CAUSES OF TRADE COLLAPSE AND RECOVERY DURING THE GREAT DEPRESSION*

by

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Economics Honors Thesis

May 2013

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*I would like to thank Professor Mario Crucini for all of his advice. I would also really like to thank my research advisor Professor Eric Bond for his guidance in my research and my academic career.

Causes of Trade Collapse and Recovery During the Depression

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April 22, 2013

Abstract

One of the notable features of the Great Depression is the sharp drop in trade to GDP ratio from 1929-34. The goal of my research was to use a gravity equation to investigate the causes of the great trade collapse and subsequent recovery that occurred during the Great Depression. This project required constructing a data set of trade flows between the US and 45 foreign countries for the period between 1921 and 1940. I am estimating a gravity equation model that incudes variables to reflect US and foreign economic activity and trade frictions. A major point of emphasis is the contributions of changes in US tariffs and the subsequent bilateral trade agreements under the Reciprocal Trade Agreements Act to the change in trade flows. Holding everything else constant, the signing of reciprocal trade agreements increased the US exports by 0.21%. Moreover, holding everything else constant, increase in the US tariffs by 1% decreased the US imports by 0.044%.

Additionally, we used the parameter values from the data to calibrate a model that matched the gravity equation. This exercise allowed us to compare the level of the tariff in 1924 with the optimal tariff, and it let us calculate the effect of the elimination of all tariffs (both US and foreign). The comparison with free trade provided an estimate of the cost of the trade war on welfare of the US. It was found that the US welfare decreased by 0.24% as a result of the trade war.

1 Introduction

During the 1930s the US experienced both trade collapse and partial recovery. This can be seen clearly in the Trade/GDP graph below. In this paper, we are trying to test the extent to which trade collapse and subsequent recovery in the 1930s should be attributed to changes in tariff levels.

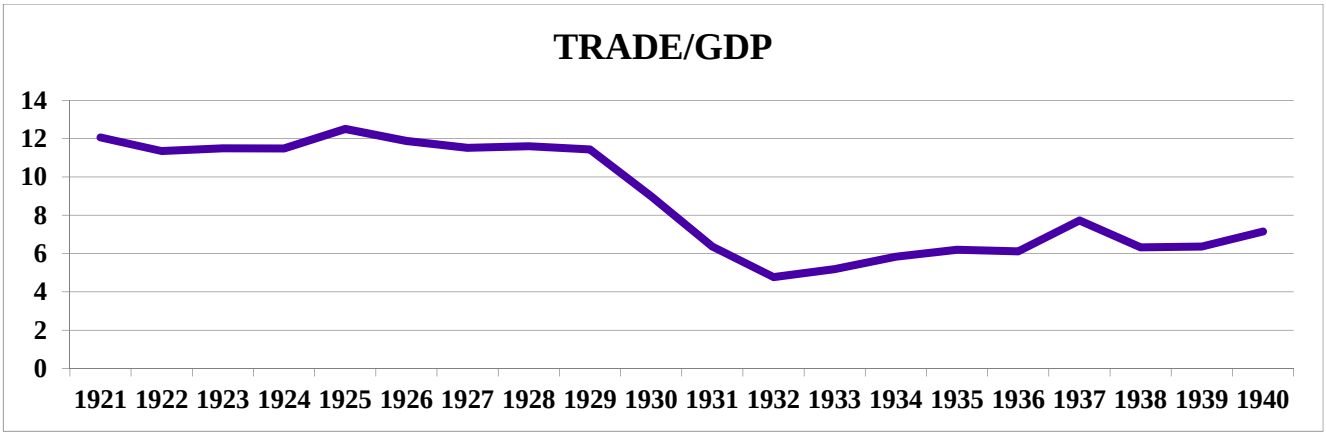

Figure 1

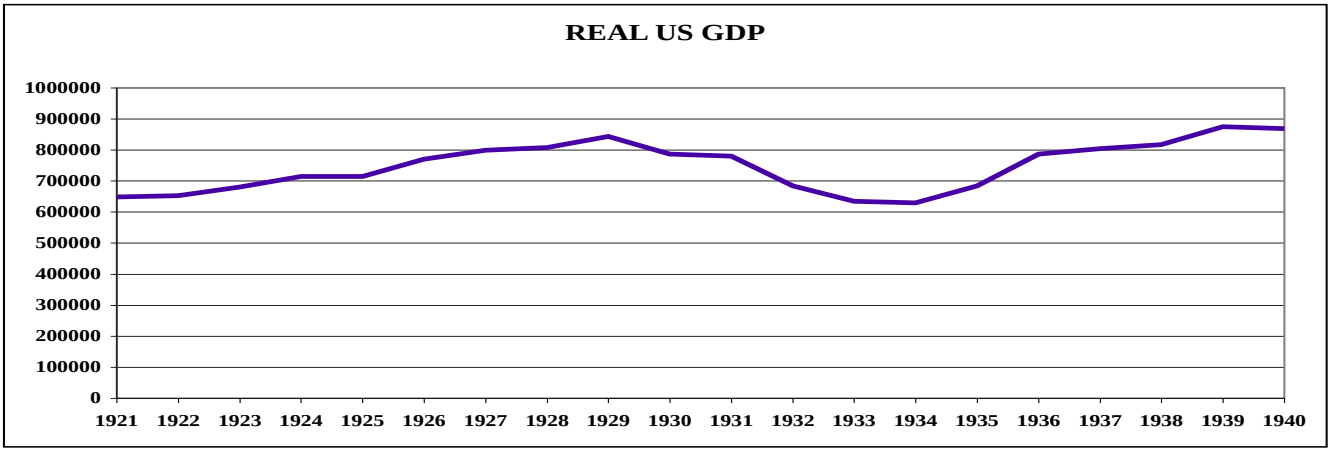

Figure 2

The Smoot-Hawley tariff of 1930 raised US duties on hundreds of imported goods to record levels, and thus it became America's most infamous trade law. The tariff started as a way to help farmers by increasing duties on agricultural imports and then it "quickly grew into a logrolling, pork barrel free-for-all in which duties were increased all around, regardless of the interests of consumers and exporters" (Irwin, 2011). As a result, US imports fell sharply and other countries retaliated by increasing tariffs on US goods, leading US exports to decrease as well. Thus, to promote economic recovery by reducing foreign tariffs on US exports, the Congress passed the Reciprocal Trade Agreement Act in 1934. This act granted the President the authority to reach tariff reduction agreements with foreign countries and also helped the US to moderate the tariff code to its liking.

The goal of our research is to use the gravity equation to investigate what factors were primarily responsible for the great trade collapse and the subsequent recovery that occurred during the Great Depression. This model can be used to test for the impact of reciprocal trade agreements on the volume of trade with trading partners. While we used the gravity equation as a base, we believed that there were a number of other economic forces that shaped the volume of trade in the global market: distance between the US and other countries; US tariff rate; foreign tariff rate; percent free, a country specific variable that captures differences in tariff rates imposed by the US on foreign goods; having a common language; "4-month Prime Commercial Paper Rates" that incorporate the effects of the financial situation in the US; and "RTAA" that takes into account whether or not the two countries signed the reciprocal trade agreement. We then collected data for 45 countries that the US traded with. These 45 countries constitute a majority of US trade; for example, in 1921 these countries represented almost 85% of total exports and almost 70% of total imports.

