX(g) more likely. However, obtaining this exception is difficult. The United States must show that its legislation is specifically designed to protect life or conserve resources, but scholars such as Fischer and Fox (2009, page 6) argue that "the validity of the assertion that border adjustments contribute to the conservation of the climate is not assured." Ultimately, Fischer and Fox (2009, 25) and Bordoff (2008, 5) conclude that border adjustment programs like those in ACESA may not be very effective at actually reducing overall emissions, especially once foreign leakage is taken into account.

The outlook for ACESA is grim and the creation of WTO valid legislation remains questionable. The dispute settlement body and more specifically the Appellate Body arrogate to themselves "considerable discretion and adjudicative authority" (Charnovitz 2007). This wide-ranging authority and the case-by-case nature of the World Trade Organization ultimately make predicting WTO validity of a US cap-and-trade system very difficult.

6. CONCLUSION

Our model and previous studies show that climate legislation will likely have little impact on regional and thus global emissions. Our work has gone beyond previous studies in that we have incorporated carbon taxes in multiple regions along with precise data on the emissions content of each of the five energy-intensive trade-exposed sectors. At a carbon price of $31.70, very little change in output and, therefore, emissions will occur unless legislation provides incentives for technology change within each industry. Our estimated effects of technology change, implemented over a period of 10 years after the passage of a carbon tax, show that legislation can improve global emissions.

If technology change is supplemented by a global carbon tax, this effect will be much stronger. However, the most likely scenario is a unilateral carbon tax implemented in the U.S., with perhaps some legislation being passed in the E.U. and ROW regions in subsequent years. China is not likely to implement a domestic carbon tax and will either enter into negotiations with the U.S. Trade Representative to reduce the import barriers or will take a case to the WTO. If a case is brought to the WTO, the U.S. legislation as it currently stands is not likely to win, as ACESA's exceptions for border taxes discriminates among U.S. trading partners.

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8. APPENDIX

Tax Rate Calculation

Baseline Tax Rate

$$\frac{\text{Total Emissions (x) Value of Tax}}{\text{Nominal GDP}}$$

Market-Based Tax Rate

$$\frac{\text{Value of Tax (x) Commodity Imbedded Emissions Coefficient}}{\text{Commodity Market Price}}$$

Tax Power Calculation

Domestic Output Tax Power

$$\frac{\text{Value of Output at Agent Prices}}{\text{Value of Output at Market Prices}}$$

Tax Power <1 = tax
Tax Power >1 = subsidy

Import Tax Power

$$\frac{\text{Value of Imports at Market Prices}}{\text{Value of Imports at World Prices}}$$

Tax Power >1 = tax
Tax Power <1 = subsidy

Shock Value Calculation

Domestic Tax Shock

$$\frac{\text{(Old Tax Power – Tax Rate) – Old Tax Power}}{\text{Old Tax Power}}$$

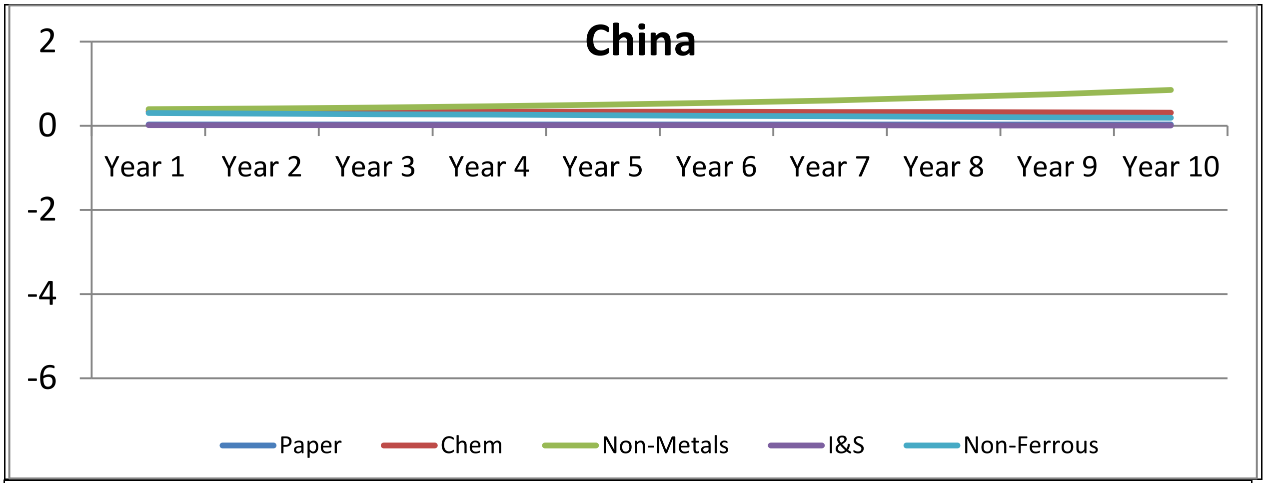
Import Tax Shock

$$\frac{\text{(Tax Rate + Old Tax Power) – Old Tax Power}}{\text{Old Tax Power}}$$

