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Abstract

This paper investigates the macroeconomic impact of commercial policy during the Great Depression. Results based on Bernanke's (1983) regression methodology show that tariffs are at least as important as unanticipated money, bank failures, or business failures in contributing to the volatility of interwar output. We develop a multi–sector dynamic equilibrium trade model to explore the impact of a tariff war on aggregate international economic activity. Simulation results using our theoretical model indicate that the global escalation of the tariff war precipitated a collapse in world trade, and significant declines in international output and investment. The simulations suggest that roughly ten percent of interwar cyclical volatility in the U.S. and its major trading partners can plausibly be attributed to commercial policy, which is consistent with our empirical findings.

Two generations after the passage of the infamous Hawley–Smoot tariffs, substantial disagreement remains as to the role of commercial policy in the international propagation of the Great Depression. While trade theorists view the period as a classic example of the destructive power of beggar–thy–neighbor policies, macroeconomists express a wide range of opinion on the quantitative role of trade policy during this period. Dornbusch and Fischer (1986) view its direct effect as small and possibly even stimulative, while Meltzer (1976) argues that it can explain virtually the entire deterioration of the downturn into the Great Depression. The predominant scholarly view, however, is that while the tariff was undoubtedly bad policy (especially given the retaliation that took place), its impact on the U.S. economy was probably small relative to monetary and non–monetary financial factors.

The goal of this paper is to apply a structural model of tariffs to the interwar period in order to evaluate their contribution to the world depression. In so doing, it challenges the conventional view and argues—both on theoretical and empirical grounds—that the tariff had at least as large an impact on the U.S. economy as other quantifiable factors. It should be emphasized that we do not claim that tariffs by themselves can account for the severity of the Great Depression, only that they are a significant contributor along with the other factors.

Although the model and associated empirical work is of interest independent of the particular historical episode under consideration, it is important to put this study in the context of existing research on the Hawley–Smoot tariffs. Most of the literature on Hawley–Smoot has concerned itself with questions of political economy, most prominently in the work by Frank Taussig (1931) and more recently by Eichengreen (1989): Why was such a bill passed at such a crucial time? Who benefited (ex ante) and who lost? The political economy of our model is that domestic producers of inputs to production and the tradable consumption good, who compete with foreign producers of substitute goods, are the primary beneficiaries. Tariffs may be imposed even when other sectors — and the economy as a whole — are hurt, provided the benefits are sufficiently concentrated and the costs sufficiently spread out. This is a fairly common story: More recently in the U.S. we observe protection of domestic producers of sugar and steel, for example, despite the adverse effects on the many industries that use these commodities as inputs. While the origins of interwar tariffs are by now fairly well understood, their economic impact is not, and this is the question on which we focus.

Section I of the paper reviews interwar tariff history from a macroeconomic perspective. Aggregate tariff indexes, combined with information on legislative amendments, paint a picture of escalating tariff levels from the end of World War I to the middle of the 1930's. To assess the relationship between U.S. tariffs and output we add a U.S. tariff index to Bernanke's (1983) output regressions. The tariff variable enters with the anticipated sign and without substantially affecting the coefficients on money disturbances or business and bank failures. The tariff is also found to be economically significant, adding substantially to the fraction of the output decline from 1929 to 1933 that is predicted by the reduced form relationship. The empirical results motivate a closer look at the role of the tariff war in the international depression.

In Section II we highlight the strength and structure of trading relationships between Canada, the U.S., Europe and developing countries. Availability of time series data for the empirical work forces the theoretical analysis into a two–country dynamic general equilibrium model — the U.S. being one country, and an aggregate of Canada, Germany, Italy, and the U.K. being the other. Multiple sectors are included to incorporate the importance of international trade in intermediate goods and to maintain realistic trade shares. The model allows us to study the steady–state and dynamic effects of unilateral and retaliatory tariffs in a world in which countries, such as the U.S., are sufficiently large to alter their terms of trade.

Next, the model is calibrated and used to gauge the quantitative impact of tariffs on aggregate variables. Section III examines the impact of permanent increases in tariff levels. The predicted impact on exports and imports are sensitive to the tariff index used, with declines ranging from 9 to 24 percent. The impact on output and investment depends on both the magnitude of the tariff increase and the elasticity of labor supply. The largest declines are predicted for the more variable tariff index and the Hansen–Rogerson specification of labor–leisure choice with output and investment declining by 4 and 6 percent, respectively.

Tariff levels are quite cyclical during the interwar period so in Section IV the model is used to generate time series predictions for macroeconomic aggregates given the time series path of international tariff levels. The quantitative effects of temporary tariff changes are comparable in magnitude to the steady state results when we compare movements from peak to trough. The principal advantage of the dynamic simulation of time series is that we can compare the theory and data on a cyclical basis. The simulated path of domestic and foreign aggregates correlate very well with the data during the interwar period. Variation in the simulated aggregates is typically about five percent of the observed variation from 1920 to 1940, with a somewhat higher fraction of cyclical variation explained for U.S. exports, U.S. imports, foreign output and foreign investment, and a somewhat lower fraction explained in the cases of U.S. output and investment. Section V summarizes the macroeconomic lessons to be drawn from the commercial policies of the interwar period.

I. The Historical Context

The relationship between tariffs and aggregate activity has been difficult to establish empirically using data after World War II. [1] In part this may be due to the fact that conventional tariff barriers have changed only gradually over time and have been partially replaced with non–tariff barriers which are more difficult to measure. The interwar period is attractive because it avoids these two shortcomings. At least for the United States, tariffs were the predominant tool of commercial policy and customs duties were an important source of government revenue. In this section we look at the height and volatility of tariff rates and then consider the relationship between tariffs and aggregate activity by including a tariff index in Bernanke's (1983) output regressions.

[1] See for example: Ostry and Rose (1989).

A. *A Brief Tariff History*

Congress and the Senate increased customs duties three times during the interwar period as detailed in the following tariff Acts: the Emergency Act of 1921, the Fordney–McCumber Act of 1922, and the Hawley–Smoot Act of 1930. However, variation in ad valorem equivalent rates was not isolated to legislative changes. Many U.S. tariffs were specific duties — nominal levies per physical quantity imported. Under this system of tariffs, price declines increase the tariff as a percentage of the price of the import. Given the volatility of the price level during the interwar period, it is not surprising that much of the variation in tariff levels arose from this source. In particular, tariff levels increased sharply during the deflation of the Great Depression and fell as price levels recovered toward the beginning of World War II.

Of course the macroeconomic impact of a domestic tariff change depends crucially on the response of foreign governments. The extent of foreign retaliation has been the subject of debate since at least the work of Jones (1934). To get at this issue we use tariff indexes computed as the ratio of customs duties to total imports. Table 1 reports average tariff levels in the twenties and thirties for seven European countries, Canada, and the United States.

Table 1 shows that tariff levels are much higher in the thirties than in the twenties. For France, Germany, Italy, the Netherlands, and the United Kingdom, tariff levels triple or quadruple. Canada, Sweden, and the United States appear to have increased tariff levels modestly relative to these other countries. However, Crucini (1994) shows that indexes such as these dramatically understate the level and volatility of U.S. tariff levels during the interwar period. A measure that does somewhat better is the ratio of customs duties collected to dutiable imports. Unfortunately we only have this tariff index for the United States. Figure 1 presents times series of tariff indexes for Canada, France, Germany, Italy, the United Kingdom, and the United States. The countries were chosen on the basis of the available data needed later in our simulation exercises.

The tariff indices using total imports show that foreign tariff levels generally surpassed U.S. levels by 1932, and they continued to climb in the mid to late thirties while U.S. levels declined sharply. In contrast, the tariff index using dutiable imports for the U.S. (marked US2 in Figure 1) indicates that U.S. tariff levels rose sharply as deflation increased real tariff rates during the thirties, and remained above foreign levels throughout the entire period. Depending on the measure used, foreign tariff levels may have been higher or lower than U.S. tariff levels during the Great Depression.

The right–hand panel of Figure 1 presents tariff wedges in log deviations from their sample means for the two different U.S. tariff measures and an aggregate of foreign tariff indexes. The foreign tariff measure is an import share weighted average of individual country tariff wedges. The import shares used in aggregation are the share of U.S. imports from each of the respective countries normalized to total 100. The basic story that emerges from this figure is that tariff levels in major industrial countries were rising rapidly during the late 1920's and early 1930's before quickly subsiding in the U.S. — but they remained high in Europe.

Before leaving the tariff question, we investigate the possibility that foreign tariff rates were also affected by price variation. Table 1 reports the correlation between prices and ad valorem equivalent tariffs indexes for Canada, Germany, Italy, Sweden, the U.S. and the U.K., in log–levels and growth rates. All countries but the U.K. exhibit a strong negative relationship between tariffs and prices.[2] These correlations suggest that a substantial amount of variation in ad valorem equivalent tariff rates is due to imperfect indexation of legislative duties in foreign countries as well as in the U.S.

B. Bernanke Regressions

There were a number of severe shocks to the U.S. economy between 1928 and 1935: In addition to Hawley–Smoot and foreign retaliation, there were crop failures

[2] Ad valorem duties seem to be more common than specific duties in the United Kingdom compared to the United States, which could account for the lack of correlation between the price level and tariff rate.

in the mid–west, a rapid deflation, and the collapse of a substantial part of the banking system. Of course these were not independent events. Meltzer (1976) has argued that the deflation was in part due to the tariff's interference with the specie flow mechanism, while Crucini (1994) establishes the opposite direction of causation; from deflation to increases in real tariff rates that were denominated in nominal terms.

Bernanke (1983) argued that while the bank failures were at least partly the result of other disturbances, they contributed independently as well. To assess the impact of commercial policy during the Great Depression, we follow Bernanke in attempting to control for alternative explanations. Briefly, the procedure involves prior regression of money growth on four lags of the growth of industrial production, wholesale prices and money itself. The residuals from this regression are used to proxy for unanticipated changes in the money stock in a second stage regression of the following form:

$$\phi(L)\Delta y_t = \alpha_0 + \gamma(L)\Delta\tilde{z}_t + \theta(L)\Delta D_t + \xi(L)\Delta B_t + \delta(L)\Delta\tau_t + \epsilon_t$$

Lower case variables refer to logarithms of variables and upper case variables to levels of variables. The $\tilde{z}$ variable is either unanticipated money or prices constructed from the first stage regression. The deposit liabilities of failed banks are denoted by D and the liabilities of failed businesses by B. The variable τ is the U.S. tariff rate computed as the ratio of customs revenue to dutiable imports.