Using these data we separately ran the regression of US exports and imports on all the variables listed above and were able to make several conclusions: foreign tariff rates had a negative effect on US exports, while US tariff rate had a negative effect on US imports and distance had a negative effect on trade whereas variables like foreign GDP, sharing a common border, and signing of reciprocal trade agreements had a positive impact on trade.

We also used the constant elasticity of substitution utility function as a base to find whether or not tariffs set by the US and foreign countries were optimal.

2 Historical Background

From 1870 to 1913 the classical gold standard linked many of the world's economies through a system of de facto pegged exchange rates. This gold standard was characterized by free flow of gold between countries - fixed values of national currencies were maintained in terms of gold and therefore

each other. In their paper, Lopez-Cordova and Meissner (2003) concluded that 20 percent of the growth in world trade between 1880 and 1910 was due to the stability provided by the exchange rate regime. This system, however, was disrupted by World War I and was resumed only in the mid-to-late 1920s due to postwar economic and monetary dislocations. The resumed gold standard was reconstructed as a gold-exchange standard, as it provided for expanded use of foreign exchange - mainly sterling and dollars - to back the monetary circulation (Eichengreen, Irwin). Thus, with some exceptions, governments largely resurrected the prewar pattern of exchange rates despite the fact that relative financial strength and competitive positions had changed irrevocably as a result of the war. Old gold parities were restored without lowering price levels back down to prewar levels, which led to a lower ratio of the value of gold to nominal transactions. The deflationary bias of the asymmetry in required adjustments was magnified by statutory fractional reserve requirements imposed on many central banks after the War. Most countries required that minimum gold holdings equal a fixed fraction of central bank liabilities – usually close to the Federal Reserve's 40% (Bernanke, James). This meant that a large portion of central bank gold holdings were immobilized by the reserve requirements and could not be used to settle temporary payment imbalances. Moreover, with fractional reserves, the relationship between gold outflow and the reduction in the money supply was not one-for-one. For example, with a 40% reserve requirement the impact on the money supply of a gold outflow was 2.5 times the external loss. Therefore, the loss of gold could lead to an immediate and sharp deflationary impact.

Figure 2 above depicts the US GDP decline from 1929 to 1934. This was because in the late 1920s, the Federal Reserve believed there was a speculative bubble in equity values. Thus, to "pop" the bubble, the Fed embarked on a highly contractionary monetary policy in January of 1928. Hamilton (1987) documents that, as a result, the U.S. price level fell about 4% over the course of 1929. A business cycle peak was reached in the United States in August 1929, and the stock market

crashed in October. The initial contraction in the United States was largely a self-inflicted wound as no binding external constraint forced the United States to deflate in 1929. However, as argued by Temin (1989), as central banks remained committed to the gold standard, the destabilization caused by these policy measures could not be prevented. The resulting competitive deflation prevented individual banks from attempting to reflate, which caused immediate gold outflows and a subsequent deflation, an issue faced even by countries with large gold reserves such as the United States.

The Smoot-Hawley tariff - that started in 1928 as an election-year plan by Republicans to appease farmers, who were suffering through years of low commodity prices - was signed by President Hoover in June of 1930 and set specific rates for more than 3,300 tariffs (Irwin, 2011). Because many of the tariffs were imposed on a per item basis, as prices fell due to the ongoing deflation of import prices, the percentage rate of the tariff rose even further. To be more specific, according to Irwin, the deflationary effects ended up being twice as large as the actual rate changes and resulted in an increase in the average effective tariff rate from 40 percent in 1929 to a peak of 59 percent in 1932 (Irwin, 2011). This sharp increase in tariff rates imposed on imported goods triggered a trade war and a sharp rise in tariffs worldwide. Rapid increases in tariffs at the beginning of the 1930's caused trade between the US and other countries to decrease sharply.

This decrease in trade between the US and other countries resulted in the Reciprocal Trade Agreement Act. This Act was passed by US Congress in 1934 and gave the President the power to negotiate trade agreements with other countries. The US Congress passed the Reciprocal Trade Agreement Act instead of decreasing tariffs unilaterally. The latter would have created an excess supply of the US exportable and an excess demand for the US importable. An excess demand would have led to a deterioration of the US' terms of trade and a fall in its real income. In contrast, reciprocal agreements have a negligible impact on the terms of trade of all trading partners, so all countries gain proportionally from the size of the deadweight losses associated with trade barriers. For example, in

the case of symmetric trading partners one country's excess supply of exportables satisfies another country's excess demand for importables. A reciprocal trade agreement would leave the terms of trade of all countries unchanged (Kouparitsas). Thus, signing of the reciprocal trade agreements was preferred over the unilateral decrease of tariffs. As a result of the Reciprocal Trade Agreement Act bilateral trade agreements were signed between the US and a number of other countries. Figure 3, below, shows how average tariffs changed between 1921 and 1940, but that is a result of a combination of factors like signing of the reciprocal trade agreements and change in import prices. Import prices rose eleven percent between 1934 and 1939 and reduced the ad valorem equivalent of the specific duties that had been nominally fixed in the Smoot-Hawley tariff (Irwin, 1998).