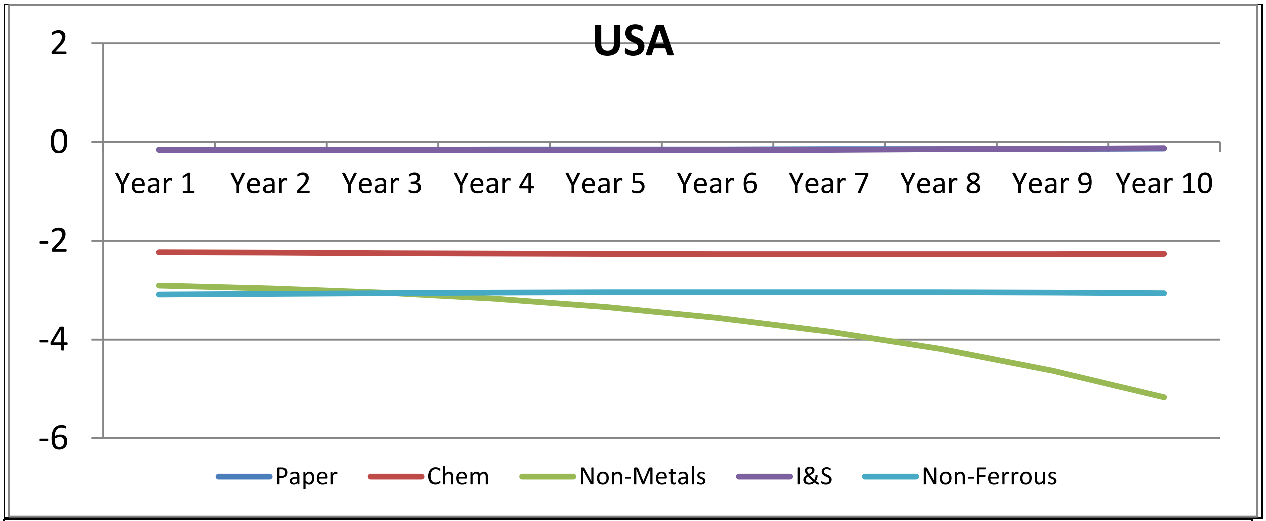
Additional Results for Dynamic Simulations

Dynamic Simulation 0

Percent Change in Domestic Production

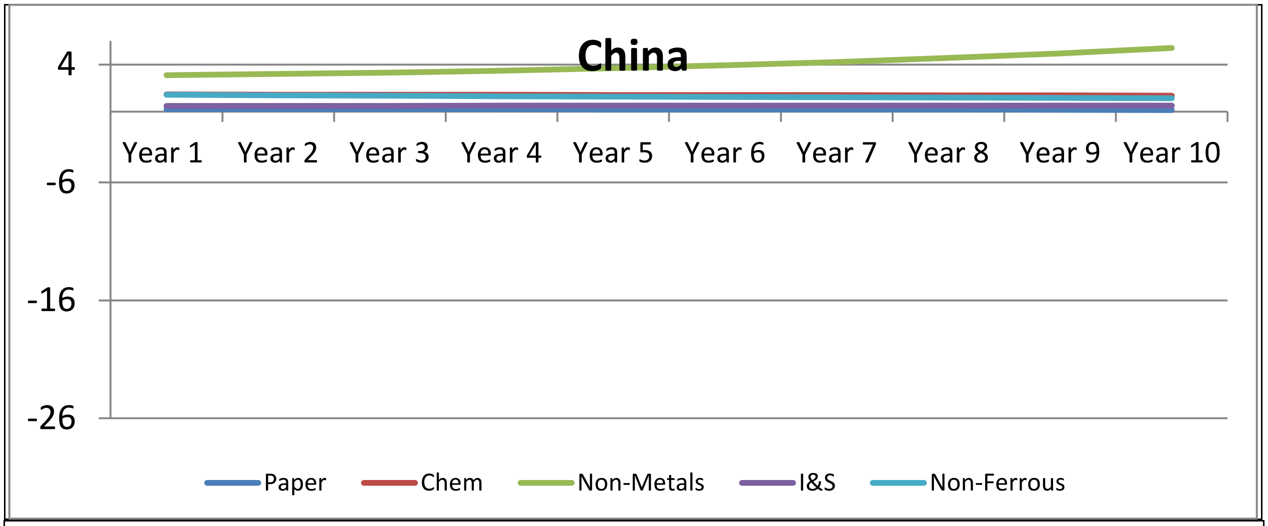


	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Paper	0.029	0.029	0.029	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Chem	0.344	0.342	0.339	0.337	0.334	0.331	0.327	0.323	0.319	0.314
NonMetals	0.395	0.412	0.435	0.465	0.501	0.547	0.603	0.672	0.754	0.853
I&S	0.014	0.014	0.014	0.014	0.013	0.013	0.012	0.01	0.009	0.007
NonFerrous	0.303	0.289	0.276	0.262	0.249	0.237	0.224	0.212	0.199	0.186