The first column of Table 2 reports the original Bernanke regression with unanticipated money, bank failures, and business failures as explanatory variables.[3] The addition of the bank and business failures was intended to disentangle the effects of monetary policy from the effects of disintermediation. The regression lends support to the view that unanticipated changes in money contributed to the Great Depression. The fact that bank failures enter the regression equation significantly without

[3] The estimated coefficients do not match Bernanke's exactly because we have not detrended industrial production growth prior to estimation and our sample period differs somewhat. However, the differences are trivial in magnitude.

adversely affecting the other coefficients suggests that the banking crisis added to the monetary crisis.

The second specification adds current and lagged changes in the ad valorem equivalent U.S. tariff to the first specification.[4] The magnitude and significance of the money and financial variables decline marginally, but none becomes insignificant or changes sign. The coefficient on the contemporaneous tariff change is negative and significant, while the lagged value is positive but not statistically significant.

The third and fourth specifications replace unanticipated changes in money with unanticipated changes in the price level. The negative correlation of tariff changes and aggregate price level changes induced by the use of nominal duties was expected to generate serious collinearity problems in the second specification. The collinearity is reduced to some extent by the use of *unanticipated* changes in prices and *actual* changes in the tariff rate. However, the inclusion of the tariff variable results in statistically insignificant coefficients for unanticipated changes in the price level. The correlation of unanticipated changes in the price level with the tariff level must be responsible for this result. In theory, both anticipated and unanticipated tariffs will reduce output consistent with the finding that the tariff variable remains significant while the price variable becomes insignificant.[5]

Of course the regression results by themselves cannot indicate the quantitative importance of the different explanatory variables. To get at this issue we take the estimated equations including the tariff variable and do a set of dynamic simulations, setting each variable equal to zero in turn, and simulating the path of the growth rate of output in each case. The three explanatory factors are the nominal shock variable, the tariff variable, and the combined bank and business failure variables.

[4] Since our tariff index is only available annually and the other data is monthly we interpolated the tariff series to a monthly frequency. We incorporated the influence of the price level on real tariff levels by using monthly variation in the price level to interpolate the original tariff series between annual observations.

[5] We also estimated versions with expected and unexpected changes in tariffs. The coefficients on both variables were negative and statistically significant, but the coefficient on unexpected tariff changes was the larger of the two.

In addition, for each case the simulations were done with and without including the estimated residual in the simulation. Each equation is used to generate seven simulated series: Three zeroing out each of the three factors in turn, one zeroing out the residual only, and three zeroing out each of the three factors in turn, but including the estimated residual.

Table 3 lists the mean, standard deviation, and percentage change from 1929 to 1933 for each simulation, and for actual industrial production. The simulations cover the period from February 1922 to December 1941. The results show that zeroing out the tariff variable has the biggest positive effect on the mean growth rate, and the biggest negative effect on the standard deviation of the growth rate. This suggests that the tariff variable had a greater adverse impact on the economy (as measured by first and second moments) than each of the other factors, although the unexplained part of the variation is still the most important component of all.

Industrial production fell by about 75 percent from end of 1929 to the beginning of 1933. The dynamic simulation indicates that leaving the tariff variable out of the equation greatly reduces the fraction of the slump explained by the reduced form. Table 3 shows that when the residual is omitted industrial production is predicted to fall by 57.3 percent using the money shock equation and about 38.7 percent using the price shock equation. Omitting the tariff variable from the equation reduces the predicted declines to 14.2 and 3.8 percent, respectively. Based on these results the tariff variable is quantitatively more important than money shocks or bank and business failures in explaining the downturn into the Great Depression.

As a final diagnostic, we present a variance decomposition in which we compare the contribution of the tariff variable with the combined contribution of the money, banking, and business failure variables (denoted by T and MB respectively in the table). The variance decompositions are reported in Table 4. The incremental change in the variation of industrial production attributed to the tariff variable is between 5 and 9 percent, depending on the ordering of variables. Combined with the results reported in Table 3, the impact of commercial policy appears to be concentrated during the 1930's as would be expected based on the tariff history reviewed in the previous subsection.

To summarize, we have added commercial policy to the list of factors contributing to the Great Depression. Using Bernanke's regression framework we found that increases in U.S. tariff levels reduced U.S. industrial production. The addition of this variable to output regressions leaves the influence of unanticipated money and financial variables unaffected while reducing the significance of unanticipated changes in prices. Simulations suggest that the actual contribution of the tariff to the volatility of interwar industrial production appears to be at least as great as that of other quantifiable factors. We use these results to justify and to motivate the remainder of the paper, which develops a realistic dynamic general equilibrium model of the impact of tariffs on economic activity. Our contention is that equilibrium trade theory can contribute to our understanding of the world–wide depression, without diminishing the role of the monetary and non–monetary financial theories advanced by Friedman and Schwartz (1963) and Bernanke (1983).

II. Theory and Measurement

The theoretical model merges two strands of the literature that are essential for studying the impact of commercial policy during the interwar period. The first is international real business cycle research which focuses on choice over time and expectation formation.[6] The second is Computational General Equilibrium research which emphasizes sectoral detail, such as studies of the economic impact of multilateral tariff reductions.

Including choice over time is important for two reasons. First, we are interested in examining the dynamic impact of tariff changes on capital accumulation and labor supply. Comparing our results to those coming from static CGE exercises suggests that ignoring these channels leads to a serious underestimate of the impact of tariff changes on aggregate economic activity.[7] Second, ad valorem equivalent

[6] See for examples: Backus, Kehoe, and Kydland (1992), Baxter and Crucini (1993), Crucini (1991), Reynolds (1992), and Stockman and Tesar (1991).

[7] Static Computational General Equilibrium models that consider the aggregative effect of GATT

tariff rates change continuously over this period of history so that model simulations of aggregates such as exports, investment, and output may be compared to the sample paths of their real world counterparts.

The sectoral detail is also important for two reasons. First, the study by Leontief (1939) indicates that between two–thirds and three–quarters of U.S. imports were intermediate inputs. Second, each country must produce a large amount of non–traded goods if trade shares are to match historical averages. Each country must have at least three sectors to match these observations: a sector producing the non–traded consumption good, a sector producing the export good, and a sector producing an intermediate input.

Providing a quantitative estimate of the impact of the tariff war requires that we construct and parameterize a complete model of two interacting economies. This involves not only deciding on particular functional forms but also on the numerical values of parameters of these functional forms. We have not found empirical measures of all the relevant parameters needed to completely specify the computational model economy, so we maintain country symmetry unless available data indicate otherwise.

A. *Interwar Trading Patterns*

Before moving on to build the model in detail, this subsection discusses the trading patterns that existed between Canada, France, Germany, Italy, Japan, the United Kingdom, the United States, and developing countries.

The first panel of Table 5 presents the distribution of exports in 1925. The U.K. (Canada excluded) was the largest market for U.S. exports by a factor of about three. Italy had a near equal share of its exports destined for the U.K., U.S., France, and Germany. Japan was heavily dependent on the U.S. market while the U.S. and U.K. were both key markets for Canadian products. Between twenty and

tariff reductions on U.S. GDP typically find the impact to be less than one–tenth of one percent. For examples see: Baldwin et al. (1980), Cline et al. (1978), Deardorff and Stern (1979), and Whalley and Wiggle (1982). Our model predicts permanent reductions in U.S. output of at least one percent.

fifty percent of import flows are captured within this group of countries.

The lower panel of Table 5 presents a breakdown of imports in 1925. Approximately one–third of U.S. imports came from the six other major industrialized countries. The largest (excluding Canada) were the U.K. and Japan at about nine percent each; the remaining three countries accounted for less than five percent of U.S. imports. The U.S. was the largest source of imports for the six other countries ranging from about sixty–five percent of total Canadian imports, to a low of about fourteen percent for French imports. The shares of imports of other industrial countries match there relative economic size with the largest countries supplying a disproportionate share of imports to each market. One exception is Japan which is a major source of imports for only the United States. Overall one–third to one–half of total imports is accounted for within the block of countries considered.

Table 6 disaggregates imports and exports by level of processing for both industrialized and developing countries during the mid 1920's. The U.S. exported about fifty percent more manufactured goods than it imported, while live animals, food and drink, and raw materials tended to be about equally distributed across exports and imports. In France and Germany the trade patterns were distinct: imports were concentrated in food and drink, and raw materials, while exports were dominated by manufactures. In the less developed countries the direction of trade was the reverse of that in France and Germany, and even more distinct.

Trade between industrialized and developing countries involved principally the exchange of raw materials for manufactured goods. As we do not have time series of tariff rates or economic aggregates for these countries, we focus on the trading patterns between Canada, Italy, the U.K., and the U.S. For trade between these countries, patterns in terms of the level of processing were less clear–cut. Thus the model will allow countries to simultaneously import and export both final goods and intermediate inputs.

B. *The Model*

The basic model that we work with reflects the level of detail of the available trade and production data. It is a dynamic general equilibrium model with two countries that produce three different goods. The goods that are produced in each country include: (i) a non–traded consumption–investment good, (ii) a traded consumption good, and (iii) materials. We treat the traded goods as imperfect substitutes in consumption and production. This subsection describes the details of the dynamic trade model.

There are two related motivations for the structure of our model: First, we have seen that roughly half of U.S. exports and imports are raw materials and parts. The model captures this feature of the data. Second, the significant presence of material inputs provides a mechanism by which tariffs give rise to production inefficiencies, which in turn allows tariffs to have a potentially larger adverse impact on the economies. In general, production inefficiencies can also result from tariffs on final goods to the extent the location of production changes. This source of inefficiency is not present in the model, however, because of the complete specialization assumption, which was made for tractability. Thus the model may, by assuming complete specialization, actually underestimate the adverse impact of tariffs.

Consumers in each country choose leisure L_t, consumption of a home non–tradable C_{1t}, consumption of the home export C_{2t}, and consumption of the foreign export C_{3t}, to maximize:

$$E(U) = E\sum_{t=0}^{\infty} \beta^t U(C_{1t}, C_{2t}, C_{3t}, L_t) \tag{1}$$

$$U(C_1, C_2, C_3, L) = \begin{cases} \frac{\left(C^\eta L^{1-\eta}\right)^{1-\sigma_c}}{1-\sigma_c} \\ \text{or} \\ logC + \kappa L \end{cases}$$

in the case of the home country, and

$$E(U) = E\sum_{t=0}^{\infty} \beta^t U(C_{1t}^*, C_{2t}^*, C_{3t}^*, L_t^*) \tag{2}$$

$$U(C_1^*, C_2^*, C_3^*, L^*) = \begin{cases} \frac{\left(C^{*\eta} L^{*1-\eta}\right)^{1-\sigma_c}}{1-\sigma_c} \\ \text{or} \\ logC^* + \kappa L^* \end{cases}$$

in the case of the foreign country. Where the variable C is a composite variable representing CES aggregation of individual consumption components:

$$C = \left[b_1 C_1{}^{-\gamma} + b_2 C_2{}^{-\gamma} + b_3 C_3{}^{-\gamma}\right]^{\frac{-1}{\gamma}}$$

The CES function for consumption goods captures the idea that domestic and foreign goods are imperfect substitutes. The weights b_1, b_2, and b_3 influence how consumption expenditure is divided between non–traded goods, the domestic export, and the imported consumption good. The second specification follows Rogerson (1988), who considers environments in which non–convexities in the labor–leisure choice at the individual level result in "representative agent" preferences that are linear in leisure. We expect that this specification will increase the response of labor to changes in tariffs for the same reasons that it raises hours variation in the real business cycle models (see for example Hansen (1985)).