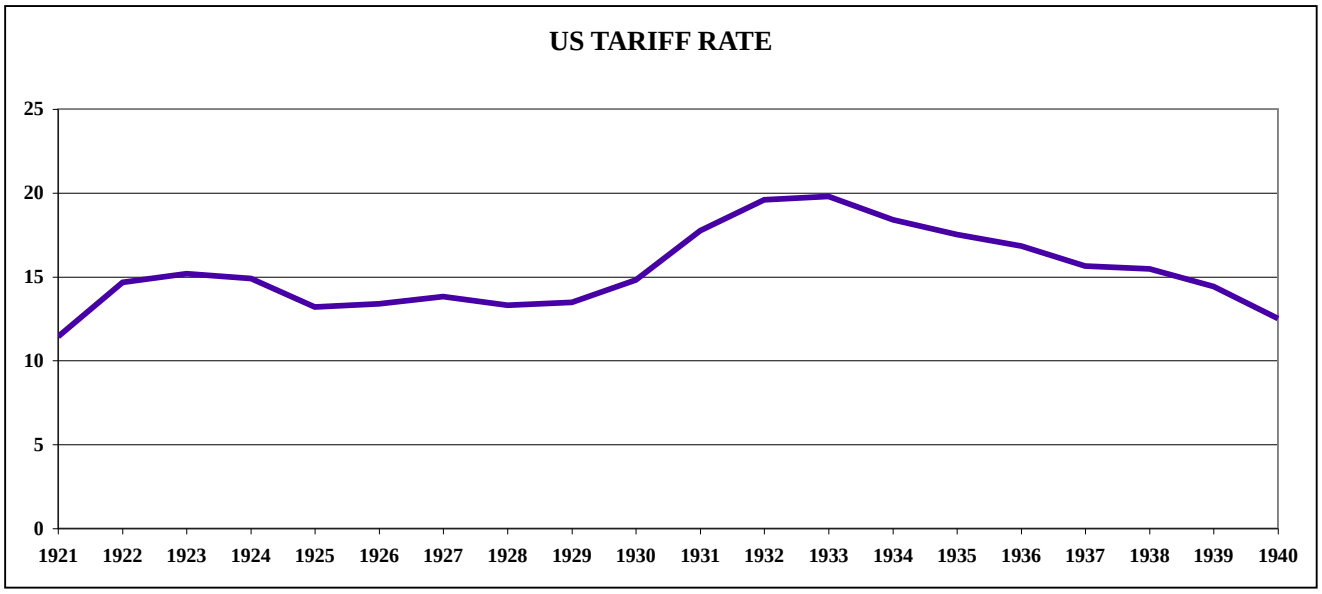

Figure 3

3.1 Economic Model

To study what factors affect trade between the US and other countries, we used an economic model called the "gravity equation." Analogous to Newton's universal law of gravitation, the gravity equation states that the patterns of bilateral aggregate trade flows between two countries are

proportional to the gross national products of those countries and inversely proportional to the distance between them. Shortly, it can be expressed in this form:

$$\frac{V}{P} = \left(\frac{Y}{P}\right) * \left(\frac{Y'}{P'}\right) * \left(\frac{P_{IMP}}{P}\right)^{-\sigma}$$

where Y is the US GDP and Y' is GDP of a foreign country, P is the US Price level, P' is the Price Level of a foreign country.

Having the gravity equation as a base, we modified it to log-linear form:

$$log(V_{ij}) = \alpha + \beta_1 log(\frac{GDP_i}{P}) + \beta_2 log(\frac{GDP_j}{P}) + \gamma X$$

where X is a vector of factors that affect the relative cost of foreign goods. Here we used the logarithmic form of the equation as changes to the logarithmic form approximate proportional changes. Thus, we worked with percentage changes in imports, exports, the US GDP and foreign GDP, as opposed to working with absolute values. Moreover, we used our modified formula separately for US Exports and Imports. The formula for US Exports helped us identify whether there was an increase in exports to any particular country and thus show how trade agreement affected the trade between two countries. The formula for US Imports demonstrated how the average tariff rate imposed by the US changed depending on the agreement.

3.2 Data

In the gravity equation above the price of foreign goods in the US market is affected by the US tariff rate, percent free, distance, and common border, and so we have included these factors in our model. Anderson and van Wincoop in "Gravity with Gravitas: A Solution to the Border Puzzle" modified McCallum's [1995] gravity equation by adding the multilateral resistance variables. In McCallum's [1995] gravity equation, bilateral trade flows between two countries depend on the output of both countries, their bilateral distance, and whether they are separated by a border. Thus, by

modifying the gravity equation and using 1993 data, Anderson and van Wincoop found that borders reduce trade between the US and Canada by 44%, while reducing trade among other industrialized countries by 29%. These results show that a shared border does have an impact on international trade. Thus, we also included in our model a "border" variable, which equals 1 when two countries share a common border and 0 otherwise. Moreover, we included a "language" variable to observe whether or not having a common language influences the pattern of trade.

As trade costs in international economics include not only physical transport costs but also policy-related costs like tariff barriers, we also included a variable "tariff rate" that is responsible for the average tariff rate imposed by the US on any other country in the model. In their paper "Continental Trading Blocs: Are They Natural or Supernatural?" Frankel, Stein, and Wei use an ad valorem tariff level in the model that indicates that prices of home and foreign goods faced by home consumers are different due to transport costs and tariffs. Moreover, when they consider welfare implications of trade agreements, they show the redistribution of the tariff revenue to consumers. Based on their model, we also included "tariff rate" variable to our model due to high variable tariff rates between 1921 and 1940. Instead of using a product-by-product tariff rate, we used the aggregate tariff rate as our starting point as it was very hard to collect data on tariff cuts on a product-by-product basis for a variety of reasons. First of all, it was hard to record data on all of the goods that the US exported and imported to/from another country. Additionally, if the US did not import a particular good from another country, then the tariff reduction on that good would not have changed the pattern of trade: we would have gotten a tariff reduction on zero goods and this tariff reduction would not have affected our research. Thus, as we wanted to take into account all of the tariff reductions by the US, we used the aggregate tariff rate. As a result, data for 138 countries for period of 20 years was collected. Data for US Exports and Imports, and tariff rate by country was obtained from *Foreign Commerce and Navigation of the United States*. However, due to a lack of data for all countries, in the

end we were able to collect data only for 45 countries. However, as previously stated, in 1921 these 45 countries represented almost 85% of total exports and almost 70% of total imports. Thus, they account for majority of US trade activity. GDP data and data for distance between the capital of foreign country and Chicago were provided by Professor Mario Crucini.

Along with including the US tariff rates, we included tariff rates set by foreign countries. We defined the US tariff rate to be the same for all foreign countries in a particular year. To capture differences in tariff rates imposed by the US on foreign goods, we included a country specific variable called "percent free." "Foreign tariff rate," which defines how much foreign countries retaliated with their tariffs, was also used as one of the defining independent variables. Due to lack of data, we used an average foreign tariff rate that was defined as Total Duties Collected over Total Imports. Foreign tariff rates included in the model are imperfect measures because they included duties on all imports from all destinations. However, they did not include specific duties on imports from the US. Data for foreign tariffs was obtained from the *International Historical Statistics*. Figure 4 - a scatter plot with the tariff rate in 1924 on x-axis and the tariff rate in 1936 on y-axis - below emphasizes how tariffs against US goods changed during this period.

