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ABSTRACT

This paper tests the hypothesis that idiosyncratic U.S. disturbances and their international propagation can account for the global Depression. Exploiting common stochastic trends in U.S. and Canadian interwar data, we estimate a small open economy model for Canada that decomposes output fluctuations into sources identifiable with world and country-specific disturbances. We find that the onset, depth and duration of output collapse in both Canada and the U.S. are primarily attributable to a common, permanent output shock leaving little significant role for idiosyncratic disturbances originating in either economy.

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1 Introduction

The conventional view of the global Depression of the 1930's is that a recession originating in the United States during 1929, and initiated by Federal Reserve stringency, was exacerbated domestically by financial crises following the Stock Market Crash and transmitted internationally through some combination of goods and financial market forces. This view is challenged by coincidence in the timing of output collapse across countries early in 1929, yet it has never been subjected to systematic empirical evaluation and remains the preeminent interpretation of events.

Canada is perhaps the quintessential small open economy, and provides a fertile testing ground for the hypothesis that idiosyncratic U.S. disturbances and their international propagation can account for the global Depression. We test this hypothesis by estimating a small open economy model for Canada in which the U.S. represents the rest of the world. This jointly identifies macroeconomic fluctuations in Canada and the U.S. with realizations from a set of country-specific and international disturbances. Our results suggest that the onset, depth and persistence of output collapse in both countries may be attributable primarily to permanent output disturbances which are common to the two economies. We find little significant role in the output collapse for temporary monetary, asset market or demand disturbances originating in either the Canadian or U.S. economy.

The experience of the Canadian economy during the interwar period and the remarkable parallels between economic performance in Canada and the U.S. can be seen in Figures 1a-1f.[1] In each country, real production declined by 30% between 1929 and 1933 and subsequently rose to its 1929 level by 1937. From 1929-1933, private investment fell by 74% and 78% in the U.S. and Canada respectively.[2] The time paths of nominal variables, M1 money stocks and velocities and (wholesale) prices, also exhibit remarkable symmetry. These similarities suggest that the two economies were influenced by similar disturbances that they propagated in similar ways, yet the economic history of each country has emphasized idiosyncratic factors.

The proximate source of the 1929 recession in the U.S. which precipitated the subsequent output collapse is widely held to be the tight money stance that the Fed undertook in 1928 to prevent gold outflows following the Poincare deflation and to stem speculation in financial markets (see Hamilton (1987) and Temin (1993)). Field (1984) and Hamilton (1987) argue that the contractionary effects of this policy were exacerbated by rising demand for transactions balances to finance the exceptional volume of asset trades, while Temin (1976) and Romer (1990) propose that an important contributing factor was the collapse of domestic consumption. Temin asserts that an 'inexplicable'

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[1] For data sources and definitions see Table 1.

[2] See Urquhart and Buckley (1965) and the U.S. Department of Commerce (1975).

decline in autonomous expenditure during 1929 is the source of this collapse in contrast to Romer's (1990) emphasis on the decline *induced* by future income uncertainty following the Stock Market Crash in October. Friedman and Schwarz (1963) attribute the *persistence* of the U.S. Depression to monetary collapse due to the Federal REserve System's inability to stem the banking crisis of 1930-33. Their emphasis on the demand effects of the attendant rise in real interest rates is disputed by Bernanke (1983) who argues that only the investment and aggregate supply effects engendered by the banking crises can explain the persistence of output collapse. Bernanke asserts that the loss of bank intermediated credit raised the cost of credit intermediation and so investment and Cecchetti and Karras (1993), using a similar econometric methodology to that applied in this paper, present some empirical support for this hypothesis. Specifically, they conclude that the onset of the Great Depression can largely be explained by aggregate demand shocks, whereas after 1931 aggregate supply shocks dominated.