We assume a single representative agent (in each country) allocates market time across the three domestic sectors of the economy and leisure subject to the constraint that these activities exhaust total hours available (which we normalize to unity).

$$1 - L_t - N_{1t} - N_{2t} - N_{4t} \geq 0 \tag{3}$$

The foreign country faces an analogous constraint:

$$1 - L_t^* - N_{1t}^* - N_{3t}^* - N_{4t}^* \geq 0 \tag{4}$$

Implicit in these constraints is the fact that labor is completely mobile across sectors within the period, yet immobile across countries.

The functional forms that describe our production sectors are given by equations (5) and (6). Domestic output in each sector is produced with capital, labor, and a fixed proportion of material inputs. The parameter α is pinned down by the share of value added accounted for by compensation to labor. Letting Y_{it} denote gross output in sector i, and for the moment ignoring the material input requirement, we have

$$\begin{aligned} Y_{it} &= F_i(K_{it}, N_{it}), \quad i = 1, 2, 4. \\ &= K_{it}{}^{\alpha} N_{it}{}^{1-\alpha} \end{aligned} \tag{5}$$

while the foreign country produces the goods according to:

$$\begin{aligned} Y_{it}^* &= F_i^*(K_{it}^*, N_{it}^*), \quad i = 1, 3, 4. \\ &= K_{it}^{*\,\alpha} N_{it}^{*\,1-\alpha} \end{aligned} \tag{6}$$

Note that production occurs in sectors 1, 2, and 4 in the home country, and sectors 1, 3, and 4 of the foreign country. The output of sector 4 is a raw material that is combined with the raw material output from the other country to produce a composite material input denoted M_t.

The fixed material input requirement for the production of good i is $\theta_i Y_{it}$. The home composite intermediate good is given by:

$$\begin{aligned} M_t &= G(m_{hht}, m_{fht}) \\ &= \left[\psi m_{hht}{}^{-\sigma} + (1-\psi) m_{fht}{}^{-\sigma} \right]^{-\frac{1}{\sigma}} \\ &= \theta_1 Y_{1t} + \theta_2 Y_{2t} + \theta_4 Y_{4t} \end{aligned} \tag{7}$$

while the foreign composite is:

$$\begin{aligned} M_t^* &= G(m_{fft}, m_{hft}) \\ &= \left[\psi^* m_{fft}{}^{-\sigma} + (1-\psi^*) m_{hft}{}^{-\sigma} \right]^{-\frac{1}{\sigma}} \\ &= \theta_1 Y_{1t}^* + \theta_3 Y_{3t}^* + \theta_4 Y_{4t}^* \end{aligned} \tag{8}$$

The notation m_{fh}, for example, refers to the amount of foreign materials used to produce the domestic composite input. The parameters ψ and ψ^* influence the fraction of domestic materials that are used in production. Note that unless

$\psi = \psi^* = 0.5$ there will be an asymmetry in the production technologies of the two countries. For example, if ψ and $\psi^* > 0.5$, production makes more intensive use (at equal prices) of the domestic raw material. This is a plausible asymmetry, since even with low (but non zero) transportation costs there will be a natural correlation between a country's particular material input requirements and its production of those raw materials.

Finally, the parameters θ_i, $i = 1, \ldots, 4$ influence the ratio of input use to total value added. We will use information from Leontief's (1939) classic study of the input–output structure of the United States to guide our selection of this parameter. The values of ψ, ψ^*, and the preference parameters b_i, $i = 1, 2, 3$ will be set to keep import shares at their average value during the historical time period.

Capital is a non–traded good, and hence is produced in sector 1 of each country. Despite being immobile across countries, it is assumed to be perfectly mobile across sectors within a country. For the home country, capital obeys the standard accumulation equation:

$$\begin{aligned} K_{t+1} &= (1-\delta)K_t + I_t \\ &= K_{1t+1} + K_{2t+1} + K_{4t+1} \end{aligned} \tag{9}$$

and

$$\begin{aligned} K^*_{t+1} &= (1-\delta)K^*_t + I^*_t \\ &= K^*_{1t+1} + K^*_{3t+1} + K^*_{4t+1} \end{aligned} \tag{10}$$

for the foreign country.

We assume that markets are complete to simplify the solution to this model. As a result, market clearing conditions are imposed by individual sector rather than by individual budget constraint. The resource constraints are:

$$Y_{1t} = C_{1t} + I_t$$

$$Y^*_{1t} = C^*_{1t} + I^*_t$$

$$Y_{2t} = C_{2t} + C^*_{2t}$$

$$Y_{3t}^* = C_{3t} + C_{3t}^*$$

$$Y_{4t} = m_{hht} + m_{hft}$$

$$Y_{4t}^* = m_{fft} + m_{fht} \tag{11}$$

Table 7 presents the details of the baseline calibration. Recall that we have maintained symmetry of the U.S. and foreign country with respect to parameters of taste, technology, and resources. The consumption and investment rates are 0.8 and 0.2, respectively. Trade is assumed to be balanced in the steady–state. Export and import shares are set at about 7 percent; approximately the U.S. average over this period of time. Given our decision to model a two country world for purposes of empirical and theoretical tractability we also decided to calibrate trade from the U.S. point of view rather than a conceptually more problematic rest–of–the–world aggregate. Assessing the impact of the tariff war on individual countries other than the U.S. would require a substantially more complicated model and additional empirical work. We leave this to future research.

The remaining parameters of taste and technology are largely determined by trade ratios. For example, the parameter b_1 is the weight on the non–traded good in utility. Quite a large value of this parameter is needed to generate realistic trade shares. We set $b_1 = 0.98$. The parameter α is capital's share of gross domestic product and is set at 0.3; thus labor gets the remaining seventy percent of output. We set θ equal to 0.20, a conservative estimate of the economic importance of materials. Finally, we set ψ and ψ^*, equal to 0.8 which means that each country primarily uses domestically produced material inputs in domestic production.

III. Steady State Effects of Permanent Tariff Increases

Computational General Equilibrium models have often been used to evaluate the equilibrium effects of unilateral and multilateral tariff reductions under GATT. In these exercises, the world supply of factors is fixed as in the H–O–S model. In this section we present steady state results that incorporate the impact that tariff distortions have on the accumulation of world capital and the steady–state level of aggregate effort. Generally, we find that the dynamic distortion gives a much larger steady state impact than would be anticipated based on previous CGE results.[8]

We examine tariff wars with tariff levels rising from 10 percent to either 30 percent or 60 percent. Recall that most tariff indexes using the ratio of customs revenue to total imports moved from about 10 percent in the twenties, to about 30 percent in the thirties. The first case (Case I) is intended to match these observations. However, the ratio of customs revenue to total imports understates the tariff level, if some imports enter duty free or if tariff levels become prohibitive. For example, the U.S. tariff rate computed using total imports moves from about 5 percent in 1920 to about 20 percent in 1932, while the tariff rate computed using dutiable imports goes from about 15 percent to about 60 percent (see Figure 1). In fact Crucini (1994) constructs a thirty–two commodity tariff index — covering about thirty percent of dutiable imports in 1929 — that shows U.S. tariffs rising from 15 percent in 1920 to 120 percent in 1932. We retain a broader index because of our macroeconomic focus and to maintain comparability with the available foreign tariff indexes. The second case (Case II) is intended to match these observations. We are more cautious about the second case from the point of view of the foreign country. We lack information on the volume of duty free goods entering European countries and the extent to which duties were prohibitive. To account for these uncertainties we consider Case I a lower bound on the potential effects of tariffs, and Case II as an upper bound for any given parameterization of the model.

We conduct sensitivity analysis along two additional dimensions. The first involves the elasticity of the labor supply. We place the upper limit on this dimension using the Hansen–Rogerson linearity assumption. The second involves the elasticity of substitution across consumption goods. Our baseline choice of the parameter $\gamma = 0$ is consistent with a large number of empirical studies that report elasticities of substitution between domestic and foreign goods of about unity.[9] However, we

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[8] Some recent work has looked at the effects of post–war tariffs on capital accumulation while keeping aggregate labor supply fixed. For example, see Eichengreen and Goulder (1989).

[9] See the evidence documented in Whalley (1985).

also consider less substitution, setting γ equal to unity and more substitution by setting γ equal to -1/3.

As is evident in Table 8, all macroeconomic aggregates except tariff revenue decline in response to a global tariff war. Beginning with the baseline case in the first panel, and the tariff increase from 10 percent to 30 percent in the second column, we see that the largest decline occurs in exports at 9.7 percent followed by declines of 2.8, 1.7, 1.4, and 1.1 percent for investment, output, consumption, and effort. The assumption that output is produced with a constant returns to scale Cobb–Douglas production function in capital and effort is responsible for the result that the change in output lies between the changes in investment and effort. This and other rankings (e.g., output more volatile than consumption but less volatile than investment) of magnitudes of effects across aggregates remain the same in each of the results discussed below.

The second column of Table 8 shows the results when the tariff in increased further to 60 percent in both countries. A useful metric to compare the relationship between the magnitude of tariff changes and the quantitative effect of the changes on macroeconomic variables is the percentage change in the tariff wedge. The first experiment had the wedge rising from 1.10 to 1.30 or by 18 percent, while the second experiment has the wedge rising from 1.10 to 1.60, or by 45 percent. Thus the second experiment increases distortions, as measured by the tariff wedge, by a factor of 2.5 compared to the first experiment. The quantitative results reported in the last column of Table 8 are approximately 2.5 times larger than those in the middle column which report the impact from the lesser tariff increase. Exports now collapse, falling by 21.7 percent while investment, output, consumption and effort fall by 6.6, 4, 3.4 and 2.5 percent respectively.

Alternative parameterizations of preferences over the consumption goods is considered in the lower two panels of the table. Less substitutability across consumption goods increases the quantitative effects while more substitution moderates the effects. The results are surprisingly insensitive to ranges of the substitution parameter that encompass most empirical estimates.