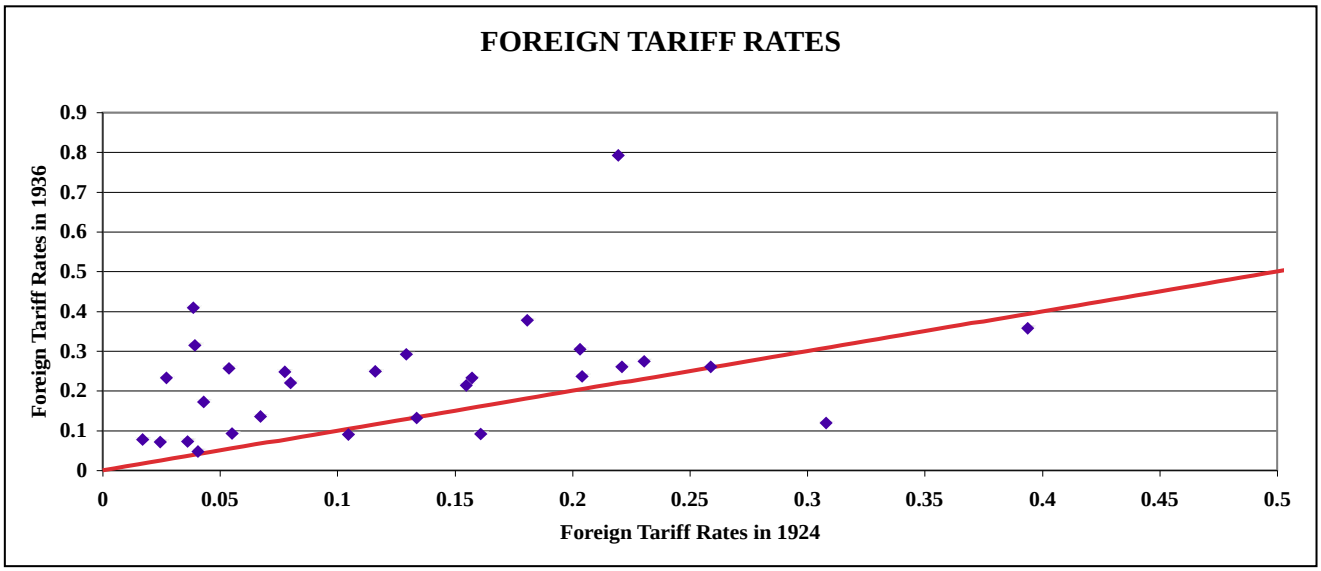

Figure 4

Additionally, we added a variable "RTAA" to our model to observe whether or not the signing of reciprocal trade agreements had an impact on trade between the US and other countries. This variable, however, does not capture how much tariffs were reduced as a result of these trade agreements and is thus an imperfect measure. "RTAA" is a crude measure that will be used to identify if the pattern of the US trade shifted toward countries with whom trade agreements had been signed. We would expect that as a result of the RTAA, the average tariff rate would decrease. However, we would also expect that only part of this reduction would be due to the RTAA as import prices rose eleven percent between 1934 and 1939 and reduced the ad valorem equivalent of the specific duties that had been nominally fixed in the Smoot-Hawley tariff (Irwin, 1998). Thus, to take into account impacts of inflation, we used real values for US GDP and Foreign GDP, defined as US GDP/US Price Level and Foreign GDP/US Price Level, respectively. The data about date reciprocal trade agreements were signed was obtained from Irwin's *From Smoot-Hawley to Reciprocal Trade Agreements: Changing the Course of U.S. Trade Policy in the 1930s*.

To incorporate the effects of financial situation in the US, i.e. credit crunch, on exports and imports, we included "4-month Prime Commercial Paper Rates." Commercial paper is a short-term unsecured promissory note issued by corporations and foreign governments. As Mary Amiti and David Weinstein (2009) argued, the higher sensitivity of exports to financial forces - explained by the fact that exporters tend to be much heavier users of trade finance than domestic firms because international transactions tend to take much longer to execute than domestic transactions and because of the perceived higher risk of international transactions - provides a reason why exports should be more susceptible to financial shocks than domestic sales. Prime commercial paper rates were found in the *International Historical Statistics*.

As Jones mentioned in his book, *Tariff Retaliation: Repercussions of the Hawley-Smoot Bill*, some countries imposed retaliatory duties on some products imported from the United States. For

example, Canada imposed duties on sixteen products imported from the US such as: white and sweet potatoes, soups and soup preparations, livestock, fresh meats, cured and pickled meats, wheat flour, oats, oatmeal, rye, cut flowers, and cast-iron pipe. The duties on these products – which represented about 30 percent of the value of all US merchandise exports to Canada – were raised to the levels charged by the United States. Thus, to include effect of partial retaliation on trade between countries, we added partial retaliation dummy to our model. The data for partial and full retaliation was obtained from the *World Economic Survey: 1931-32.* Moreover, we also included time dummies to our equation to take into account variation over the years.

Our final formulae for exports and imports looked like this:

$$Real\ Exports = \alpha + \beta_1 Real\ Foreign\ GDP + \beta_2 Real\ US\ GDP + \beta_3 Foreign\ Tariff\ Rate + \beta_4 RTAA\ Dummy + \beta_5 Distance + \beta_6 Border + \beta_7 Language + \beta_8 Prime\ Commercial\ Paper + \beta_9 Percent\ Free + \beta_{10} US\ Tariff\ Rate$$

$$Real\ Imports = \alpha + \beta_1 Real\ US\ GDP + \beta_2 Real\ Foreign\ GDP + \beta_3 Percent\ Free + \beta_4 US\ Tariff\ Rate + \beta_5 RTAA\ Dummy + \beta_6 Distance + \beta_7 Border + \beta_8 Language + \beta_9 Prime\ Commercial\ Paper + \beta_{10} Foreign\ Tariff\ Rate$$

Data on exports showed that between 1921 and 1940, Argentina, Canada, Cuba, France, Germany, Italy, Japan, Mexico and United Kingdom consistently imported more US goods than other countries whereas the US mostly imported goods from Brazil, Canada, China, Cuba, France, Germany, Japan, and the United Kingdom. The data also shows that from these countries over time Brazil, China, Cuba, Japan imported more goods from the US than exported. Thus, for these countries trade with the US was less important than trade with these countries for the US. Argentina, Canada, France, Germany, Italy, and United Kingdom exported more products to the US than imported. Therefore, for these countries trade with the US was more important than trade with these countries

for the US. Table 5 below shows average trade shares of foreign countries in their trade with the US between 1921 and 1940. Variance decomposition of exports shows that 45% percent of variation was due to a country variation and 55% of variation was due to time variation whereas variance decomposition of imports shows that country variation was more important in explaining trade patterns of the US with other countries over this time period.

Country	Average Trade Share	Average Import Share	Average Export Share
United Kingdom	16.01%	9.73%	20.69%
Canada	15.91%	14.64%	16.87%
Japan	8.27%	10.36%	6.71%
Germany	6.35%	4.91%	7.42%
France	5.24%	4.22%	6.01%
Cuba	4.91%	7.11%	3.28%
Brazil	3.48%	5.56%	1.94%
Mexico	3.32%	3.73%	3.02%
China	3.16%	4.10%	2.47%
Italy	3.06%	2.65%	3.36%
Argentina	3.01%	2.95%	3.06%
Philippines	2.77%	3.87%	1.94%
Netherlands	2.65%	2.20%	2.98%
Belgium	2.34%	2.13%	2.49%
India	2.32%	3.78%	1.22%
Other Countries	17.18%	18.06%	16.52%

Table 5

$$\%\ increase\ in\ exports$$
$$= 0.05 * rtaa + 0.02 * time\ dummy\ for\ 1936 + 0.35 * time\ dummy\ for\ 1937$$
$$- 0.02 * time\ dummy\ for\ 1938 - 0.02 * time\ dummy\ for\ 1939 + 0.07$$
$$* time\ dummy\ for\ 1940 + 1.10$$

$$\%\ increase\ in\ imports$$
$$= -0.03 * rtaa - 0.16 * time\ dummy\ for\ 1936 + 0.02 * time\ dummy\ for\ 1937$$
$$- 0.73 * time\ dummy\ for\ 1938 - 0.20 * time\ dummy\ for\ 1939 - 0.43$$
$$* time\ dummy\ for\ 1940 + 1.41$$

In the equation above RTAA variable had a value of 1 for the year the RTAA was signed and a value of 0 otherwise. Regression of growth rate of exports and imports from 1935 until 1940 on RTAA

shows that signing of bilateral trade agreements increased exports by 0.05% and decreased imports by 0.03%. This means that the signing of bilateral trade agreements, in general, was more beneficial for the US than for other countries as it increased US exports to other countries and decreased US imports from other countries when compared to the trade between the US and countries that did not sign the reciprocal trade agreement. This demonstrates how important these trade agreements were for the US.