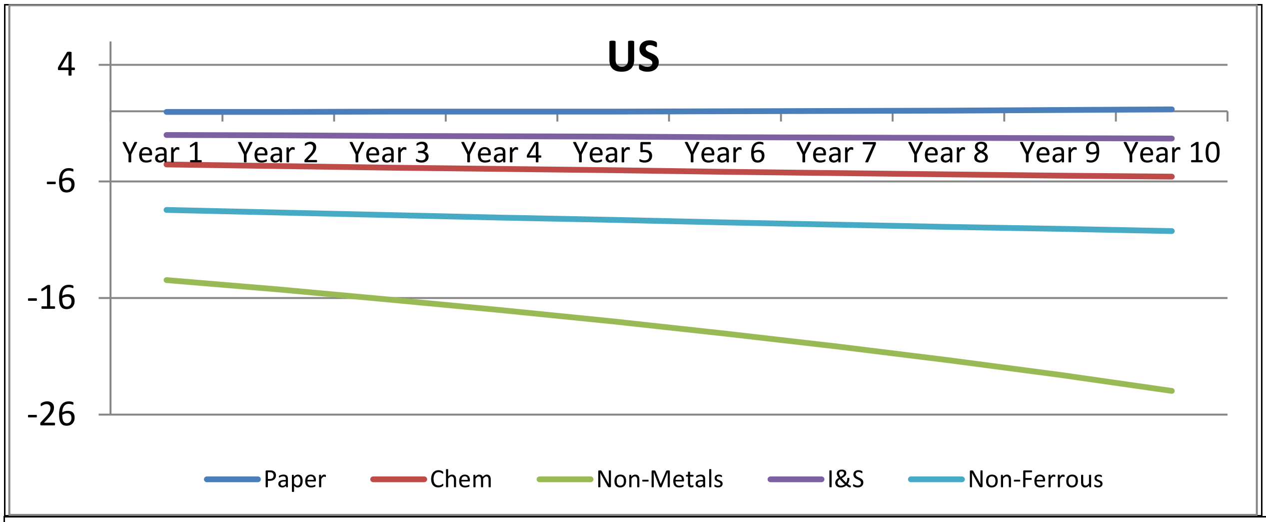


	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Paper	-0.156	-0.156	-0.155	-0.154	-0.153	-0.151	-0.148	-0.144	-0.139	-0.132
Chem	-2.23	-2.242	-2.252	-2.26	-2.266	-2.271	-2.273	-2.272	-2.269	-2.264
NonMetals	-2.91	-2.966	-3.053	-3.176	-3.343	-3.562	-3.842	-4.194	-4.631	-5.169
I&S	-0.16	-0.162	-0.164	-0.164	-0.163	-0.16	-0.155	-0.148	-0.137	-0.123
NonFerrous	-3.091	-3.076	-3.064	-3.053	-3.045	-3.041	-3.041	-3.044	-3.05	-3.061

Percent Change in Exports



	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Paper	0.214	0.212	0.21	0.207	0.202	0.196	0.188	0.177	0.164	0.149
Chem	1.455	1.448	1.44	1.431	1.422	1.413	1.402	1.392	1.38	1.368
Non-Metals	3.095	3.191	3.317	3.479	3.68	3.924	4.215	4.556	4.949	5.396
I&S	0.494	0.497	0.5	0.503	0.506	0.509	0.513	0.516	0.519	0.522
NonFerrous	1.439	1.395	1.353	1.314	1.278	1.245	1.214	1.186	1.162	1.139



	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Paper	-0.038	-0.036	-0.031	-0.021	-0.007	0.013	0.04	0.073	0.115	0.166
Chem	-4.565	-4.691	-4.815	-4.938	-5.06	-5.178	-5.293	-5.403	-5.507	-5.604
Non-Metals	-14.458	-15.276	-16.139	-17.053	-18.021	-19.052	-20.151	-21.329	-22.595	-23.964
I&S	-2.016	-2.056	-2.097	-2.135	-2.172	-2.207	-2.24	-2.269	-2.294	-2.316
NonFerrous	-8.466	-8.682	-8.897	-9.107	-9.314	-9.515	-9.712	-9.902	-10.087	-10.265

Regional Changes

Percent Changes in GDP

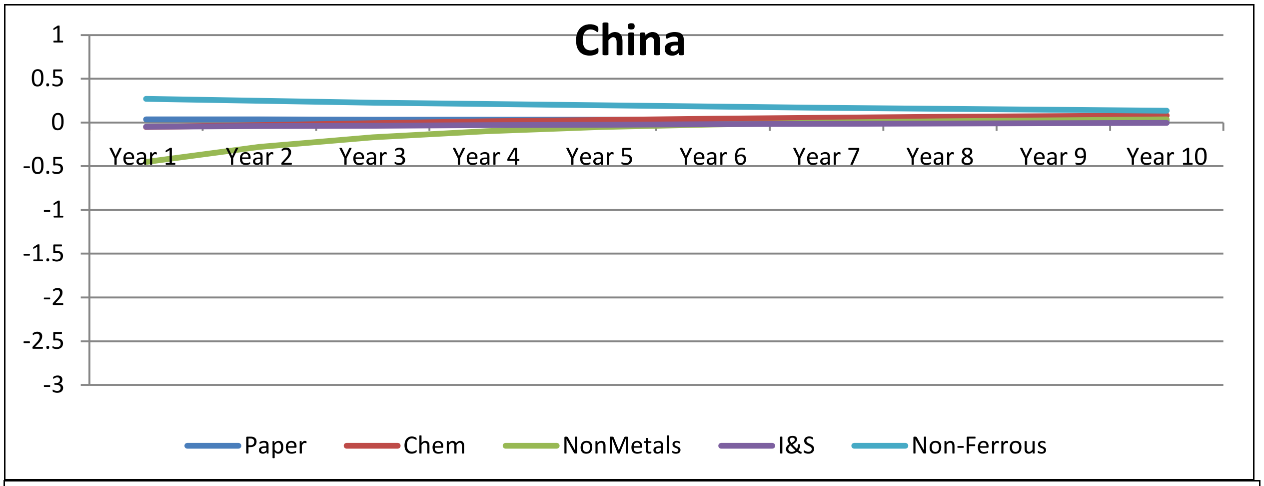
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
China	0.083	0.083	0.084	0.084	0.085	0.087	0.088	0.09	0.093	0.095
USA	-0.356	-0.365	-0.373	-0.383	-0.394	-0.407	-0.421	-0.437	-0.456	-0.477