The onset and persistence of the global Depression is frequently attributed to international transmission of real and nominal U.S. disturbances through strict nominal parity relations under the gold exchange standard, at least until 1931. Temin (1991), Eichengreen (1992), Romer (1993) and Temin (1993) all support this view of the transmission mechanism. Bernanke and James (1991) and Calomiris (1993) argue that imported *monetary* contractions from the U.S., especially, explain the duration as well as the onset of the worldwide output collapse. Debtor defaults associated with unanticipated 'debt-deflation', and the supply-side effects of attendant bankruptcies and banking crises can account for international persistence of a transmitted monetary contraction. Others have emphasized the role of declining export markets and capital flows in highly integrated goods and capital markets under the fixed exchange rate as the important source of transmission of the U.S. output collapse (Kindleberger (1984)). Yet typically, the economic history of Canada and Europe stresses significant country-specific factors with potential to generate recession in the late 1920's quite independently of the U.S. collapse.

Safarian's (1959) informal Keynesian analysis remains the leading interpretation of events in Canada. Safarian emphasizes not only Canada's dependence on primary commodity exports and peculiar vulnerability to the collapse of world trade, but also declining investment opportunities in the domestic economy. These reflected overexpansion during the 1920's in the new resource intensive industries, such as pulp and paper, exacerbated by the completion of Western settlement. He notes that while Canadian exports had recovered their 1929 level by 1937, investment remained at half its 1929 peak at that date. Similarly, Green and Sparks (1988) present empirical evidence to suggest that, while both the onset and severity of the Depression in Canada are explicable by the decline in exports, the initial domestic downturn is attributable to a reduction in the autonomous export component. This is independent of changes in U.S. income and the terms of trade, implying that the export collapse did not simply reflect transmission of disturbances from the U.S.

Haubrich (1990) examines the role of financial market disruptions in exacerbating the Canadian Depression. The absence of bank failures in Canada, despite substantial financial market disruption and in contrast to the U.S. experience, allows Haubrich to isolate their contribution to the output collapse. He finds that neither debt level nor commercial failure measures can explain the decline in Canadian output. He interprets these results to imply that bank failures *per se* were the financial market source of output fluctuations in the U.S.. Haubrich also finds little explanatory power for U.S. monetary aggregates or reduced export volume in accounting for Canadian output fluctuations.

Our goal is to evaluate systematically these competing views about the open economy experience of the Great Depression using data from the interwar Canadian macroeconomy. In particular, we test whether the transmission of idiosyncratic U.S. disturbances can explain the output collapse in Canada, whether shocks of domestic origin were more important, or whether the Depression in Canada and the U.S. originated from a common source. Using monthly data on output, prices and money stocks for the interwar sample 1925-1940, we estimate a small open economy model for Canada in which data from the U.S. represent the rest of the world. Specifically, we identify a structural moving average representation which is consistent with the long-run, equilibrium and dynamic properties of such a model. The representation decomposes output fluctuations in Canada into sources due to five fundamental disturbances.

First, we identify a permanent real output shock which is common to the two economies. This drives the stochastic trend in both output series, permanently affects all of the variables in the empirical model and could be interpreted as a supply shock - the result of disturbances to the level of resources and to technology. Second, we identify a permanent nominal shock to the U.S. money stock which we interpret as originating in U.S. monetary policy and which is inherited by the Canadian money stock under the fixed exchange rate regime. This permanent shock to money stocks is also reflected in the permanent component of prices for both economies but by construction has no long-run output effects. Third, we find a permanent common money demand disturbance which generates additional permanent shocks to prices in both Canada and the U.S. but is not reflected in output or monetary fluctuations. The fourth disturbance is a purely transitory U.S. shock, which we associate with real demand disturbances, and the fifth an idiosyncratic Canadian shock, which may incorporate purely transitory real and monetary shocks originating in the domestic economy.