3.3 Regression

To run the regression, we used panel data regression in Stata. The use of panel rather than cross-sectional data is generally preferred because panel-based models offer a better opportunity to account for changes taking place within and between countries over time. Additionally, it generates more efficient parameter estimates. We ran fixed-effects regressions as we were interested in making explicit comparisons of one level against another; i.e., this type of regression will allow for different intercepts for our country variables while constraining the slopes to be the same across countries. Because we ran fixed-effects regression, variables that did not change over time like distance, border, and language were omitted.

After we ran the regression, our Ordinary Least Squares formula was:

Real Exports	**Coefficient**	**Std. Error**	**P**	**Confidence**	**Interval (95%)**
Real Foreign GDP	0.890	0.038	0.000	0.816	0.964
RTAA Dummy	0.747	0.179	0.000	0.394	1.100
Distance	-0.0001	0.00002	0.000	-0.0001	-0.00004
Border	1.114	0.222	0.000	0.679	1.549
Prime Commercial Paper	0.119	0.049	0.016	0.023	0.217
Percent Free	0.014	0.002	0.000	0.011	0.017

Real Imports	**Coefficient**	**Std. Error**	**P**	**Confidence**	**Interval (95%)**
Percent Free	0.014	0.001	0.000	0.011	0.016
RTAA Dummy	0.712	0.165	0.000	0.389	1.035
Real Foreign GDP	1.097	0.038	0.000	1.024	1.171
Border	1.690	0.171	0.000	1.355	2.026

Language	-0.797	0.099	0.000	-0.990	-0.603
Prime Commercial Paper	0.218	0.046	0.000	0.129	0.308
Foreign Tariffs	1.953	0.333	0.000	1.298	2.607

Adjusted R-squared for exports was 50% and adjusted R-squared for imports was 67%. This means that our variables explained 50% of the variability observed in the level of exports and 67% of that which was observed with respect to imports.

As was expected, increase in foreign GDP increased both US exports and imports. US GDP was correlated with time dummies and thus was omitted from the regression. Signing of bilateral trade agreements between the US and other countries had positive effect on both American exports and imports. Looking at the OLS equations we also see that an increase in distance between countries decreased US exports to other countries. However, it was surprising that distance did not have a negative relation to US imports from other countries. The border coefficient showed that US trade with both Mexico and Canada increased not only because distance between them was relatively small, but also because they share a common border. We also expected that countries that spoke English as their native language would trade more. However, our expectation was not the case in our equation, as the coefficient in front of the language variable was negative. The fact that our expectations were not met may be because we were only looking at one language. Moreover, our language dummy does not take into account the fact that English is commonly spoken in most countries and thus may be less of a barrier for trade. The US tariff rate did not seem to affect US imports. This may be because percent free serves as a better measure of tariff rates set by the US. The fact that the prime commercial paper rate coefficients for exports and imports are both positive suggest that our model is not capturing the financial effect that we hoped it would. Surprisingly, foreign tariffs did not appear to affect US exports, contrary to our prediction that foreign tariffs would have a significant impact on exports, as

higher tariffs on the US goods should have led to fewer exports. The problem with the insignificance of foreign tariffs was resolved when we ran the fixed-effects regression:

Real Exports	**Coefficient**	**Std. Error**	**P**	**Confidence**	**Interval (95%)**
Foreign Tariffs	-0.935	0.300	0.002	-1.525	-0.346
Real Foreign GDP	0.704	0.201	0.000	0.309	1.098
RTAA Dummy	0.210	0.087	0.016	0.039	0.381
Prime Commercial Paper	0.099	0.036	0.005	0.029	0.169
US Tariffs	-0.050	0.015	0.001	-0.079	-0.021

Real Imports	**Coefficient**	**Std. Error**	**P**	**Confidence**	**Interval (95%)**
US Tariffs	-0.044	0.012	0.000	-0.069	-0.020
RTAA Dummy	-0.228	0.069	0.001	-0.364	-0.092
Real Foreign GDP	0.909	0.143	0.000	0.628	1.189
Prime Commercial Paper	0.056	0.026	0.034	0.004	0.107

When we ran fixed-effects regression we saw that an increase in foreign GDP by 1% tended to coincide with an increase in US exports by 0.7% and an increase US imports by 0.9%. This finding was consistent with those typical of observations conducted with a traditional gravity model. By looking at the exports equation we also saw that an increase in foreign tariffs would tend to decrease exports. Moreover, as we expected, an increase in US tariffs would make it more profitable to produce in the US instead of exporting the product, which in turn would lead to a decrease in exports. This means that an increase in tariffs could pull resources away from exports playing toward the country's comparative advantages and reposition them toward less efficient uses. Additionally, the exports equation shows that signing of reciprocal trade agreements results in an increase in exports. An increase in the prime commercial paper rate means that corporations are forced to borrow money at a higher cost when they decide to invest in their production of goods and services. When cost of borrowing increases it costs more to obtain funds to use for investment. This indicates that cost of production of corporations could go up and this leads to a decrease in exports. Moreover, higher cost

of production could increase price of goods, potentially contributing to declines in consumption amongst individuals which in turn can negatively impact the level of imports. The fact that the prime commercial paper rate coefficients for exports and imports are both positive seems to suggest our model is not capturing any financial effect that we hoped it would.

In the imports equation, as we expected, increase in US tariffs decreased US imports. It is interesting to note that signing of bilateral trade agreements does not seem to have a positive effect on imports. What was also surprising is the fact that the coefficient in front of real US GDP variable is omitted. This may be because the real US GDP is correlated with something else, which could have a very strong relationship with trade. No conclusion about the impact of GDP can be drawn in this case. In the results with time dummies, the reason is clear - the US GDP is perfectly correlated with time dummies because there is no cross sectional variation in the variable. Since all of our results include time dummies, we have omitted US GDP.

4 Calibration

In this section we used the parameter values from the data to calibrate a model that matched the gravity equation. This exercise allows us to compare the level of the Smoot-Hawley tariff with the optimal tariff, and also to calculate the effect of the elimination of all tariffs (both US and foreign). The comparison with free trade provides an estimate of the cost of the trade war on welfare of the US.

In our model, we used the Armington assumption that internationally traded products are differentiated by country of origin and national goods are imperfect substitutes. Good 1 is taken as a numeraire, p is the relative price of country 2's output, and y_i represents output of country i in terms of good i. Moreover, we assumed that each country imposes tariffs on imports. This means that price of good 2 in country 1 is $p(1+\tau_1)$.