Percent Changes in Exports

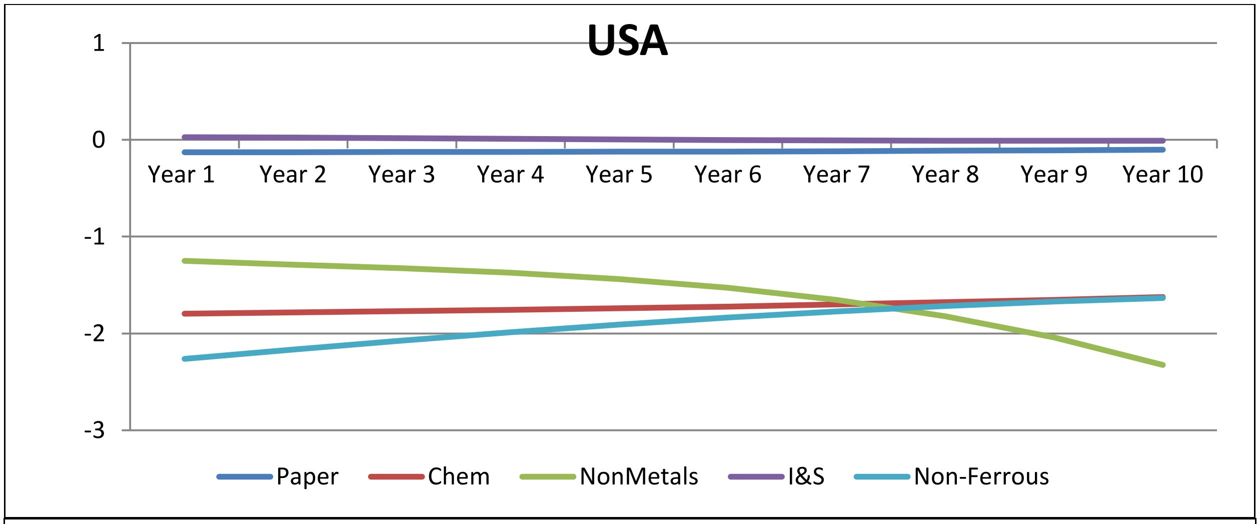
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
CHINA	0.012	0.012	0.013	0.013	0.013	0.014	0.015	0.015	0.016	0.018
USA	0.507	0.556	0.609	0.664	0.724	0.787	0.856	0.93	1.01	1.098

Dynamic Simulation 1

Percent Change in Domestic Production

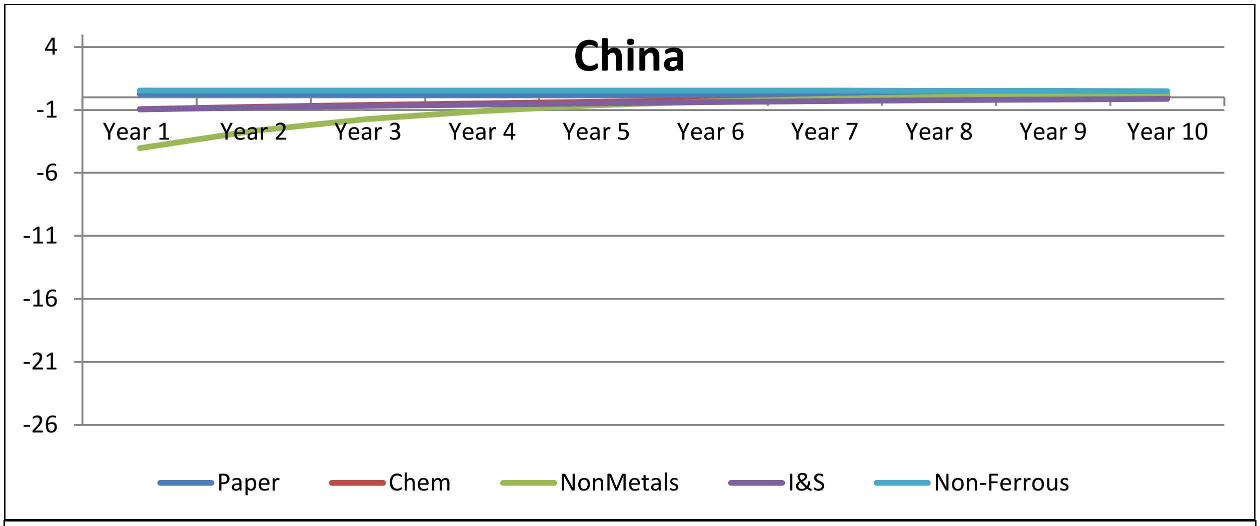


	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Paper	0.036	0.034	0.033	0.032	0.031	0.029	0.028	0.027	0.026	0.024
Chem	-0.053	-0.029	-0.008	0.012	0.028	0.042	0.054	0.063	0.071	0.078
NonMetals	-0.453	-0.28	-0.17	-0.099	-0.053	-0.022	-0.001	0.014	0.026	0.036
I&S	-0.047	-0.042	-0.037	-0.031	-0.026	-0.021	-0.016	-0.012	-0.009	-0.005
NonFerrous	0.271	0.247	0.227	0.21	0.195	0.181	0.168	0.156	0.146	0.136