Our results are stark, although their interpretation is less so. From 1929-1936 the twelve month interest rates. Given output and prices, domestic asset demand disturbances and the world interest rate, the domestic money supply must respond with complete elasticity to equilibrate asset markets following both external and domestic disturbances. The small open economy system is 'recursive' even in the short-run. In particular, any nominal or real external disturbance that affects prices or interest rates in the rest of the world can invoke transitory fluctuations in the domestic price level and output and, therefore, in the money supply.

To close the system requires a specification for the 'rest of the world'. We assume that the coefficients and elasticities in the Canadian model economy are approximately equal to those in the rest of the world. We also assume that the underlying fundamental stochastic processes satisfy the same properties worldwide.

$$
\begin{aligned}
y_t^* &= \theta_t^* - a_2(R_t^* - E\Delta p_{t+1}^*) + \eta_t^{d^*} && (6)\\
p_t^* &= E_{t-1}p_t^* + b_1(y_t^* - \theta_t^*) && (7)\\
\theta_t^* &= \theta_{t-1}^* + \eta_t^{s^*} && (8)\\
(m_t^* - p_t^*) &= c_1 y_t^* - c_2 R_t^* + \eta_t^{md^*} && (9)\\
m_t^* &= \bar{m}_t^* + \gamma\theta_t^* && (10)\\
\bar{m}_t^* &= \bar{m}_{t-1}^* + \eta_t^{ms^*} && (11)
\end{aligned}
$$

The interpretations of equations (6)-(9) are the same as for the Canadian economy, although there is by definition no role for 'external' determinants, and equations (10) and (11) specify the exogenous stochastic process for the money stock in the rest of the world.

Equation (10) states that the money stock grows endogenously with permanent output growth and also has an exogenous permanent component which evolves according to equation (11). We assume that under a commodity exchange standard which does not impose a 100% reserve backing, the world money stock is roughly proportional to total reserves and monetary policy institutions have some autonomy in determining the level of domestic reserves. We therefore allow for a non-zero monetary policy shock in the rest of the world to reflect the aggregate effects of this leverage, $\eta_t^{ms^*}$, which permanently affects the level of the world money stock. This rationalizes a permanent *nominal* component in the world economy. However, total world reserves of gold and foreign exchange also are driven exogenously by variables such as world income and the level of world trade.[8] We assume, therefore, that the money stock in the rest of the world is determined also by permanent output growth, θ_t^*.

The general, short-run solution for the rest of the world's economy has y_t^*, p_t^* and R_t^* as linear

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[8] McClosky and Zecher (1976) and Eichengreen (1990) Chapter 10 argue this point.

functions of past and current realizations of the four fundamental disturbances $\eta_t^{d^*}, \eta_t^{s^*}, \eta_t^{md^*}$ and $\eta_t^{ms^*}$, while the money stock, m_t^*, is determined only by the permanent money supply and output shocks. Specifically,

$$\begin{aligned}
m_t^* &= \lambda_m^*(\theta_{t-1}^*, \bar{m}_{t-1}^*, \eta_t^{s^*}, \eta_t^{ms^*}) && (12a)\\
p_t^* &= \lambda_p^*(\theta_{t-1}^*, \bar{m}_{t-1}^*, \eta_t^{s^*}, \eta_t^{ms^*}, \eta_t^{d^*}, \eta_t^{md^*}) && (12b)\\
y_t^* &= \lambda_y^*(\theta_{t-1}^*, \eta_t^{s^*}, \eta_t^{ms^*}, \eta_t^{d^*}, \eta_t^{md^*}) && (12c)\\
R_t^* &= \lambda_R^*(\eta_t^{s^*}, \eta_t^{ms^*}, \eta_t^{d^*}, \eta_t^{md^*}) && (12d)
\end{aligned}$$

where the λ^*'s are vectors of coefficients in the underlying structural parameters. These solutions imply that Canadian output, prices, and money are determined in the short run by the four external disturbances through the terms of trade and world interest rate *and* the two domestic demand disturbances. By assumption there is no feedback from Canada to the rest of the world. The solutions are,