Preferences are given by the constant elasticity of substitution function. The constant elasticity of substitution equations for home and foreign countries can be expressed in the following way:

$$u_1 = u(c_1^1, c_1^2) = ((\beta_1^{\frac{1}{\sigma}}) * (c_1^1)^{\frac{\sigma-1}{\sigma}} + (1-\beta_1^{\frac{1}{\sigma}}) * (c_1^2)^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}}$$

$$u_2 = u(c_2^2, c_2^1) = ((\beta_2^{\frac{1}{\sigma}}) * (c_2^2)^{\frac{\sigma-1}{\sigma}}) + (1-\beta_2^{\frac{1}{\sigma}}) * (c_2^1)^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}}$$

In the formulae above β_1 and β_2 are two budget shares, one for home country and one for foreign countries. These taste parameters can help us identify whether or not countries exhibit home bias in trade. For example, if products produced in two countries are the same, we would expect them to have same trade shares. However, international trade involves factors like trade costs, which among other things include tariffs, nontariff barriers, and transport costs that may affect consumer choices, leading to a tendency for domestic consumers to purchase domestic goods rather than imports (to a home bias toward home-produced goods). Moreover, home bias implied by the model can also be partly explained in terms of trade composition, i.e. the absence of non-traded goods, trade in intermediates can also bias our results. Aggregating all foreign countries can additionally bias the taste parameters as aggregation does not take into account differences in distance and transportation costs between the US and other countries. Later we could add transportation costs to our model to identify whether or not including transportation costs changes our results.

Since income will include the sum of output and total revenue. These assumptions implied the following demand functions: $c_1^1 = \frac{\beta_1(y_1+\tau_1 p c_2^1)}{\beta_1+(1-\beta_1)(p(1+\tau_1))^{1-\sigma}}$

$$c_2^1 = \frac{(1-\beta_1)(p(1+\tau_1))^{-\sigma}(y_1+\tau_1 p c_2^1)}{\beta_1+(1-\beta_1)(p(1+\tau_1))^{1-\sigma}}$$

$$c_1^2 = \frac{(1-\beta_2)(1+\tau_2)^{-\sigma}(p y_2+\tau_2 c_1^2)}{\beta_2(1+\tau_2)^{1-\sigma}+(1-\beta_2)p^{1-\sigma}}$$

$$c_2^2 = \frac{\beta_2 p^{-\sigma}(py_2 + \tau_2 c_1^2)}{(1-\beta_2)(1+\tau_2)^{1-\sigma} + \beta_2 p^{1-\sigma}}$$

where c_j^{i1} is consumption of good i in country j

the market clearing condition is:

$$c_2^1 p - c_1^2 = 0$$

This condition requires that the value of home country imports equal the value of its exports to the foreign country. Using the demand functions above, we can express the respective country import demands as

$$c_2^1 = \frac{\beta_1 y_1 (p(1+\tau_1))^{\sigma}}{\beta_1 (p(1+\tau_1))^{\sigma} + (1-\beta_1)p}$$

$$c_1^2 = \frac{\beta_2 p^{1+\sigma} y_2}{p(1+\tau_2)^{\sigma} + \beta_2 (p^{\sigma} - p(1+\tau_2)^{\sigma})}$$

Given the values of the taste parameters, income levels, and tariffs, the import demand functions can be substituted into the equilibrium condition to solve for world prices.

After finding all these formulae, we used the parameter values from the data to calibrate a model. By looking at Figure 2, we used 1924 as our base year. For that year the US tariff rate or τ_1 was equal to 14.89%; the weighted-average foreign tariff rate was 8.77%; the US GDP, or y_1, equaled $713,989; and the weighted-average foreign GDP was $1,288,733. In defining the foreign GDP we did not include all foreign countries in our model, as data for GDP or tariff rates was unavailable for some of the countries. Thus, at the end, we only included 13 foreign countries to our model. σ is the elasticity of substitution between the goods. When the two goods are differentiated by country of origin, as in our case, this elasticity is commonly referred to as the *Armington elasticity* (Ruhl). This elasticity is one of the critical parameters for determining the behavior of trade flows and international prices and thus was already estimated by different authors using different techniques. For example, estimates of the

Armington elasticity that were derived from cross sectional studies or the response of trade flows to changes in tariffs ranged from 4 to 13. Head and Ries (2001) found elasticities that ranged from 7.9 to 11.4 in a regression relating trade shares to both tariff and non-tariff barriers between Canada and the US. In a detailed study of the US trade that featured data on thousands of goods, Romalis (2002) estimated elasticity that ranged between 4 and 13. In a model of economic geography with explicit consideration of transportation costs, Hummels (2001) used data from Argentina, Brazil, Chile, New Zealand, Paraguay, and the United States to estimate the elasticity of substitution and, at the end, he got elasticity ranging from 3 to 8. In our model, we used a value of 5 - a mean of a range between 3 to 8 - for the elasticity of substitution. After having all of these values, we solved for the preference parameters β_1, β_2, and the price p by using the equations below:

$$\frac{p(\tau_1+1)c_2^1}{y_1+p(1+\tau_1)c_2^1} = US\ Import\ Share = \frac{US\ Imports}{US\ GDP} = 2.84$$

$$\frac{(\tau_2+1)c_1^2}{py_2+(1+\tau_2)c_1^2} = Foreign\ Import\ Share = \frac{\sum_1^{13} Foreign\ Imports}{\sum_1^{13} ForeignGDP} = 2.68$$

$$c_2^1 p - c_1^2 = 0$$

In this case $c_2^1\ and\ c_1^2$ were defined above. As a result we got that $\beta_1 = 0.965, \beta_2 = 0.05, p = 1.18$. Given these values, we looked for optimal tariff rate for the US, i.e. the value of the tariff rate that maximized the utility function, given the tariffs of the rest of the world. Figure 5 below shows that the utility is maximized at the value of when the tariff rate set by the US is equal to 26%, which is much higher than the tariff rate of 14.89% that was set in 1924. Thus, it can be concluded that tariffs set in 1924 did not maximize the US' utility.