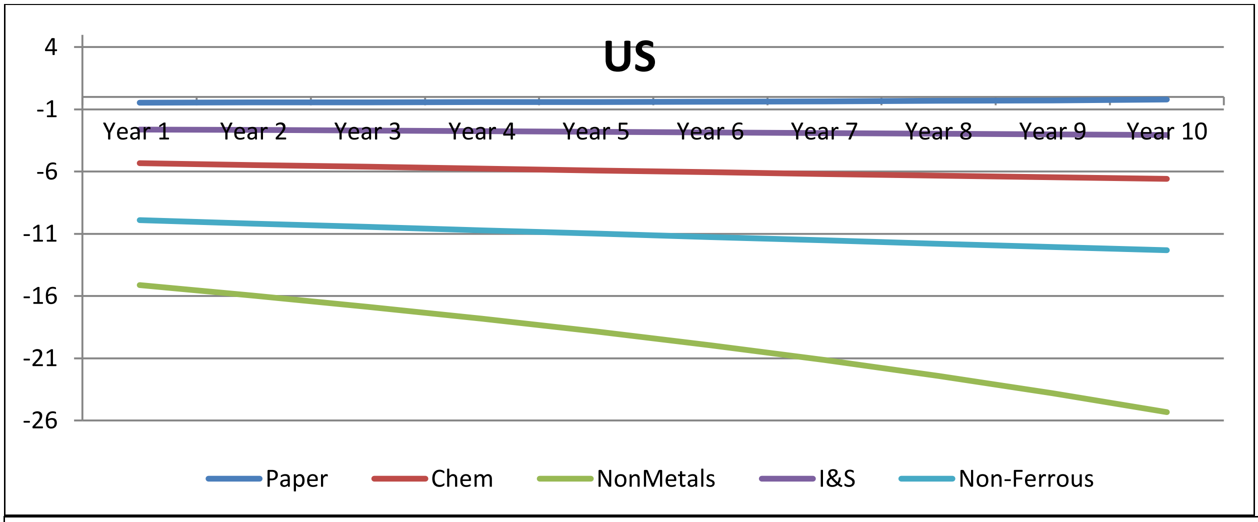


	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Paper	-0.128	-0.127	-0.126	-0.125	-0.123	-0.121	-0.117	-0.113	-0.107	-0.1
Chem	-1.795	-1.784	-1.771	-1.757	-1.741	-1.722	-1.701	-1.678	-1.653	-1.625
NonMetals	-1.25	-1.29	-1.327	-1.374	-1.438	-1.529	-1.654	-1.821	-2.04	-2.324
I&S	0.029	0.023	0.016	0.01	0.004	-0.001	-0.006	-0.008	-0.009	-0.008
NonFerrous	-2.264	-2.166	-2.073	-1.987	-1.907	-1.836	-1.772	-1.717	-1.671	-1.633

Percent Change in Exports



	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Paper	0.256	0.227	0.205	0.188	0.174	0.162	0.15	0.138	0.125	0.11
Chem	-0.944	-0.766	-0.606	-0.465	-0.341	-0.233	-0.139	-0.058	0.011	0.071
NonMetals	-4.031	-2.653	-1.714	-1.075	-0.638	-0.335	-0.121	0.036	0.159	0.263
I&S	-0.948	-0.806	-0.679	-0.567	-0.467	-0.379	-0.301	-0.231	-0.168	-0.112
NonFerrous	0.532	0.546	0.553	0.554	0.549	0.541	0.53	0.519	0.507	0.497



	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Paper	-0.457	-0.447	-0.437	-0.424	-0.408	-0.386	-0.357	-0.319	-0.272	-0.211
Chem	-5.334	-5.474	-5.616	-5.761	-5.906	-6.051	-6.193	-6.331	-6.464	-6.589
NonMetals	-15.115	-15.959	-16.86	-17.822	-18.851	-19.954	-21.141	-22.425	-23.818	-25.338
I&S	-2.621	-2.659	-2.703	-2.749	-2.797	-2.847	-2.899	-2.951	-3.005	-3.059
NonFerrous	-9.907	-10.175	-10.447	-10.719	-10.992	-11.264	-11.534	-11.802	-12.066	-12.327

Regional Changes

Percent Change in GDP

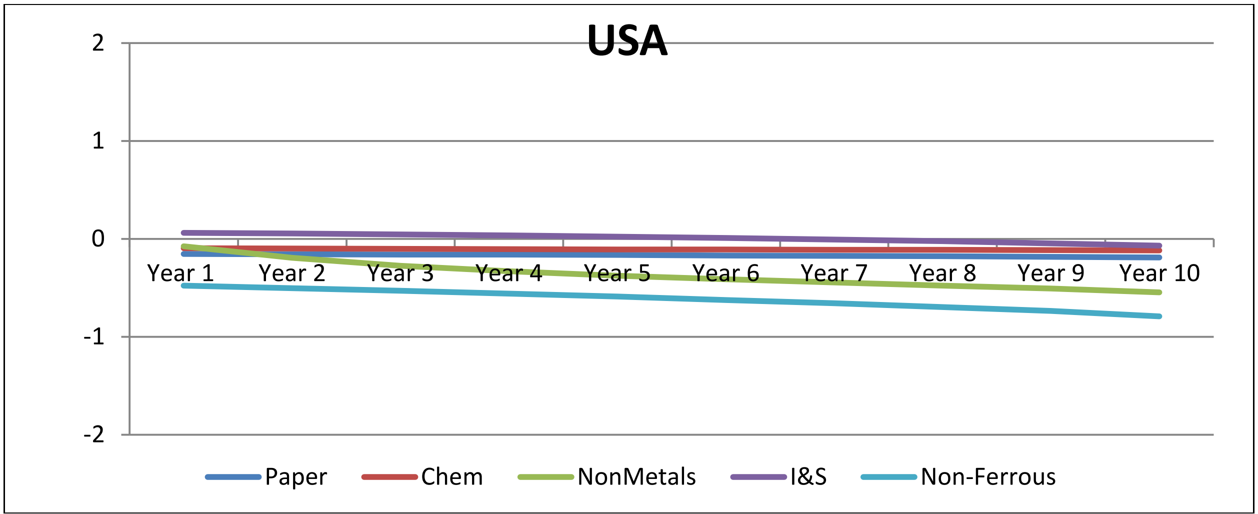
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
China	0.018	0.027	0.033	0.037	0.041	0.044	0.047	0.05	0.052	0.054
USA	-0.28	-0.289	-0.298	-0.308	-0.317	-0.328	-0.339	-0.352	-0.367	-0.385