The effects of tariff changes and taste parameters on tariff revenue is also interesting. Reducing the substitutability of consumption goods raises tariff revenue from 0.7 to about 1.2 percent of income. Tripling the tariff rate from 10 percent to 30 percent approximately doubles tariff revenue while increasing the tariff rate six–fold from 10 percent to 60 percent increases tariff revenue by about 150 percent. While the tariff levels remain below prohibitive levels — even with tariff rates of 60 percent — the revenue raising capability of the tariff is seriously eroded.

Table 9 reports results for the same experiments as Table 8, but with utility that is both separable between consumption and leisure and linear in leisure. Based on results in the real business cycle literature we would expect more elastic responses of macroeconomic variables with this specification of utility since it implies an infinite aggregate labor supply elasticity. The results in Table 9 confirm our intuition. The quantitative impact of the tariff war is greater for all variables except tariff revenue. The increased impact is not too great for exports with declines now ranging from 9.3 percent to 24.1 percent compared to 9 percent and 22.4 percent previously. The reason exports are not materially affected is that we have already permitted perfect factor mobility across sectors within countries.

The impact of the increased labor supply elasticity is most readily apparent in the effort responses with reductions ranging from 1.4 percent to 6.3 percent compared to only 1.1 percent to 4.7 percent previously. Given our neoclassical production function the effects are also larger for investment and output. Investment declines are in the range of 3.1 to 10.4 percent, compared to 2.7 to 8.7 percent previously. The investment effects are less sensitive to changes in the labor supply elasticity than labor itself so that change in labor are now much closer to the changes in output and investment. Table 9 repeats the sensitivity analysis with respect to the magnitude of the tariff increase and the substitutability across consumption goods with results qualitatively similar to those reported in Table 8.

The declines in output are easily ten times larger than one would expect based on CGE studies of GATT tariff reductions. In most CGE exercises the aggregate supply of factors is fixed as in the H–O–S model. The dynamic trade model, by incorporating the fact that permanent tariff increases reduce investment by between 2.7 and 10.4 percent and reduce the labor supply by between 1 and 6.3 percent, predicts that commercial policy has economically significant aggregate effects.

The steady state results are promising. The aggregative effects are sufficiently large to be economically interesting — even in the context of the Great Depression — yet not so large as to be implausible. However, the steady state comparisons are counterfactual in the sense that tariff levels did not remain at their new higher levels forever. Another way to investigate the dynamics of commercial policy is to use the tariff indexes directly as inputs into the reduced form of the structural model.

IV. Cyclical Effects of Tariffs and Retaliation

In this section the model's structural equations are used to generate time series predictions conditional on the path of domestic and foreign tariff indexes. Again we use three different indexes for this purpose. The first two are the ratios of total customs duties collected to total imports for the U.S. and a weighted average of foreign levels (using the same weights as before). The third index uses the ratio of total customs duties to dutiable imports for the United States. Simulations that refer to the low U.S. tariff use the two comparable tariff indices while simulations referring to the high U.S. tariff use the alternative U.S. tariff index. We also report the simulations for the two different parameterizations of utility.

The data for foreign investment and output are country–size weighted averages of the individual country data. The size measures used in the weighting are total GNP and are taken from Bairoch's (1976) study of Europe's GNP evaluated in U.S. dollars. The total size of the foreign aggregate is normalized to 100 in 1929.[10] The export data are total U.S. merchandise exports while the import data are total U.S. merchandise imports.

[10] Specifically, we use the values of GNP in U.S. dollars from Table 10, pg. 295. for Italy, Germany and the United Kingdom. For lack of a better available choice we assume that Canada is the same economic size as Italy in 1929.

Based on the variance decompositions of Section II we expect that tariffs would be able to explain on the order of 10 percent of the variation in interwar aggregates. For this reason, the results of the two simulations — one for each U.S. tariff series and the single foreign tariff series — are presented alongside actual time series scaled by a factor of 0.10. Simulations are produced for exports, investment and output expressed as log–level deviations from a deterministic trend. The data is also log–linearly detrended, but without imposition of common trends across series or countries. The table below each figure reports the correlation between the three simulated time series and actual data, for both log–linearly detrended data and the growth rate of log–linear detrended data. The table also reports the ratio of the variance of the simulated series to the variance of the actual series under both detrending methods. The simulations begin in 1920 and continue through 1940. Each figure contains two graphs. The left–hand panel reports results for the U.S. while the right–hand panel presents results for the foreign aggregate.

The simulated path of U.S. exports will basically mirror the path of the foreign tariff levels as higher foreign tariffs reduce the export of consumption goods and raw materials from the U.S. to the rest of the world. Figure 2 shows that the model is able to track the path of U.S. exports and imports remarkably well during the interwar period. The model predicts a slight slump in U.S. exports following World War I, which the model attributes to the modest increases in foreign duties in 1921 and 1922. A rapid collapse of U.S. exports occurs as protectionism accelerates during the early 1930's. The correlation of the predicted path of U.S. exports and actual U.S. exports is about 0.4 in log–levels and about 0.6 in terms of growth rates. Exports do not recover as quickly as observed because the foreign tariff levels remain high throughout the thirties, depressing U.S. exports at approximately their 1931 levels.

The choice of U.S. tariff index is not important for the predicted path of U.S. exports because it is the foreign tariff variable that drives U.S. exports. The results are also insensitive to the labor supply elasticity in large part because labor was assumed to be mobile across sectors independently of the preference specification.

As we will see below, the linearity in leisure simply acts as a multiplier on the aggregative effects of tariffs as captured by the movements in aggregate output and investment.

The model tracks the decline in U.S. imports quite well during the Depression both in terms of the timing of the trough and the length of the contraction and expansion phases. Import levels recover to their trend paths in the data and in the simulations, toward the end of the sample. The correlation of the predicted and actual series is about the same, regardless of which tariff index is used. In terms of log–deviations from trend growth the correlations are about 0.7, compared to correlations above 0.8 for growth rates.

The quantitative performance of the model is evaluated on the basis of variance ratios. The model captures about 10 percent of the variation in log–linear detrended exports and about 4 percent of the variation in the growth of detrended exports (see the tables accompanying figure 2). In contrast to exports, the quantitative predictions for imports are sensitive to the tariff index used. When we use the less volatile tariff index, computed as the ratio of customs duties to total imports, the model captures about 5 percent of the variation in U.S. imports regardless of the detrending method. Using the more volatile tariff index gives better results; the variation in simulated imports is now about 10 to 13 percent of the variance in actual imports.

The effect on output and investment of an increase in the tariff rates on intermediate inputs is best understood using an analogy to oil price shocks. Increases in the relative price of an imported intermediate good, such as oil, tends to reduce both output and investment. During periods in which the domestic tariff is rising, investment is falling because the costs of production in the domestic economy are rising. Figure 3 presents the time series paths for U.S. and foreign investment.

Actual U.S. investment swings dramatically, upward during the twenties, and downward during the thirties. The model predicts most of the variation in U.S. investment occurs in the thirties when U.S. tariff levels rise sharply and then fall sharply. The correlation of the predicted and actual series is in the neighborhood of 0.5, lower than what was found for either exports or imports.

The choice of tariff index and labor supply elasticity are both important for the behavior of U.S. investment. The less variable tariff index and Cobb–Douglas utility generate investment variance that is between 2 to 4 percent of actual investment variance. Switching to the more variable U.S. tariff index approximately doubles the variability of investment, as does the assumption of linearity in leisure, at least in terms of growth rates. Variance ratios are as high as 8.5 percent with these two assumptions combined.

The actual and predicted path of foreign investment appear to follow slightly different trends in Figure 3. The correlation of actual and predicted log–levels is in the range of 0.3 to 0.4. In terms of growth rates, the correlations are similar to what we found for U.S. investment ranging from 0.4 to 0.5. The twenties are most problematic for the model, when actual investment is growing while it is predicted to be falling relative to trend. Partly this could be due to capital reconstruction in the United Kingdom and Italy, about which the model has nothing to say. From the late twenties onward the model follows the investment cycle very closely.

The choice of tariff index has a second order effect on foreign investment but the results remain sensitive to the labor supply elasticity. The model is able to capture more of the cycle in foreign investment than it did for U.S. investment across all four parameterizations. The ratio of predicted to actual variance is now on the order of 5 to 15 percent, compared to a range of 2 to 8.5 percent for U.S. investment. As is apparent in Figure 3 there are two reasons that the model does better in terms of capturing the variation in foreign investment. First, the actual declines in investment during the Great Depression were much larger in the U.S. than abroad. Second, the model predicts that foreign investment would fall by more and typically for a longer period because of the long swing in foreign tariff levels.

Figure 4 presents the simulation results for output. The model predicts a cycle in U.S. output that is very prolonged by business cycle standards, suggesting that the tariff war contributed to both the depth and duration of the cycle. The correlation between the actual and predicted series is ranges from 0.3 to 0.4. The assumption of linearity in leisure using the more volatile tariff index gives the largest impact of tariffs on aggregate U.S. output. In that case, the model is able to account for 7 percent of the variation in log–linear detrended U.S. output and about 6 percent of the variance in terms of growth rates. These variance ratios are in the range found for the variance decompositions of U.S. industrial production where the variance of industrial production growth attributable to the U.S. tariff was found to be in the range of 4.7 to 8.9 percent. The close correspondence between these two sets of quantitative results is reassuring given that one set comes from a highly structured and abstract trade model while the other set comes from reduced form estimates.

The model's predictions for foreign output enjoy the same successes and suffer the same failures as did the U.S. predictions up until the middle of the 1930's. From about 1934 onward predicted foreign output remains low due to the sustained levels of foreign tariffs while actual foreign output recovers very quickly towards trend. The simulations are not terribly sensitive to which U.S. tariff is used since this has only an indirect effect on foreign investment and consumption — the foreign tariff level is the key. The cases with more elastic labor supply magnify the quantitative effects as was true for the U.S. case. The correlation between log–linearly detrended simulated and actual foreign output is somewhat lower in the case of the foreign country due to model's inability to account for the rapid recovery of foreign output in the middle to late thirties. However, the correlation of actual and simulated output growth is similar to — and often cases higher than — that found for the U.S., ranging from 0.5 to 0.6. In terms of variance ratios, the model captures about the same magnitude of variation as it did for U.S. output in terms of growth rates — 2 to 4 percent.

V. Conclusions

This paper has explored the macroeconomic effects of commercial policy in the context of the Great Depression. In the first part of the analysis we re–estimated Bernanke's (1983) U.S. output equations with the U.S. tariff added as an explanatory variable. The original regression attempted to capture the influence of the banking crisis independently of the monetary hypothesis of Friedman and Schwartz (1963). The addition of the tariff variable was intended to add a potentially important real disturbance with a natural international interpretation. Not only was the tariff variable statistically significant, it also explained as much or more of the output decline as unanticipated money or bank failures. Another promising feature of the estimation results was that the tariff variable barely diminished the roles of these other factors. Thus we view these three explanations as complimentary rather than competing.