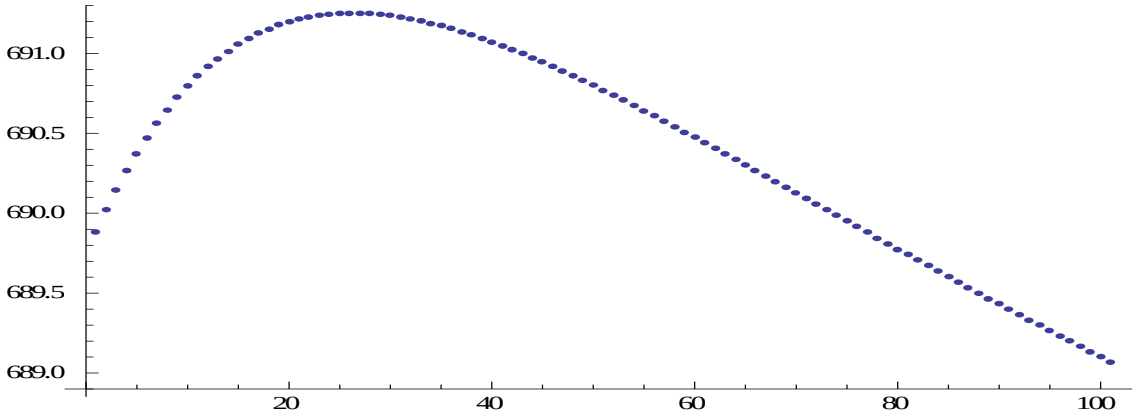

Figure 5

To determine the welfare effects of trade barriers, we also did the calibration exercise for free trade case, i.e. when the tariff rate was set to zero. As a result, we found that tariff elimination would have increased the US' utility by 0.24%, i.e. the welfare effect of tariff elimination would have been minimal. This minimal increase in welfare as a result of tariff liberalization may partially be due to the fact that the US government needs to find another way to finance government spending due to elimination of tariff revenue. For example, in the case when the tariff revenue is replaced by increase in income tax, consumption that increased due to decrease in price levels as a result of trade liberalization may increase by a smaller amount. All of this happens alongside an increase in income tax, explaining a small increase in welfare as a result of trade liberalization. Moreover, to identify how changes in import shares affect the US' utility, we did the calibration exercise again. This time we assumed that both the US and foreign import shares were 6% of the US GDP and foreign GDP, respectively. As a result, we came to the conclusion that the US' utility would have increased by 0.356% when import shares increased from 3% to 6%.

5 Conclusion

Our results indicate that foreign tariff rate has a negative effect on US exports whereas US tariff rate has a negative effect on US imports. Additionally, distance has a negative effect on trade

whereas variables like foreign GDP, sharing a common border, and signing of reciprocal trade agreements have a positive impact on trade as we expected. The fact that the prime commercial paper rate coefficients for exports and imports are both positive seems to suggest our gravity model is not capturing any financial effect that we hoped it would.

Our results are mainly consistent with the results that have been previously obtained in gravity equation models by other researchers. Our research mainly focuses on what caused the drop in Trade/GDP in 1929 and why, by the end of the 1930s, it still had not completely recovered to the 1929 value. As the drop in Trade/GDP was a function of decrease in both GDP and tariff levels, we would expect that if the tariff levels and GDP returned to their 1929 values by the end of the 1930s, Trade/GDP would also reach its previous value by the end of the decade. However, even if the tariff levels return to the original value, GDP recovers slowly. It can be observed in Figure 3 that tariff rates almost came back to the original value, but despite our prediction that GDP grows slowly, it did grow between 1929 and 1940. The only explanation for partial recovery instead of a full recovery would be the fact that the rest of the world was in a bad position. External factors like Germany's preparations for World War II may have been causing trade to fall. If this is the case, it would appear in our time dummy coefficients. Positive time dummies can be interpreted as trade being higher for that particular year. However, as can be seen in the appendices, we do not see any unusual coefficients.

Our calibration results emphasized that the tariff rate of 14.89% set by the US in 1924 did not maximize the utility. The utility was maximized when the tariff rate was equal to 26%. To determine the welfare effects of trade barriers, we did the calibration exercise for free trade case, i.e. when the tariff rate was set to zero. As a result, we found that the comparison of welfare in 1924 with free trade welfare provided an estimate cost of 0.24% decrease in welfare of the US as a result of the trade war. Moreover, to identify how changes in import shares affect the US' utility, we did the calibration

exercise again. As a result, we came to the conclusion that the US' utility would have increased by 0.356% when both the US and foreign import shares increased from 3% to 6%.

Appendix A:

realexports	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
realgdp	.8900439	.0378949	23.49	0.000	.8156549	.9644329
rtaadummy	.747147	.1797855	4.16	0.000	.394222	1.100072
dist	-.0000723	.0000184	-3.93	0.000	-.0001085	-.0000362
border	1.113922	.2215317	5.03	0.000	.6790481	1.548797
primecommer~r	.1197852	.049557	2.42	0.016	.0225031	.2170673
percentfree	.0140094	.001517	9.24	0.000	.0110315	.0169873
v19	.0944025	.2533662	0.37	0.710	-.4029638	.5917688
v20	.1146689	.2561674	0.45	0.655	-.3881963	.6175341
v21	.1153644	.2469502	0.47	0.641	-.3694071	.6001359
v22	.2033011	.2428375	0.84	0.403	-.2733971	.6799992
v23	.0989675	.2419813	0.41	0.683	-.3760501	.573985
v24	.1781851	.241064	0.74	0.460	-.2950316	.6514018
v25	.1379252	.2458053	0.56	0.575	-.3445989	.6204493
v26	.0295934	.2557075	0.12	0.908	-.472369	.5315557
v27	-.0269064	.2358597	-0.11	0.909	-.489907	.4360942
v28	-.3695466	.2446302	-1.51	0.131	-.8497638	.1106707
v29	-.8475656	.2456156	-3.45	0.001	-1.329717	-.3654139
v30	-.5662151	.2575261	-2.20	0.028	-1.071747	-.0606828
v31	-.2185503	.2736851	-0.80	0.425	-.7558033	.3187027
v32	-.1378283	.2806808	-0.49	0.624	-.6888141	.4131575
v33	-.3194519	.2690303	-1.19	0.235	-.8475675	.2086637
v34	-.120765	.2649507	-0.46	0.649	-.6408721	.3993421
v35	-.1628805	.2679315	-0.61	0.543	-.6888391	.3630781
v36	-.0032332	.281631	-0.01	0.991	-.5560844	.5496179
v37	0	(omitted)				
_cons	.2449809	.3785581	0.65	0.518	-.4981415	.9881033

Appendix B:

realimports	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
percentfree	.0137276	.0014743	9.31	0.000	.010832	.0166233
rtaadummy	.711929	.16454	4.33	0.000	.3887503	1.035108
realgdp	1.097163	.0375022	29.26	0.000	1.023504	1.170823
border	1.690262	.1707714	9.90	0.000	1.354844	2.02568
language	-.7968625	.0985055	-8.09	0.000	-.9903407	-.6033844
primecommer~r	.2182866	.0456868	4.78	0.000	.1285516	.3080217
foreigntari~s	1.952516	.3334713	5.86	0.000	1.297533	2.607498
v19	.5137691	.231073	2.22	0.027	.0599106	.9676277
v20	.633317	.2420946	2.62	0.009	.1578107	1.108823
v21	.6491414	.2290547	2.83	0.005	.1992471	1.099036
v22	.6227824	.2213433	2.81	0.005	.1880343	1.05753
v23	.4087532	.2199873	1.86	0.064	-.0233315	.8408379
v24	.2146698	.2213811	0.97	0.333	-.2201525	.6494921
v25	.098821	.2219622	0.45	0.656	-.3371425	.5347846
v26	-.1373193	.2346918	-0.59	0.559	-.5982856	.3236471
v27	-.006067	.2123353	-0.03	0.977	-.4231221	.410988
v28	-.1980365	.21649	-0.91	0.361	-.623252	.2271791
v29	-.7229703	.221764	-3.26	0.001	-1.158545	-.2873961
v30	-.2838724	.2307621	-1.23	0.219	-.7371203	.1693755
v31	-.0817758	.2447205	-0.33	0.738	-.5624397	.3988881
v32	.2220039	.2509783	0.88	0.377	-.2709512	.7149591
v33	.2400309	.2427936	0.99	0.323	-.2368485	.7169103
v34	.4699987	.2369149	1.98	0.048	.004666	.9353313
v35	-.0521039	.2456763	-0.21	0.832	-.5346453	.4304374
v36	.1815342	.2547993	0.71	0.476	-.3189258	.6819943
v37	0	(omitted)				
_cons	-2.75463	.3915533	-7.04	0.000	-3.523694	-1.985567