Percent Change in Exports

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
CHINA	-0.072	-0.063	-0.056	-0.051	-0.047	-0.045	-0.043	-0.042	-0.043	-0.044
USA	0.009	0.07	0.131	0.192	0.255	0.32	0.389	0.462	0.541	0.628

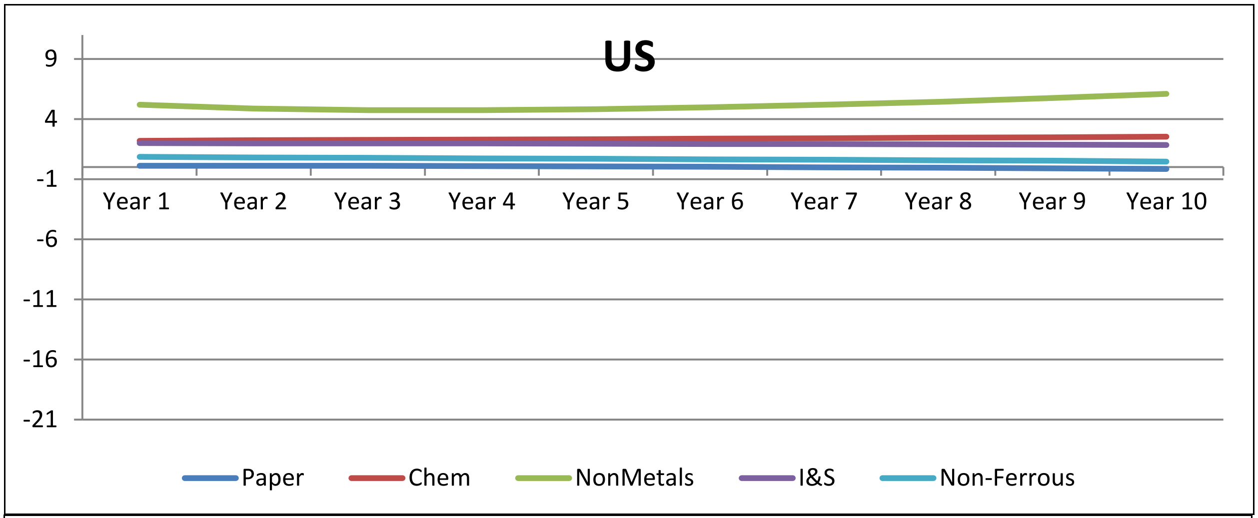
Dynamic Simulation 2

Percent Change in Domestic Production (China Graphs displayed in Paper)



	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Paper	-0.155	-0.157	-0.159	-0.162	-0.165	-0.169	-0.174	-0.178	-0.184	-0.19
Chem	-0.096	-0.099	-0.101	-0.105	-0.107	-0.109	-0.111	-0.111	-0.115	-0.117
NonMetals	-0.076	-0.193	-0.274	-0.332	-0.377	-0.413	-0.445	-0.476	-0.507	-0.545
I&S	0.062	0.056	0.045	0.036	0.022	0.008	-0.007	-0.024	-0.045	-0.07
NonFerrous	-0.479	-0.504	-0.531	-0.558	-0.587	-0.623	-0.656	-0.696	-0.737	-0.79

Percent Change in Exports



	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Paper	0.123	0.114	0.101	0.079	0.057	0.028	-0.01	-0.05	-0.1	-0.156
Chem	2.199	2.229	2.262	2.291	2.327	2.366	2.406	2.449	2.49	2.534
NonMetals	5.196	4.878	4.744	4.74	4.819	4.974	5.184	5.442	5.754	6.096
I&S	1.995	1.985	1.97	1.961	1.94	1.925	1.915	1.9	1.879	1.853
NonFerrous	0.85	0.811	0.77	0.734	0.701	0.651	0.616	0.568	0.524	0.456