Next, we developed a dynamic equilibrium three–sector trade model to investigate the quantitative effect of tariffs and retaliation on macroeconomic variables. The primary innovation in the modeling strategy was to combine sufficient sectoral detail to capture static production inefficiencies with dynamic effects of taxation on long run capital accumulation and labor supply. The results indicated that the aggregative impacts of permanent tariff increases by a factor of at least ten compared to static CGE exercises. The dynamic structure of the model also allowed us to study the important cyclical effects of tariff variation during the interwar period. The modeling strategy should also prove useful in exploring the transitional and long run effects of more recent commercial policy changes such as the NAFTA.

The simulations demonstrated that the theoretical model was able to account for the qualitative behavior of macroeconomic aggregates during the interwar period. Correlations between the data and simulated variables typically fell in the range — 0.3 to 0.6. Further, these conclusions are not restricted to trade variables despite the fact that the only disturbances introduced were international tariffs. The quantitative predictions of the model, while somewhat sensitive to the choice of tariff index and parameters, corresponded well to the order of magnitude of impacts suggested by the empirical variance decomposition.

The results consistently indicated that the tariff war was severe enough to qualify as an important international disturbance, even in the context of the Great Depression. Based on these findings we feel that it is inconceivable that Smoot–

Hawley and foreign retaliation had negligible or possibly positive effects on the U.S. economy. On the contrary, the interwar period remains the most prominent historical example of the devastating effects of retaliatory commercial policy among large developed economies.

Appendix A — The Model Solution

This appendix describes the details of the solution to our model. We begin with definitions and notation followed by the set–up of the Lagrangian and first–order necessary conditions. The first–order conditions, not subscripted by time, form the system of non–linear equations that are solved in Gauss for experiments involving permanent changes in tariff levels.

The time series simulation results are generated using a linear approximation to this steady–state. The linearization procedure produces a numerical reduced form model which is simulated by passing tariff innovations through the equilibrium model. These linear approximation techniques are currently widely used in studying dynamic behavior of models that do not yield closed form solutions. For examples see Kydland and Prescott [1982], King, Plosser, and Rebelo [1987]). These programs were written in Matlab (386).

A. *Lagrangian and First–Order Necessary Conditions.*

The Lagrangian for our problem is:

$$\begin{aligned}
&\sum_{t=0}^{\infty}\beta^t\Big\{\omega U(C_{1t},C_{2t},C_{3t},L_t)+(1-\omega)U(C_{1t}^*,C_{2t}^*,C_{3t}^*,L_t^*)\\
&+w_t[1-L_t-N_{1t}-N_{2t}-N_{4t}]\\
&+w_t^*[1-L_t^*-N_{1t}^*-N_{3t}^*-N_{4t}^*]\\
&+p_{mt}[G(m_{hht},m_{fht})-\theta_1Y_{1t}-\theta_2Y_{2t}-\theta_4Y_{4t}]\\
&+p_{mt}^*[G(m_{fft},m_{hft})-\theta_1Y_{1t}^*-\theta_3Y_{3t}^*-\theta_4Y_{4t}^*]\\
&+p_{1t}[Y_{1t}-C_{1t}-I_t]\\
&+p_{1t}^*[Y_{1t}^*-C_{1t}^*-I_t^*]\\
&+p_{2t}[Y_{2t}-C_{2t}-(1+\tau_{2t}^*)C_{2t}^*+T_{2t}^*]\\
&+p_{3t}^*[Y_{3t}^*-(1+\tau_{3t})C_{3t}-C_{3t}^*+T_{3t}]\\
&+p_{4t}[Y_{4t}-m_{hht}-(1+\tau_{4t}^*)m_{hft}+T_{4t}^*]\\
&+p_{4t}^*[Y_{4t}^*-m_{fft}-(1+\tau_{4t})m_{fht}+T_{4t}]\\
&+\xi_t[K_t-K_{1t}-K_{2t}-K_{4t}]\\
&+\xi_t^*[K_t^*-K_{1t}^*-K_{3t}^*-K_{4t}^*]\\
&+\lambda_t[-K_{t+1}+(1-\delta)K_t+I_t]\\
&+\lambda_t^*[-K_{t+1}^*+(1-\delta)K_t^*-I_t^*]\Big\} \qquad (A1)
\end{aligned}$$

The first–order necessary conditions for our problem are:

$$D_1U(t) = p_{1t} \quad (c_{1t})$$
$$D_2U(t) = p_{2t} \quad (c_{2t})$$
$$D_3U(t) = (1+\tau_{3t})p^*_{3t} \quad (c_{3t})$$
$$D_4U(t) = w_t \quad (L_t)$$
$$(p_{1t} - \theta_1 p_{mt})D_2F_1(t) = w_t \quad (N_{1t})$$
$$(p_{2t} - \theta_2 p_{mt})D_2F_2(t) = w_t \quad (N_{2t})$$
$$(p_{4t} - \theta_4 p_{mt})D_2F_4(t) = w_t \quad (N_{4t})$$
$$(p_{1t} - \theta_1 p_{mt})D_1F_1(t) = \xi_t \quad (K_{1t})$$
$$(p_{2t} - \theta_2 p_{mt})D_1F_2(t) = \xi_t \quad (K_{2t})$$
$$(p_{4t} - \theta_4 p_{mt})D_1F_4(t) = \xi_t \quad (K_{4t})$$
$$p_{mt}D_1G(t) = p_{4t} \quad (m_{hht})$$
$$p_{mt}D_2G(t) = (1+\tau_{4t})p^*_{4t} \quad (m_{fht})$$
$$\lambda_t = p_{1t} \quad (I_t)$$
$$1 - L_t - N_{1t} - N_{2t} - N_{4t} = 0 \quad (w_t)$$
$$G(m_{hht}, m_{fht}) - \theta_1 Y_{1t} - \theta_2 Y_{2t} - \theta_4 Y_{4t} = 0 \quad (p_{mt})$$
$$Y_{1t} - C_{1t} - I_t = 0 \quad (p_{1t})$$
$$Y_{2t} - C_{2t} - C^*_{2t} = 0 \quad (p_{2t})$$
$$Y_{4t} - m_{hht} - m_{hft} = 0 \quad (p_{4t})$$
$$K_t - K_{1t} - K_{2t} - K_{4t} = 0 \quad (\xi_t)$$
$$\beta\xi_{t+1} - \lambda_t + (1-\delta)\beta\lambda_{t+1} = 0 \quad (K_{t+1})$$
$$-K_{t+1} + (1-\delta)K_t + I_t = 0 \quad (\lambda_t)$$

First–order conditions of the foreign country are omitted for brevity.

B. *Linearization of the Model.*

Linearization of the first–order conditions for the domestic country.

$$b_1(\frac{c_1}{C})^{-\gamma}\hat{c}_{1t} + b_2(\frac{c_2}{C})^{-\gamma}\hat{c}_{2t} + b_3(\frac{c_3}{C})^{-\gamma}\hat{c}_{3t} = \hat{C}_t \quad (C_t)$$
$$\psi(\frac{m_{hh}}{M})^{-\sigma}\hat{m}_{hht} + (1-\psi)(\frac{m_{fh}}{M})^{-\sigma}\hat{m}_{fht} = \hat{M}_t \quad (M_t)$$
$$[(1-\sigma_c)\eta + \gamma)]\hat{C}_t - (1+\gamma)\hat{c}_{1t} + (1-\sigma_c)(1-\eta)\hat{L}_t = \hat{p}_{1t} \quad (c_{1t})$$
$$[(1-\sigma_c)\eta + \gamma)]\hat{C}_t - (1+\gamma)\hat{c}_{2t} + (1-\sigma_c)(1-\eta)\hat{L}_t = \hat{p}_{2t} \quad (c_{2t})$$
$$[(1-\sigma_c)\eta + \gamma)]\hat{C}_t - (1+\gamma)\hat{c}_{3t} + (1-\sigma_c)(1-\eta)\hat{L}_t = \hat{p}^*_{3t} + \hat{\Omega}_{3t} \quad (c_{3t})$$
$$(1-\sigma_c)\eta\hat{C}_t + [(1-\sigma_c)(1-\eta) - 1]\hat{L}_t = \hat{w}_t \quad (L_t)$$
$$\hat{p}_{1t} - \theta_1\frac{p_m}{p_1}\hat{p}_{mt} + \alpha_1(1-\theta_1\frac{p_m}{p_1})\hat{K}_{1t} - \alpha_1(1-\theta_1\frac{p_m}{p_1})\hat{N}_{1t} = (1-\theta_1\frac{p_m}{p_1})\hat{w}_t \quad (N_{1t})$$

$$\hat{p}_{2t} - \theta_2 \frac{p_m}{p_2} \hat{p}_{mt} + \alpha_2 (1 - \theta_2 \frac{p_m}{p_2}) \hat{K}_{2t} - \alpha_2 (1 - \theta_2 \frac{p_m}{p_2}) \hat{N}_{2t} = (1 - \theta_2 \frac{p_m}{p_2}) \hat{w}_t \quad (N_{2t})$$

$$\hat{p}_{4t} - \theta_4 \frac{p_m}{p_4} \hat{p}_{mt} + \alpha_4 (1 - \theta_4 \frac{p_m}{p_4}) \hat{K}_{4t} - \alpha_4 (1 - \theta_4 \frac{p_m}{p_4}) \hat{N}_{4t} = (1 - \theta_4 \frac{p_m}{p_4}) \hat{w}_t \quad (N_{4t})$$

$$\hat{p}_{1t} - \theta_1 \frac{p_m}{p_1} \hat{p}_{mt} - (1 - \alpha_1)(1 - \theta_1 \frac{p_m}{p_1}) \hat{K}_{1t} + (1 - \alpha_1)(1 - \theta_1 \frac{p_m}{p_1}) \hat{N}_{1t} = (1 - \theta_1 \frac{p_m}{p_1}) \hat{\xi}_t \quad (K_{1t})$$

$$\hat{p}_{2t} - \theta_2 \frac{p_m}{p_2} \hat{p}_{mt} - (1 - \alpha_2)(1 - \theta_2 \frac{p_m}{p_2}) \hat{K}_{2t} + (1 - \alpha_2)(1 - \theta_2 \frac{p_m}{p_2}) \hat{N}_{2t} = (1 - \theta_2 \frac{p_m}{p_2}) \hat{\xi}_t \quad (K_{2t})$$

$$\hat{p}_{4t} - \theta_4 \frac{p_m}{p_4} \hat{p}_{mt} - (1 - \alpha_4)(1 - \theta_4 \frac{p_m}{p_4}) \hat{K}_{4t} + (1 - \alpha_4)(1 - \theta_4 \frac{p_m}{p_4}) \hat{N}_{4t} = (1 - \theta_4 \frac{p_m}{p_4}) \hat{\xi}_t \quad (K_{4t})$$