$$\begin{aligned}
m_t &= \lambda_m(\theta_{t-1}^*, \bar{m}_{t-1}^*, \eta_t^{s^*}, \eta_t^{ms^*}, \eta_t^{d^*}, \eta_t^{md^*}, \theta_{t-1}, \eta_t^{s}, \eta_t^{d}, \eta_t^{md}) && (13a)\\
p_t &= \lambda_p(\theta_{t-1}^*, \bar{m}_{t-1}^*, \eta_t^{s^*}, \eta_t^{ms^*}, \eta_t^{d^*}, \eta_t^{md^*}, \eta_t^{s}, \eta_t^{d}) && (13b)\\
y_t &= \lambda_y(\theta_{t-1}, \eta_t^{s^*}, \eta_t^{ms^*}, \eta_t^{d^*}, \eta_t^{md^*}, \eta_t^{s}, \eta_t^{d}) && (13c)\\
R_t &= \lambda_R^*(\eta_t^{s^*}, \eta_t^{ms^*}, \eta_t^{d^*}, \eta_t^{md^*}) && (13d)
\end{aligned}$$

The current value of each variable in the model except the common nominal interest rate depends on both a permanent, stochastic trend component driven by the non-stationary processes θ and $\bar{m}$ and a second, transitory component due to current realizations of each white noise disturbance.

The *long-run* equilibrium of the model is defined by the absence of new disturbances or price surprises, so that output lies at its exogenous supply-driven level in both the rest of the world and the domestic economy, and transitory dynamics of external and domestic origin disappear. Only permanent components matter. This implies that nominal and real interest rates, and expected and actual inflation rates, are constant at their zero-mean levels in the rest of the world and domestic economy. Long-run outputs are given (from (1),(2),(6) and (7)) by

$$\begin{aligned}
y^* &= \theta^* && (14)\\
y &= \theta && (15)
\end{aligned}$$

where the long-run levels of θ and θ^* are represented by their conditional expected values. Long-run money market equilibrium in the rest of the world, (9), and domestic goods market equilibrium for the small open economy, (1) and (2), imply that long-run price levels are given by

$$\begin{aligned}
p^* &= \bar{m}^* + (\gamma - c_1)\theta^* && (16)\\
p &= p^* + e && (17)
\end{aligned}$$

The long-run price level in the rest of the world, p^*, is determined by the exogenous permanent components of aggregate output and the money stock and, from (1), a long-run purchasing power parity (PPP) relation pins down Canadian prices at this level. Long-run PPP is (implicitly) rationalized by international goods market integration in a single, composite commodity world. Despite the presence of country-specific supply shocks, Canada is too small to affect the common currency world price of the composite commodity. External determination of long-run prices for Canada also determines the associated long-run domestic money stock. Since

$$m = (p^* + e) + c_1\theta \tag{18}$$

and

$$m^* = \bar{m}^* + \gamma\theta^* \tag{19}$$

then, from above,

$$\begin{aligned} m &= m^* + e + c_1(\theta - \theta^*) &(20)\\ m &= \bar{m}^* + e + (\gamma - c_1)\theta^* + c_1\theta &(21) \end{aligned}$$

In the long-run, Canadian monetary authorities accomodate both the exogenously given aggregate supply at home and exogenously fixed world prices for that output by elastically supplying the amount of currency required to ensure that all output is consumed and invested.

2.3 Testable Implications Of The Model

These solutions provide some testable implications for international transmission and macroeconomic dynamics. While for simplicity of exposition we have presented a model with very simple dynamics and the strong restriction of white noise fundamental shocks, in our empirical work we allow disturbances to be represented by *any* invertible, stationary and causal autoregressive moving average (ARMA) process in white noise. In this case, the elements of λ^* and λ associated with the disturbances are lag polynomial, rather than coefficient, vectors.