Regional Changes

Percent Change in GDP

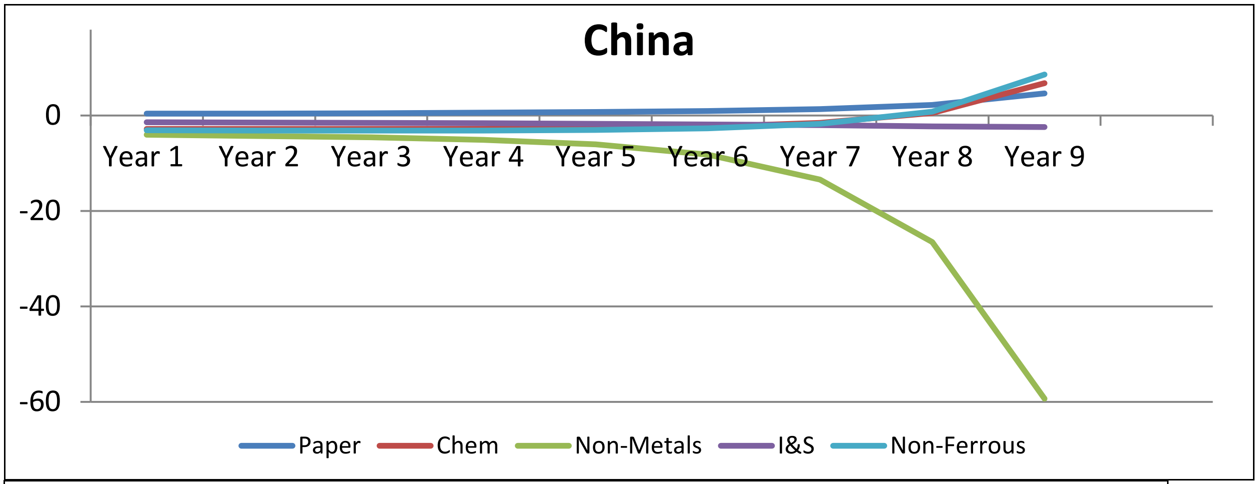
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
CHINA	-0.155	-0.114	-0.081	-0.053	-0.029	-0.006	0.015	0.037	0.06	0.085
USA	0.011	0.005	0.001	-0.003	-0.007	-0.01	-0.013	-0.016	-0.019	-0.023

Percent Change in Exports

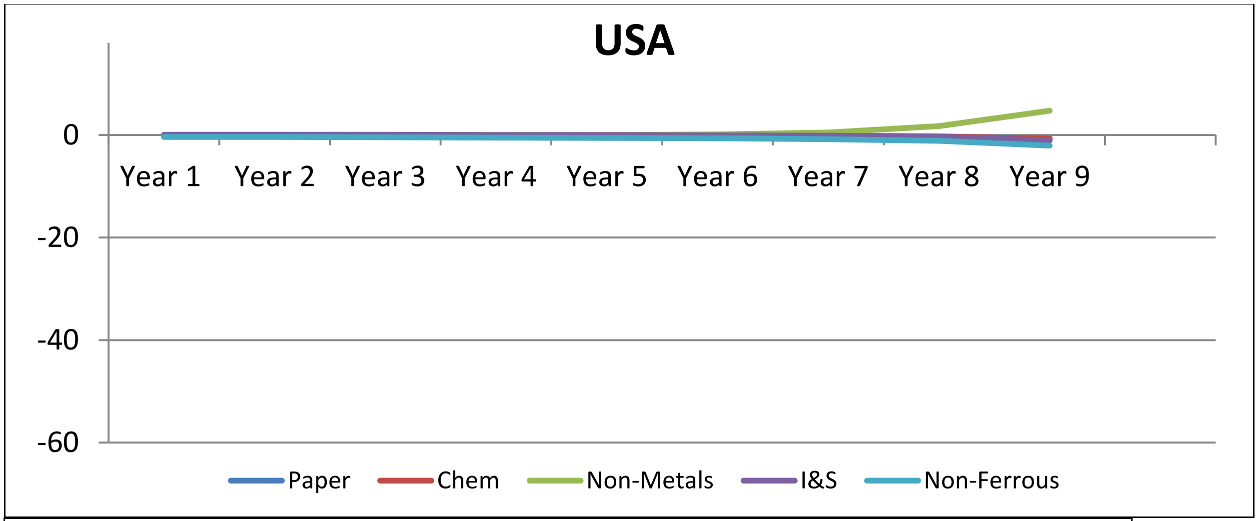
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
CHINA	-0.603	-0.571	-0.551	-0.539	-0.533	-0.532	-0.537	-0.545	-0.558	-0.576
USA	0.105	0.111	0.114	0.115	0.114	0.111	0.105	0.096	0.083	0.065

Dynamic Simulation 3

Percent Change in Domestic Production (Year 10 Results were unreliable)