$$\hat{p}_{mt} + (1 + \sigma) \hat{M}_t - (1 + \sigma) \hat{m}_{hht} = \hat{p}_{4t} \quad (m_{hht})$$

$$\hat{p}_{mt} + (1 + \sigma) \hat{M}_t - (1 + \sigma) \hat{m}_{fht} = \hat{p}^*_{4t} + \hat{\Omega}_{4t} \quad (m_{fht})$$

$$\hat{\lambda}_t = \hat{p}_{1t} \quad (I_t)$$

$$-L\hat{L}_t - N_1 \hat{N}_{1t} - N_2 \hat{N}_{2t} - N_4 \hat{N}_{4t} = 0 \quad (w_t)$$

$$\hat{M}_t - \frac{\theta_1 y_1}{M} \hat{y}_{1t} - \frac{\theta_2 y_2}{M} \hat{y}_{2t} - \frac{\theta_4 y_4}{M} \hat{y}_{4t} = 0 \quad (p_{mt})$$

$$\hat{y}_{1t} - (\frac{c_1}{y_1}) \hat{c}_{1t} - (\frac{I}{y_1}) \hat{I}_t = 0 \quad (p_{1t})$$

$$\hat{y}_{2t} - (\frac{c_2}{y_2}) \hat{c}_{2t} - (\frac{c^*_2}{y_2}) \hat{c}^*_{2t} = 0 \quad (p_{2t})$$

$$\hat{y}_{4t} - \frac{m_{hh}}{y_4} \hat{m}_{hht} - \frac{m_{hf}}{y_4} \hat{m}_{hft} = 0 \quad (p_{4t})$$

$$\hat{K}_t - \frac{K_1}{K} \hat{K}_{1t} - \frac{K_2}{K} \hat{K}_{2t} - \frac{K_4}{K} \hat{K}_{4t} = 0 \quad (\xi_t)$$

$$\alpha_1 \hat{K}_{1t} + (1 - \alpha_1) \hat{N}_{1t} = \hat{y}_{1t} \quad (y_{1t})$$

$$\alpha_2 \hat{K}_{2t} + (1 - \alpha_2) \hat{N}_{2t} = \hat{y}_{2t} \quad (y_{2t})$$

$$\alpha_4 \hat{K}_{4t} + (1 - \alpha_4) \hat{N}_{4t} = \hat{y}_{4t} \quad (y_{4t})$$

$$(1 - \beta + \delta\beta) \hat{\xi}_{t+1} + (1 - \delta) \beta \hat{\lambda}_{t+1} - \hat{\lambda}_t = 0 \quad (K_{t+1})$$

$$-\hat{K}_{t+1} + (1 - \delta) \hat{K}_t + \delta \hat{I}_t = 0 \quad (\lambda_t)$$

Appendix B — Data Sources.

The macroeconomic aggregates: Output (Y), prices (P), investment (I), net exports (NX), government spending (G), consumption (C), money supply (M) for Canada, Italy, the United Kingdom, and the United States were generously provided by David Backus. They are described in detail in *Backus et al.* (1992).

Data used to replicate and augment Bernanke's (1983) regressions: industrial production, wholesale prices, liabilities of failed banks, liabilities of failed businesses, currency plus demand deposits were generously provided by Ben Bernanke.

The tariff indices for Germany, Italy, Sweden, and the United Kingdom were computed as the ratio of customs revenue to total imports. These series were taken from European Historical Statistics 1750–1970.

The tariff indices for Canada are from Canada Year Book, selected years.

The tariff indices for the US and imports by country of origin are from The Statistical History of the United States: from Colonial Times to the Present. For more detail on U.S. interwar tariff history see: Crucini (1994).

Trade tables 3 and 4 are constructed from League of Nations sources.

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Table 1 — International Tariff Levels

	Sample Averages		Correlation with GNP Deflator	
	Percent Ad Valorem			
Country	1920–1929	1930–1940	Log–levels	Growth rates
Belgium	2.9	7.5	NA	NA
Canada	13.4	15.2	-0.76	-0.72
France	7.1	21.0	NA	NA
Germany	7.2	26.1	0.30	-0.57
Italy	4.5	16.8	-0.15	-0.39
Netherlands	2.0	6.5	NA	NA
Sweden	8.6	9.5	-0.58	-0.36
United Kingdom	9.8	23.2	0.62	-0.22
United States	13.7	16.6	-0.76	-0.72

Note: The tariff levels are computed as the ratio of customs revenue to total imports and expressed as a percentage. Correlations are computed from annual data from 1900 to 1940.

Table 2 — Regression Results

	Money specifications (1)	(2)	Price specifications (3)	(4)
Δy_{t-1}	0.619	0.629	0.616	0.623
	(9.89)	(9.90)	(9.76)	(9.59)
Δy_{t-2}	-0.158	-0.196	-0.130	-0.171
	(-2.61)	(-3.21)	(-2.12)	(-2.67)
$\Delta \tilde{z}_t$	0.349	0.256	0.461	0.200
	(2.99)	(2.20)	(4.05)	(1.22)
$\Delta \tilde{z}_{t-1}$	0.103	0.054	0.261	0.237
	(0.874)	(0.460)	(2.22)	(1.64)
$\Delta \tilde{z}_{t-2}$	0.104	0.046	0.006	0.005
	(0.879)	(0.387)	(0.054)	(-0.041)
$\Delta \tilde{z}_{t-3}$	0.177	0.112	0.060	0.081
	(1.52)	(0.976)	(0.529)	(0.703)
ΔD_t	-0.0861	-0.0790	-0.0803	-0.0799
	(-4.22)	(-3.97)	(-4.09)	(-4.11)
ΔD_{t-1}	-0.0402	-0.0321	-0.0342	-0.0325
	(-1.92)	(-1.57)	(-1.70)	(-1.63)
ΔL_t	-0.264	-0.202	-0.207	-0.183
	(-2.02)	(-1.58)	(-1.59)	(-1.42)
ΔL_{t-1}	-0.328	-0.266	-0.227	-0.218
	(-2.52)	(-2.09)	(-1.73)	(-1.68)
$\Delta \tau_t$		-4.42	—	-3.94
	—	(-3.67)	—	(-2.18)
$\Delta \tau_{t-1}$	—	0.999	—	1.27
	—	(0.860)	—	(0.754)
R^2	0.42	0.46	0.44	0.46
D.W.	2.00	2.00	1.97	1.97

Note: The sample period for the regression is March 1921 to December 1941. The money specifications refer to regressions with money disturbances the right–hand–side, while the price specifications refer to regressions with price disturbances on the right–hand–side.

Table 3 —Contribution of Regressors to: Output Growth, Output Variability and the Great Contraction

Series	Mean	Standard Deviation	Peak to Trough Movements Percent change 1929–1933	Fraction Explained
			Money shock equation - no residual	
Fitted IP	0.38	1.65	-57.3	77
Excluding Tariffs	0.44	1.06	-14.2	19
Exlcuding Failures	0.37	1.20	-44.5	59
Exlcluding Money	0.38	1.44	-40.2	54
			Price shock equation - no residual	
Fitted IP	0.38	1.65	-38.7	52
Excluding Tariffs	0.42	1.16	- 3.8	5
Exlcuding Failures	0.37	1.17	-25.5	34
Exlcluding Prices	0.35	1.27	-32.7	44
			Money shock equation - residual left in	
Actual IP	0.38	3.31	-74.7	100
Excluding Tariffs	0.43	3.05	-29.8	40
Exlcuding Failures	0.36	3.08	-61.3	82
Exlcluding Money	0.38	3.2	-58.8	79
			Price shock equation - residual left in	
Actual IP	0.38	3.3	-74.7	100
Excluding Tariffs	0.42	3.08	-39.3	52
Exlcuding Failures	0.36	3.09	-61.9	83
Exlcluding Prices	0.35	3.1	-68.9	92

Note: Entries in the first two columns are in terms of monthly percentage changes. The third column reports the cummulative percentage change from 1929 to 1933. The last column is the third column divided by the actual percentage change in industrial production, expressed as a percentage. Each panel gives simulation results from the regressions reported in Table 2. Each row in the Table gives statistics with all regressor effects left in except the variable noted in the first column.

Table 4—Variance Decomposition

Ordering	Y,T,MB	Y,MB,T
Variable		
T	8.94%	4.69%
MB	7.56%	11.80%

Note: The entries give the incremental contribution of tariffs (T) or banking and business failures (MB) to the variance of industrial production growth after controlling for the influence of the other variables. The ordering of variables in the regression is given at the top of each column.

Table 5 — Direction of Trade

	Total	France	Germany	Italy	Japan	United Kingdom	United States
Exporting country	Panel A: Percentage of Exports (1925)						
Canada	81.7	1.1	2.3	1.0	2.6	38.6	36.1
France	40.3	—	13.4	0.4	0.1	19.7	6.7
Germany	26.8	3.0	—	4.2	2.0	10.7	6.9
Italy	42.7	11.1	11.1	—	NA	10.2	10.3
Japan	49.7	2.6	0.5	0.4	—	2.6	43.6
United Kingdom	20.9	4.0	5.7	2.4	2.1	—	6.7
United States	45.1	5.7	9.6	4.2	4.6	21.0	—
Importing country	Panel B: Percentage of Imports (1925)						
Canada	88.2	2.3	1.1	0.3	1.0	17.7	65.8
France	38.0	—	5.4	3.9	0.8	13.4	14.5
Germany	38.1	8.6	—	4.0	0.2	7.6	17.7
Italy	50.2	7.6	8.6	—	NA	10.4	23.6
Japan	40.9	1.3	4.8	0.1	—	8.8	25.9
United Kingdom	29.6	5.2	3.6	1.5	0.6	—	18.7
United States	29.2	4.1	3.9	2.4	9.1	9.7	—

Source: League of Nations.

Table 6 — Specialization: Percentage of Exports and Imports by Commodity Classes

Country		Live Animals	Food and Drink	Raw Materials and Parts	Manu- factures	Gold Silver
France	Imports	1.5	22.6	54.3	20.9	0.7
	Exports	0.4	9.0	20.8	69.4	0.4
Germany	Imports	1.3	28.2	48.9	14.4	7.2
	Exports	0.2	6.2	21.7	71.3	0.6
United States	Imports	0.2	24.0	49.5	21.5	9.8
	Exports	0.1	19.8	45.1	31.3	3.7
Developing Countries	Imports	1.0	21.7	12.5	63.5	1.3
	Exports	0.2	32.9	56.8	4.2	5.5

Source: Leaugue of Nations.