Three implications for the small economy's dynamics hold in either case, with generalizations in parentheses. First, domestic money stock fluctuations reflect contemporaneous (and historical) realizations of all disturbances in both the domestic and external economies and prevent the transmission of contemporaneous domestic asset market shocks to output. Second, domestic price fluctuations in Canada reflect contemporaneous (and historical) realizations of domestic goods market disturbances and both nominal and real external disturbances which engender transitory deviations from trend in output. Third, domestic output fluctuations reflect contemporaneous (and historical) realizations of all disturbances in the rest of the world and all domestic shocks except those originating in domestic asset markets.

Additionally, the model predicts that the impact and short-run responses of all variables in the model will differ across the two economies due to international transmission even though long-run responses may be identical. Since the domestic economy is subject to shocks of both domestic and external origin in the short-run, the vectors of (lag polynomial) parameters λ and λ^* will in general differ across the two economies. Moreover, the rest of the world's economy is not affected by Canadian disturbances and the money stock in the rest of the world is unaffected by any but the autonomous nominal and real permanent external shocks.

The solutions also generate testable implications for long-run equilibrium. Our representation rationalizes stochastic non-stationarity in the log level of output, prices and money both in the domestic and world economies, so these implications take the form of conditions on common stochastic trends or cointegrating relations between variables both within and across countries.[9] When variables share common stochastic trends, common sources of non-stationarity cancel out in the unique linear combination which represents a structural equilibrium relation. Consequently, although money stocks, prices and outputs are individually non-stationary, and so can wander widely with no mean reverting tendancy, their equilibrium linear combinations *are* stationary and the variables trend together over time. Our empirical representation in ARMA disturbances implies we would observe purely transitory stationary deviations from three, long-run equilibrium conditions.

First, there is a long-run money market equilibrium condition in the external economy which implies that prices in the rest of the world inherit the stochastic trends in output and the nominal money stock (see (16)). Second, long-run purchasing power parity holds, that is, Canadian prices share this stochastic trend of prices in the rest of the world (as in (17)). Third, there is a long-run money market equilibrium condition for the domestic economy in which the nominal money stock inherits the stochastic trends in money and output in the rest of the world and in domestic output ((20) and (21)). While the first two equilibrium conditions are shared by many closed and two-country models with long-run price flexibility, the third uniquely characterizes international monetary equilibrium for a small open economy of this class. Additionally, we also consider whether there are common supply shocks such that outputs in the domestic and external economies have a common stochastic trend. This common trend can be rationalized by world technology shocks or technology shocks which are diffused rapidly across geographic and economic boundaries and the test is suggested by the similarity of output behaviour across countries during the interwar era.

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[9] See Engle and Granger (1987) for definition and discussion of cointegration in time-series.

The condition implies that, provided international money market equilibrium (20) holds, domestic nominal money, real money and velocity share stochastic trends with their external counterparts.

3 Econometric Methodology

3.1 Overview

We estimate a moving average representation (MAR) for integrated macroeconomic data from the interwar era for Canada that accounts for and uses information on common stochastic trends. The Canadian macroeconomic variables of interest are assumed to be jointly determined by a set of fundamental (orthogonal) disturbances with interpretation as internal and external shocks to a small open economy with short-run non-neutralities due to nominal rigidities. The MAR expresses the current value of each variable as the cumulative effect of current and past realizations of this set of disturbances. It can represent the dynamics of the small open economy model we maintain as generating the Canadian macroeconomy, subject to the long-run equilibrium constraints of the model which take the form of common stochastic trends. The estimated responses of the empirical model to each type of disturbance can then be inspected and their consistency with the stylized responses predicted by the Keynesian small open economy framework evaluated.