Appendix C:

realexports	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
foreigntari~s	-.9354626	.3001429	-3.12	0.002	-1.525046	-.3458791
realgdp	.7040238	.2007239	3.51	0.000	.3097334	1.098314
rtaadummy	.2100721	.0872181	2.41	0.016	.0387459	.3813983
primecommer~r	.099234	.0355511	2.79	0.005	.0293994	.1690685
ustariffs	-.0505248	.0149572	-3.38	0.001	-.0799059	-.0211437
v19	.1479505	.1105348	1.34	0.181	-.0691776	.3650786
v20	.215013	.1156922	1.86	0.064	-.0122461	.4422721
v21	.4432368	.1074124	4.13	0.000	.2322421	.6542315
v22	.3908164	.1037289	3.77	0.000	.1870573	.5945756
v23	.358474	.1007212	3.56	0.000	.1606232	.5563249
v24	.4538077	.1002887	4.53	0.000	.2568063	.6508091
v25	.4318748	.1072341	4.03	0.000	.2212304	.6425192
v26	.3415102	.1290056	2.65	0.008	.088099	.5949214
v27	.3170432	.0938463	3.38	0.001	.1326968	.5013895
v28	.0661397	.0986403	0.67	0.503	-.1276236	.259903
v29	-.1736396	.112574	-1.54	0.124	-.3947735	.0474942
v30	0	(omitted)				
v31	.2855987	.1047556	2.73	0.007	.0798228	.4913746
v32	.3230864	.1046813	3.09	0.002	.1174565	.5287163
v33	.2720394	.102084	2.66	0.008	.0715115	.4725673
v34	.4623554	.1010331	4.58	0.000	.2638917	.660819
v35	.3779944	.1059718	3.57	0.000	.1698295	.5861593
v36	.3146006	.1129525	2.79	0.006	.0927232	.536478
v37	0	(omitted)				
_cons	2.605135	1.613643	1.61	0.107	-.5646113	5.774882

--more--

Appendix D:

realimports	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ustariffs	-.0444054	.0123154	-3.61	0.000	-.0685827	-.0202281
rtaadummy	-.2281362	.0691474	-3.30	0.001	-.3638839	-.0923884
realgdp	.9087353	.1428996	6.36	0.000	.6281995	1.189271
primecommer~r	.0557572	.0262664	2.12	0.034	.0041919	.1073225
v19	.3993929	.0898115	4.45	0.000	.223078	.5757078
v20	.5358052	.0917324	5.84	0.000	.3557193	.7158912
v21	.5369824	.0857894	6.26	0.000	.3685636	.7054011
v22	.5266263	.0846444	6.22	0.000	.3604552	.6927975
v23	.573244	.0829476	6.91	0.000	.4104041	.736084
v24	.4962848	.081543	6.09	0.000	.3362025	.6563672
v25	.4204766	.0870641	4.83	0.000	.2495552	.5913979
v26	.4458436	.1005126	4.44	0.000	.2485207	.6431665
v27	.2877243	.0779438	3.69	0.000	.1347077	.440741
v28	.140881	.0830427	1.70	0.090	-.0221456	.3039076
v29	-.2209155	.09379	-2.36	0.019	-.4050408	-.0367901
v30	0	(omitted)				
v31	.0380592	.0874289	0.44	0.663	-.1335782	.2096967
v32	.2497928	.0872056	2.86	0.004	.0785937	.4209918
v33	.4428052	.0846206	5.23	0.000	.2766808	.6089295
v34	.6768973	.0835714	8.10	0.000	.5128328	.8409619
v35	.2053515	.0853704	2.41	0.016	.0377552	.3729477
v36	.3146547	.0916823	3.43	0.001	.134667	.4946423
v37	0	(omitted)				
_cons	.8845467	1.105516	0.80	0.424	-1.285765	3.054858
sigma_u	1.4728862					

Appendix E: Ratification of US Trade Agreements by the Legislators of the Foreign Countries Concerned, as of Jan 27, 1937:

Country	**Date Signed**	**In effect**
Belgium	Feb 27, 1935	May 1, 1935
Cuba	Aug 24, 1934	Sep 3, 1934
Canada	Nov 15, 1935	Jan 1, 1936
France	May 6, 1936	June 15, 1936
Netherlands	Dec 20, 1935	Feb 1, 1936
Switzerland	Jan 9, 1936	Feb 15, 1936
Brazil	Feb 2, 1935	Jan 1, 1936
Colombia	Sep 13, 1935	May 20, 1936
Costa Rica	Nov 28, 1936	not yet in force
Finland	May 18, 1936	Nov 2, 1936
Guatemala	Apr 24, 1936	Jun 15, 1936
Haiti	Mar 28, 1935	Jun 3, 1935
Honduras	Dec 18, 1935	Mar 2, 1936
Nicaragua	Mar 11, 1936	Oct 1, 1936
Sweden	May 25, 1935	Aug 5, 1935

Appendix F: Complete list of foreign countries included in calibration:

1. Argentina
2. Australia
3. Belgium
4. Brazil
5. Canada
6. France
7. Germany
8. India
9. Italy
10. Japan
11. Netherlands
12. Spain
13. United Kingdom

Appendix G: The constant elasticity of substitution utility function is defined as:

$$u = u(c_1, c_2) = (\alpha_1 {c_1}^{\rho} + \alpha_2 {c_2}^{\rho})^{\frac{1}{\rho}}$$

where c_i is country i's consumption for i=1,2. To maximize the utility, we solved the first-order condition: $\frac{1}{\rho}(\alpha_1 {c_1}^{\rho} + \alpha_2 {c_2}^{\rho})^{1/\rho - 1} \alpha_i {c_i}^{\rho-1} \rho = \lambda p_i \; for \; i = 1,2$. By adding the budget constraint: $\sum_{i=1}^{2} p_i c_i = y + T$ to the first-order condition, we were able to solve for the demand functions:

$$c_1 = (\frac{\beta_1}{\beta_2}) \frac{{p_1}^{-\sigma}(y+T)}{{p_1}^{1-\sigma}(\frac{\beta_1}{\beta_2}) + {p_2}^{1-\sigma}}$$

$$c_2 = \frac{{p_2}^{-\sigma}(y+T)}{{p_1}^{1-\sigma}(\frac{\beta_1}{\beta_2}) + {p_2}^{1-\sigma}}$$

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