Table 7 — Baseline Calibration

	Home	Foreign
Panel A: Steady–state shares of output		
Consumption	0.80	0.80
Investment	0.20	0.20
Exports	0.07	0.07
Imports	0.07	0.07
Tariff revenue	0.007	0.007
Panel B: Taste parameters		
$\bar{N}$	0.27	0.27
σ_c	2.0	2.0
θ_c	0.30	0.30
θ_L	0.70	0.70
γ	0	0
b_1	0.98	0.98
b_2	0.01	0.01
b_3	0.01	0.01
$r = \frac{1}{\beta}$	0.05	0.05
Panel C: Technological parameters		
ψ	0.8	0.8
σ	0.6	0.6
α_1	0.3	0.3
α_2	0.3	NA
α_3	NA	0.3
α_4	0.3	0.3
θ_1	0.2	0.2
θ_2	0.2	NA
θ_3	NA	0.2
θ_4	0.2	0.2
δ	0.10	0.10

Table 8 — Steady State Simulation with Symmetric Retaliation
Cobb–Douglas Utility in Consumption and Leisure

	Steady–state level	Case I	Case II
	Baseline parameterization ($\gamma = 0$)		
Exports	7	-9.7	-21.7
Investment	20	-2.8	-6.6
Output	100	-1.7	-4.0
Consumption	80	-1.4	-3.4
Effort	0.27	-1.1	-2.5
Tariff revenue	0.7	+100	+157
	Less substitution in consumption ($\gamma = 1$)		
Exports	12	-9.9	-22.4
Investment	20	-3.7	-8.7
Output	100	-2.7	-6.3
Consumption	80	-2.1	-5.0
Effort	0.27	-2.0	-4.7
Tariff revenue	1.2	+98.6	+154
	More substitution in consumption ($\gamma = -1/3$)		
Exports	6	-8.9	-19.9
Investment	20	-2.7	-6.4
Output	100	-1.6	-3.8
Consumption	80	-1.3	-3.2
Effort	0.27	-1.0	-2.3
Tariff revenue	0.6	+101	+159

Note: Baseline refers to the parameterization described in Table 7. Steady–state levels are normalized such that output equals 100. Case I is tariff rise from 10 % to 30% both at home and abroad and Case II is tariff rise from 10 % to 60% both at home and abroad. Results are identical across countries due to the symmetry of the model and the assumption of symmetric retaliation.

Table 9 — Steady State Simulation with Symmetric Retaliation
Utility Separable Between Consumption and Leisure and Linear in Leisure

	Steady–state level	Case I	Case II
	Baseline parameterization ($\gamma = 0$)		
Exports	7	-10.2	-22.7
Investment	20	-3.2	-7.5
Output	100	-2.1	-5.0
Consumption	80	-1.8	-4.3
Effort	0.27	-1.5	-3.4
Tariff revenue	0.7	+100	+156
	Less substitution in consumption ($\gamma = 1$)		
Exports	12	-10.6	-24.1
Investment	20	-4.5	-10.4
Output	100	-3.4	-7.9
Consumption	80	-2.9	-6.7
Effort	0.27	-2.8	-6.3
Tariff revenue	1.2	+98.0	+152
	More substitution in consumption ($\gamma = -1/3$)		
Exports	6	-9.3	-20.7
Investment	20	-3.1	-7.2
Output	100	-2.0	-4.7
Consumption	80	-1.7	-4.1
Effort	0.27	-1.4	-3.2
Tariff revenue	0.6	+100	+158

Note: Baseline refers to the parameterization described in Table 7. Steady–state levels are normalized such that output equals 100. Case I is tariff rise from 10 % to 30% both at home and abroad and Case II is tariff rise from 10 % to 60% both at home and abroad. Results are identical across countries due to the symmetry of the model and the assumption of symmetric retaliation.

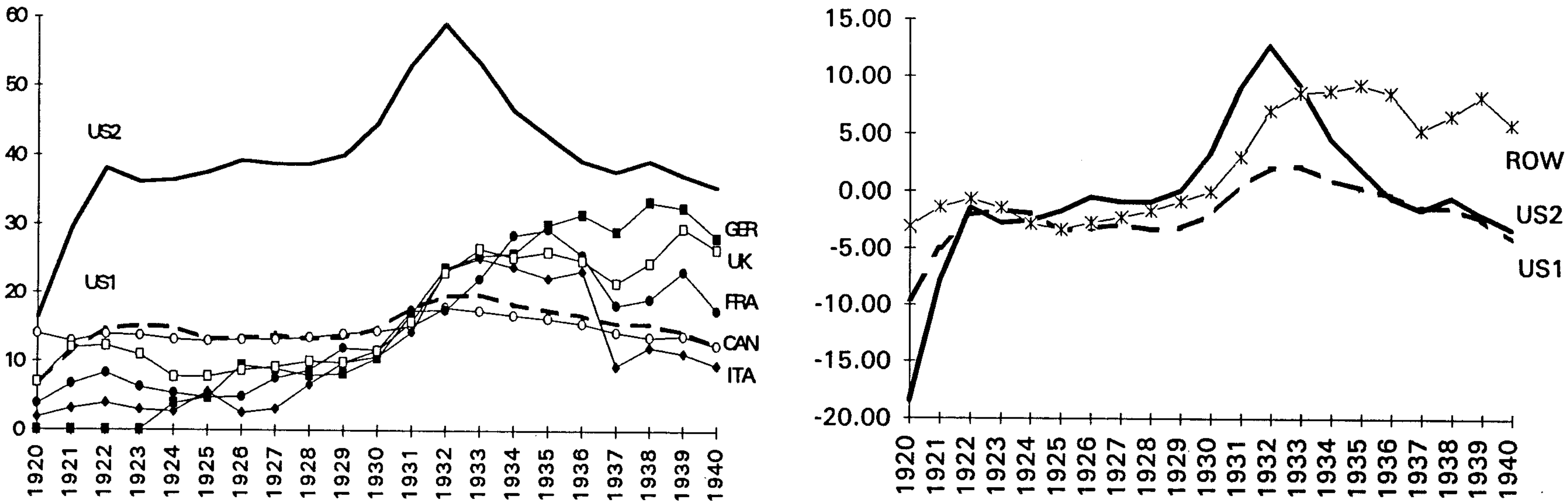
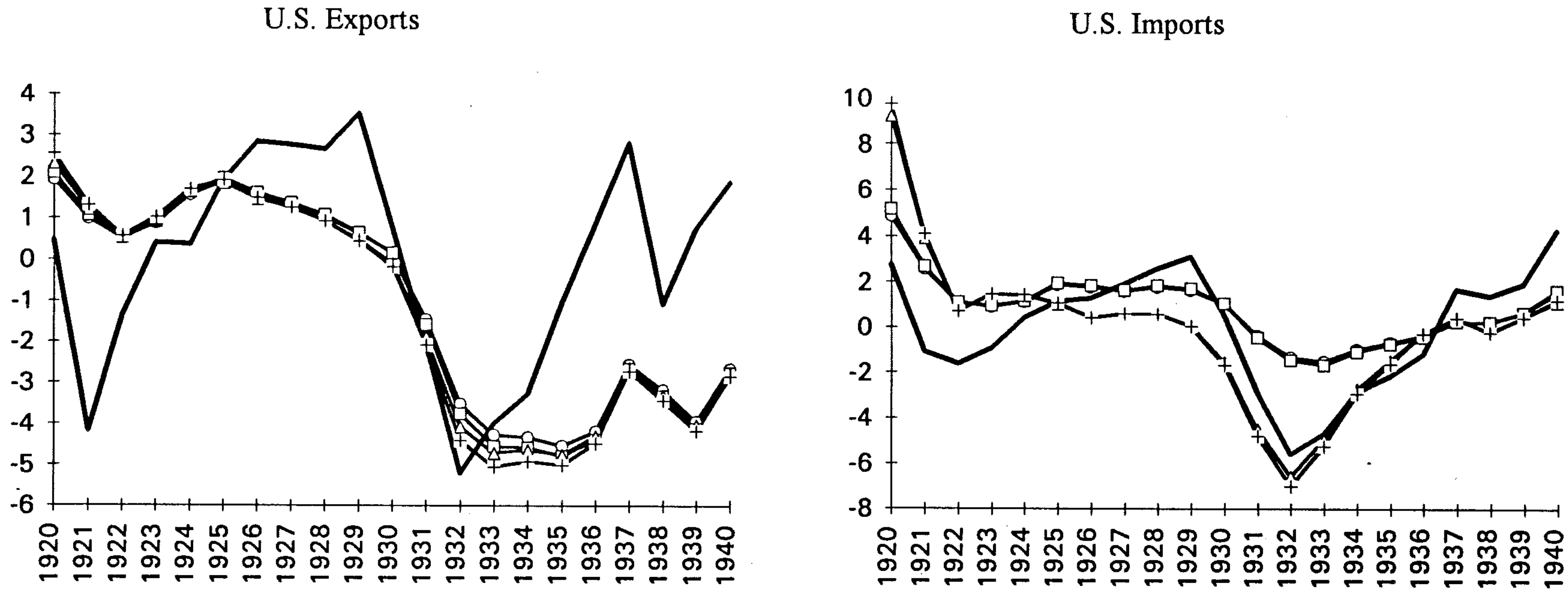


FIGURE 1 - U.S. AND FOREIGN AGGREGATE TARIFF INDEXES

Notes: The first graph plots aggregate tariff indexes for Canada, France, Germany, Italy, the United Kingdom, and the United States. The foreign tariff indexes are computed as the ratio of customs duties to total imports. The Canadian index uses imports from the United States while the indexes for each of the other countries uses imports from all countries. The line marked "US2" in the U.S. tariff index computed as the ratio of customs duties to dutiable imports, while the line marked "US1" uses total imports. The second graph plots the logarithm of the tariff wedge relative to its sample mean for "US2", "US1", and an aggregate of the tariff series for Canada, France, Germany, and the U.K (ROW). The weights used in the aggregation are the share of U.S. imports from each of these countries (normalized to 100) in 1929: 13.6%, 12.9%, 7.9%, 30.1%, and 35.4% respectively. German data is unavailable for the period 1920-1924 so the remaining countries are used to compute the foreign tariff index during that period.