3.2 The Structural Moving Average Representation

Recent advances in macroeconometric theory and practice mean that the methods required to conduct our empirical analysis are well documented and so only a brief review of the methodology is presented here.[10]

Assume that ΔX_t is an N-vector of jointly covariance stationary variables (X_t requires first differencing to achieve stationarity) such as $[\Delta y_t, \Delta y_t^*, \Delta m_t, \Delta(m_t^* + e), \Delta p_t, \Delta(p_t^* + e)]$ where the elements of X_t are cointegrated. We posit the existence of a structural MAR for some appropriate transformation of the elements of X_t in an N-vector of fundamental disturbances, η_t, which have interpretation as the shocks in a simple open economy Keynesian model when some of the shocks are known to be permanent for and common to the elements of X_t. This representation in η_t is assumed to be 'complete'; given the maintained model, it fully captures the determination, dynamics and interrelations of the N variables.[11] It is also assumed to be fundamental for X_t[12] and to account

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[10] See, for example, Blanchard and Quah (1989), and King, Plosser, Stock and Watson (1991).

[11] See Quah (1992). We also assume that conditions required for an N-disturbance representation to approximate an underlying generating process for X of higher dimension are satisfied. Blanchard and Quah (1989) present a discussion, Theorem and proof.

[12] Lippi and Reichlin (1993) and Blanchard and Quah (1993) discuss conditions under which an assumption of fundamentalness of the MAR may not be valid.

for common stochastic trends or long-run equilibrium relations between the elements of X_t. The objective is to study the dynamics and long-run properties of this structural system to shed light on sources of output fluctuations by estimating an empirical representation.

The appropriate MAR for a cointegrated system takes the triangular form:[13]

$$\begin{bmatrix} \Delta X_{1_t} \\ (X_{2_t} - \alpha X_{1_t}) \end{bmatrix} = \Gamma(L)\eta_t \tag{22}$$

where X_t is partitioned into subvectors X_{1_t} and X_{2_t} of dimension N1 and N2, N1+N2=N, and α is an (N1×N2) matrix of (known) cointegrating coefficients where N2 is the number of cointegrating relations and N1=N-N2. The matrix lag operator, $\Gamma(L)$, can be partitioned conformably with X_t into $\Gamma_1(L)$ and $\Gamma_2(L)$ of dimensions (N1×N) and (N2×N) respectively. The (N×1) error vector η_t represents the set of structural disturbances from the theoretical model with covariance matrix Σ_η diagonal to reflect orthogonality of these disturbances. All dependent variables in this representation are stationary so that estimation of and inference from an associated reduced form is based on standard asymptotic distribution theory.

The structural MAR can be estimated, given knowledge of the cointegrating vectors, as a reduced form VAR

$$B(L)\begin{bmatrix} \Delta X_{1_t} \\ (X_{2_t} - \alpha X_{1_t}) \end{bmatrix} = \begin{bmatrix} \epsilon_{1_t} \\ \epsilon_{2_t} \end{bmatrix} \tag{23}$$

with X_{1_t} and X_{2_t} defined as above. B(L) and ϵ_t are the reduced form parameter and error vectors respectively and can be partitioned conformably with X_t. The reduced form has impact matrix B(0) = I and variance-covariance matrix $E(\epsilon_t\epsilon_t\prime) = \Sigma_\epsilon$. Inversion yields the infinite order reduced form MAR

$$\begin{bmatrix} \Delta X_{1_t} \\ (X_{2_t} - \alpha X_{1_t}) \end{bmatrix} = C(L)\begin{bmatrix} \epsilon_{1_t} \\ \epsilon_{2_t} \end{bmatrix} \tag{24}$$

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[13] We know from Engle and Granger (1987) that in the presence of cointegration in levels between the elements of X_t simple MAR representations for ΔX_t in η_t of the form

$$\Delta X_t = D(L)\eta_t$$

are misspecified since there are fewer independent permanent shocks in the system than is implied by the N-variable specification. One or more of the shocks must be purely transitory for all variables and the long-run multiplier matrix

$$D(1) = \sum_{i=0}^{\infty} D_i$$

which represents the cumulative effect of shocks on the first difference of X or the infinite horizon effect on the level of X is singular, having one or more columns containing all zeros. The correct structural representation for cointegrated X_t restores the long-run multiplier matrix to full rank by renormalizing the system to account for the cointegrating relations. The resulting vector-error correction, or alternative triangular, system contain equivalent information and we apply the triangular form (Phillips (1991).

where $C_i(L) = [B_i(L)]^{-1}$ and C(0) = $[B(0)]^{-1} = \mathrm{I}$. From this reduced form the underlying structural MAR can be identified given standard algebraic relations between the reduced form and structural parameters and identifying restrictions imposed by theory.