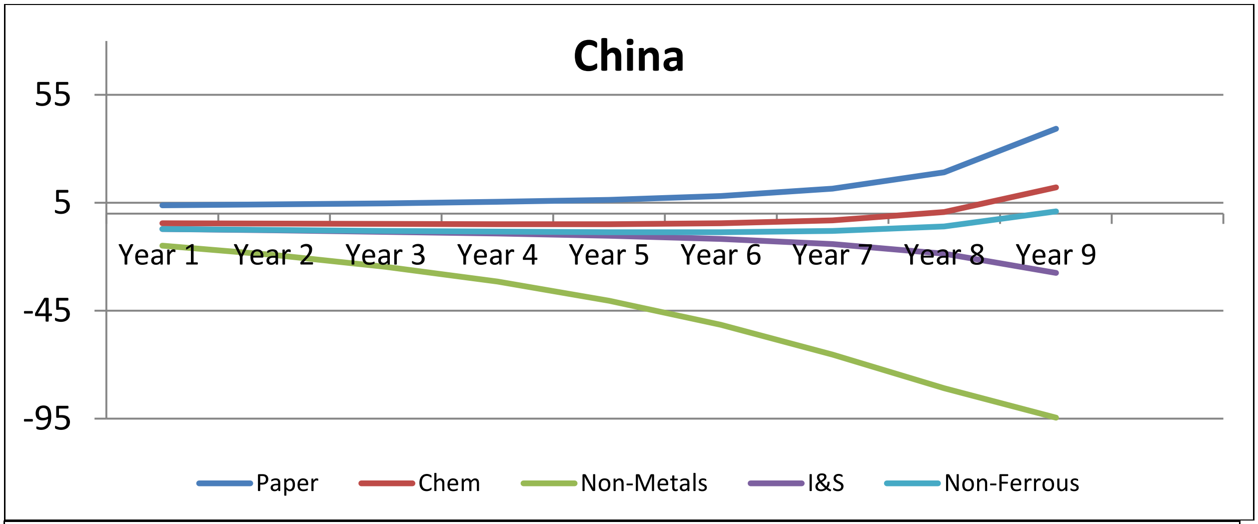


	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Paper	0.391	0.437	0.499	0.587	0.718	0.936	1.344	2.243	4.645
Chem	-2.788	-2.823	-2.836	-2.802	-2.675	-2.347	-1.546	0.543	6.765
Non-Metals	-4.002	-4.27	-4.578	-5.057	-6.022	-8.209	-13.421	-26.518	-59.348
I&S	-1.411	-1.461	-1.524	-1.604	-1.707	-1.84	-2.012	-2.251	-2.429
NonFerrous	-3.091	-3.134	-3.16	-3.139	-3.019	-2.667	-1.734	0.795	8.629

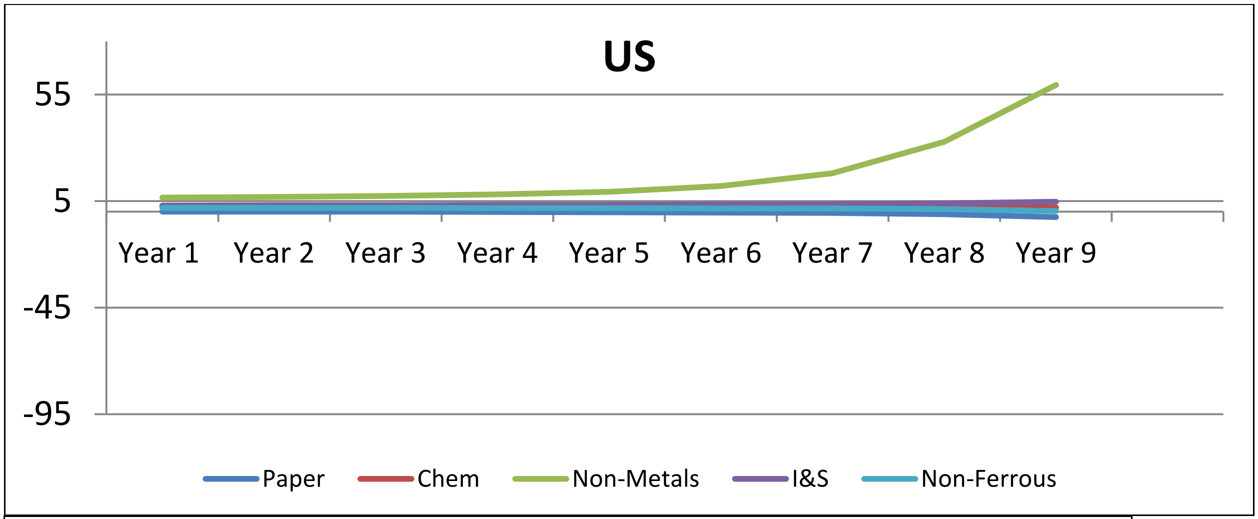


	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Paper	-0.175	-0.181	-0.189	-0.2	-0.215	-0.239	-0.279	-0.362	-0.62
Chem	-0.01	-0.01	-0.011	-0.018	-0.031	-0.057	-0.113	-0.241	-0.711
Non-Metals	0.031	0.028	0.018	0.011	0.03	0.143	0.531	1.74	4.751
I&S	0.091	0.08	0.065	0.047	0.017	-0.03	-0.118	-0.323	-1.069
NonFerrous	-0.348	-0.382	-0.422	-0.469	-0.53	-0.625	-0.773	-1.076	-2.05

Percent Change in Exports



	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Paper	3.926	4.283	4.754	5.425	6.455	8.224	11.619	19.182	39.363
Chem	-4.398	-4.615	-4.803	-4.912	-4.849	-4.403	-3.066	0.693	12.221
Non-Metals	-14.805	-19.104	-24.558	-31.49	-40.316	-51.484	-65.263	-80.837	-94.45
I&S	-7.135	-7.719	-8.401	-9.229	-10.282	-11.739	-14.047	-18.493	-27.495
NonFerrous	-7.144	-7.565	-7.984	-8.353	-8.615	-8.617	-8.009	-5.936	1



	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Paper	0.083	0.041	-0.011	-0.086	-0.185	-0.341	-0.604	-1.096	-2.427
Chem	2.668	2.712	2.754	2.784	2.807	2.807	2.76	2.606	1.938
Non-Metals	6.668	7.022	7.471	8.158	9.405	12.03	18.091	32.749	59.526
I&S	2.972	3.026	3.081	3.155	3.231	3.348	3.55	3.989	4.782
NonFerrous	1.824	1.81	1.789	1.76	1.717	1.624	1.491	1.235	0.335

Regional Change

Percent Change in GDP

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
China	-0.599	-0.699	-0.818	-0.968	-1.181	-1.554	-2.413	-5.016	-14.758
USA	0.09	0.093	0.097	0.101	0.107	0.116	0.132	0.175	0.373

Percent Change in Exports

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
CHINA	1.616	1.814	2.097	2.519	3.199	4.403	6.83	12.622	29.232
USA	0.09	0.078	0.059	0.029	-0.021	-0.106	-0.261	-0.585	-1.755