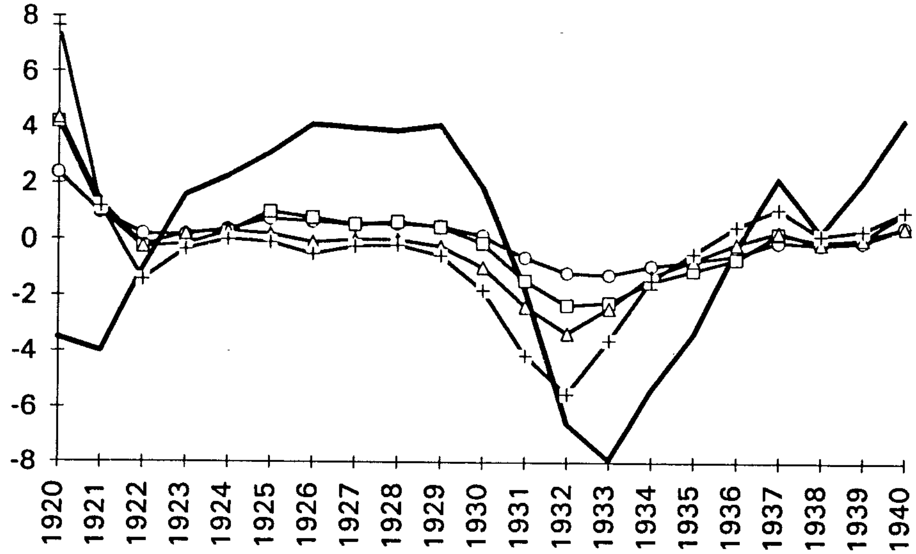
____ Data scaled by 0.10 -o-o-o- Simulation, tariff US1, Cobb-Douglas utility -□-□-□- Simulation, tariff US1, linear utility in leisure
-Δ-Δ-Δ- Simulation, tariff US2, Cobb-Douglas utility -+-+-+- Simulation, tariff US2, linear utility in leisure

		U.S. Exports				U.S. Imports			
		Log-linear Detrended		Growth rates		Log-linear Detrended		Growth rates	
Utility Function	Tariff index	Correlation	Variance Ratio	Correlation	Variance Ratio	Correlation	Variance Ratio	Correlation	Variance Ratio
Cobb-Douglas	Low	0.43	9.6 %	0.57	3.8 %	0.71	5.6 %	0.87	4.5 %
	High	0.44	10.2 %	0.60	4.0 %	0.67	12.3 %	0.84	10.0 %
Linear in Leisure	Low	0.44	10.1 %	0.57	4.1 %	0.71	6.0 %	0.87	4.8 %
	High	0.45	10.7 %	0.61	4.3 %	0.67	13.0 %	0.84	10.6 %

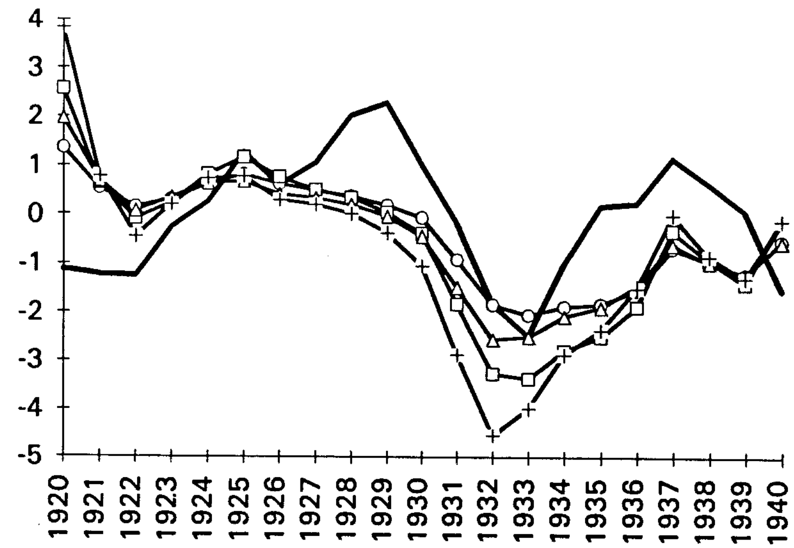
FIGURE 2 - ACTUAL AND MODEL SIMULATED U.S. EXPORTS AND IMPORTS

Notes: The first graph shows the path of actual and simulated exports for the U.S and the second graph shows the path of actual and simulated exports for the foreign aggregate. The foreign aggregate weights output as folllows: Canada (14.9%), Germany (36.0%), Italy (14.9%), and U.K. (34.2). From 1920-1924 German data are not available and the foreign aggregate is computed using data from Canada, Italy and the U.K. only. The series are log-deviations from a constant time trend. The table shows the correlation of the actual and simulated series and variance of the simulated series relative to the actual series expressed in percent for both log-linear detrending and growth rates.

U.S. Investment



Foreign Investment

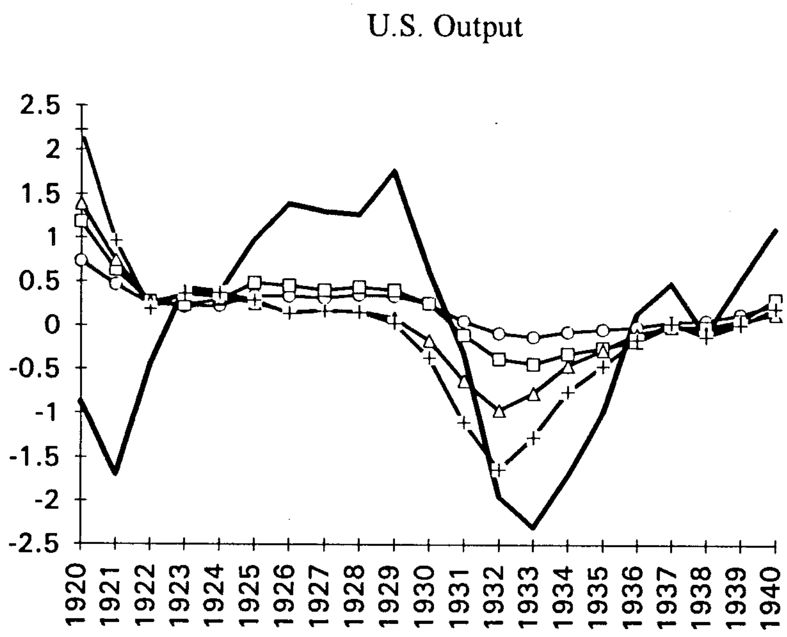


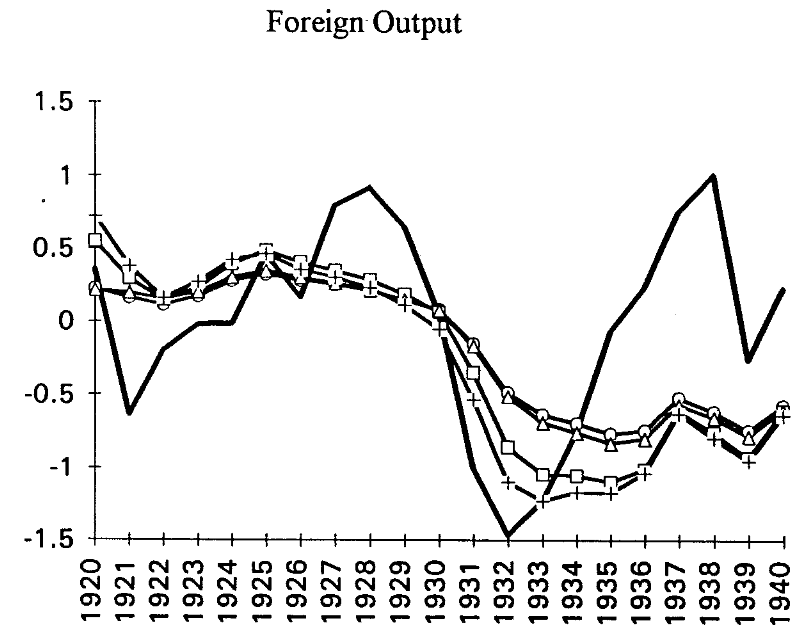
—— Data scaled by 0.10
-o-o-o- Simulation, tariff US1, Cobb-Douglas utility
-Δ-Δ-Δ- Simulation, tariff US2, Cobb-Douglas utility
-□-□-□- Simulation, tariff US1, linear utility in leisure
-+-+-+- Simulation, tariff US2, linear utility in leisure

		U.S. Investment				Foreign Investment			
		Log-linear Detrended		Growth rates		Log-linear Detrended		Growth rates	
Utility Function	Tariff index	Correlation	Variance Ratio	Correlation	Variance Ratio	Correlation	Variance Ratio	Correlation	Variance Ratio
Cobb-Douglas	Low	0.45	2.1 %	0.50	2.1 %	0.37	8.2 %	0.45	4.8 %
	High	0.31	4.0 %	0.44	4.3 %	0.33	9.3 %	0.47	5.9 %
Linear in Leisure	Low	0.44	3.6 %	0.46	4.3 %	0.38	12.3 %	0.43	9.1 %
	High	0.25	6.6 %	0.38	8.5 %	0.32	14.6 %	0.44	11.8 %

FIGURE 3 - ACTUAL AND MODEL SIMULATED INVESTMENT

Notes: The first graph shows the path of actual and simulated investment for the U.S and the second graph shows the path of actual and simulated investment for the foreign aggregate. See the notes to figure 2 for construction of the foreign aggregate. The series are log-deviations from a constant time trend. The table shows the correlation of the actual and simulated series and variance of the simulated series relative to the actual series expressed in percent for both log-linear detrending and growth rates.





_____ Data scaled by 0.10 -o-o-o- Simulation, tariff US1, Cobb-Douglas utility
-Δ-Δ-Δ- Simulation, tariff US2, Cobb-Douglas utility
-□-□-□- Simulation, tariff US1, linear utility in leisure
-+-+-+- Simulation, tariff US2, linear utility in leisure

		U.S. Output				Foreign Output			
		Log-linear Detrended		Growth rates		Log-linear Detrended		Growth rates	
Utility Function	Tariff index	Correlation	Variance Ratio	Correlation	Variance Ratio	Correlation	Variance Ratio	Correlation	Variance Ratio
Cobb-Douglas	Low	0.40	1.8 %	0.48	1.3 %	0.29	6.2 %	0.53	2.1 %
	High	0.30	4.2 %	0.51	3.2 %	0.28	6.6 %	0.49	2.2 %
Linear in Leisure	Low	0.43	3.3 %	0.52	2.6 %	0.39	8.8 %	0.61	3.6 %
	High	0.30	6.7 %	0.50	5.6 %	0.42	9.6 %	0.65	4.0 %

FIGURE 4 - ACTUAL AND MODEL SIMULATED OUTPUT

Notes: The first graph shows the path of actual and simulated output for the U.S and the second graph shows the path of actual and simulated output for the foreign aggregate. See the notes to figure 2 for construction of the foreign aggregate. The series are log-deviations from a constant time trend. The table shows the correlation of the actual and simulated series and variance of the simulated series relative to the actual series expressed in percent for both log-linear detrending and growth rates.