By assumption, $C(L)\epsilon_t = \Gamma(L)\eta_t$. This implies that $\Gamma(0)\eta_t = \epsilon_t$ and that the structural MAR polynomial is given by

$$\Gamma(L) = C(L)\Gamma(0) \tag{25}$$

Therefore, both the structural parameters in $\Gamma(L)$ and innovations η_t can be identified from the reduced form estimates if $\Gamma(0)$ is known. In practice, the structural impact multiplier matrix is not known and must be estimated. In the absence of additional information there are fewer known reduced form coefficients than unknown structural parameters. This requires that $\Gamma(0)$ be identified by imposing restrictions on the structural parameters to reduce the number of unknowns.

Some information is available which can be used directly in the identification of $\Gamma(0)$. From above there is a covariance condition to be satisfied which uses reduced form information:

$$\Sigma_\epsilon = \Gamma(0)\Sigma_\eta\Gamma(0)\prime \tag{26}$$

where Σ_η is assumed to be diagonal or, as here, normalized to be the identity matrix. This condition provides (N(N+1)/2) non-linear restrictions on the elements of $\Gamma(0)$. Since there are N^2 unknown elements in $\Gamma(0)$, exact identification calls for another (N(N-1)/2) restrictions.[14]

We follow Blanchard and Quah (1989) by using zero restrictions implied by our theoretical model on the matrix of long-run multipliers $\Gamma(1) = \sum_{i=0}^{\infty}\Gamma_i$ as the remaining identifying assumptions. Such restrictions are meaningful only in the presence of non-stationarity. If the vector, X_t, is stationary $\Gamma(1)$ is a zero matrix since no shock can permanently affect the level of stationary variables. Unit roots in the variables of a MAR system, however, can always be decomposed into a transitory and a permanent component (Quah (1992)), each of which can be viewed as having multiple structural sources. In multivariate systems that allow identification of multiple structural disturbances, this decomposition can be exploited and the two components isolated by imposing theory-driven zero restrictions on $\Gamma(1)$. By using all of the zero-parameter long-run restrictions of our model, in addition to three other (short-run) implications as linear restrictions on the elements

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[14] A number of alternative approaches have been employed to derive such restrictions. Sims (1980) identifies $\Gamma(0)$ by assuming that it is lower triangular (a Wold causal chain generates the system which is said to be resursive). Bernanke (1986), Fackler and Parker (1990) and others estimate 'structural models' of the contemporaneous relations; rather than arbitrarily assume recursivity in $\Gamma(0)$ they impose identifying restrictions derived from economic theory. These approaches do not use long-run information implied by theory which implies restrictions on the long-run multiplier matrix, as we do, although such restrictions are often less arbitrary and controversial than those placed on contemporaneous relations.

of $\Gamma(0)$ (see Section 5), we can just identify the structural parameters and disturbances.[15] The resulting estimates of $\Gamma(L)$ and η_t describe the propagation mechanisms for growth rates, and $\Gamma(L)/(1-L)$ describes the dynamics and long-run properties for the levels of variables which are of most interest.

3.3 Model Specification Tests

We can directly evaluate whether the data are consistent with the model's implications in several ways using this empirical framework. First, we assess which of the model's long-run equilibrium constraints can be imposed on the triangular specification in the form of the 'error-correction' terms with univariate and multivariate integration and cointegration tests. These inform on whether individual variables and their linear combinations are stationary, and on the number of independent stochastic trends in the data. The tests are commonly applied in empirical macroeconomics and we do not discuss them further here.[16]

Second, we evaluate consistency of the multivariate triangular reduced form selected by the non-stationarity tests with a decomposition for the non-stationary variables into transitory and permanent components using the Granger-priority test suggested by Quah (1992). This involves applying a standard χ^2 block-exogeneity test to the lags of $X_{2_t} - \alpha X_{1_t}$ in the equations for ΔX_{1_t}. If the block of lags for the error-correction terms have no predictive power for ΔX_{1_t}, while the converse does not hold, the implied MAR with innovations orthogonalized by zero restrictions on $\Gamma(1)$ has no permanent/transitory decomposition for ΔX_{1_t}. Specifically, this structural MAR has zero coefficients at all lags for shocks to the transitory component for the integrated variables and zero restrictions applied to elements of $\Gamma(1)$ to invoke a permanent/transitory decomposition cannot be justified.[17]

Finally, consistency of the data with the model's predictions for short-run dynamics and international transmission of disturbances can be evaluated by inspecting the estimated dynamics of the structural MAR. The information admitted by such inspection is conditional on the presence of 'overidentifying restrictions' for the theoretical model. The model in Section 2 generates many long-run and some short-run implications which can be imposed as zero and linear restrictions to identify the structural MAR parameters and innovations with those of the economic model. However, there are more of these restrictions than are required to exactly-identify the N^2 elements of

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[15] We follow Cecchetti and Karras (1993), Gali (1992) and Ahmed at al (1993) in extending Blanchard and Quah's (1989) bivariate decomposition of output fluctuations to the multivariate case.

[16] See King, Plosser, Stock and Watson for data analysis that is motivated by the same concern with model specification.

[17] See Quah (1992) for details, theorem and proof.

$\Gamma(0)$ in the empirical representation. We therefore select a subset of these economic restrictions to identify the structural MAR and can assess the compatibility of the estimated innovations, responses and variance decompositions with the remaining, non-imposed and testable implications of the model.[18]

4 Data Analysis

We make the strong assumption that the U.S. data can represent the rest of the world relative to Canada. However, the arguments of Bordo and Redish (1990) that Canada fixed her currency exchange rate against the $U.S. for most of the interwar era, and the large fraction of external trade in goods and assets for Canada accounted for by the U.S., suggest that this is a reasonable first approximation.

We use monthly data, deterministically adjusted for seasonality, on six variables of interest for the interwar subsample 1924:1-1939:12 : Canadian and U.S. industrial production, wholesale prices and M1 money stocks, where the U.S. price and money stock variables are adjusted by the nominal Canada/U.S. exchange rate and all variables are expressed as natural logarithms (unless otherwise stated). The exchange rate adjustment is consistent with the model and does not alter the time-series properties of the data given Canada's fixed exchange rate policy for much of the sample period.[19] Since real and nominal interest rates are predicted to be purely endogenous, stationary outcomes of the model we do not incorporate them explicitly in our empirical representation in the interests of parsimony.[20] The sample period 1925:1-1939:12 is used in all tests and regressions, with values for 1924:1-1924:12 used up as lags in pre-estimation data analysis and in VAR lags and lag length tests. Data sources, notation and definitions are given in Table 1. All notation in the text now reflects use of U.S. and Canadian data to represent the rest of the world and the domestic small open economy respectively.

4.1 The Interwar Data

Figures 1a-1f and Tables 2a, 2b and 2c present some informal (unconditional) evidence on the behaviour of important Canadian and U.S. variables during the Great Depression. The figures, which plot the seasonally adjusted data normalized to the 1935-1939 average, show the very similar

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[18] See Gali (1992) for use of overidentifying restriction tests as evaluation of a macreoconomic model.

[19] Repeating the analysis of this paper using the unadjusted M1 and price series changes few results. Despite the depreciation of the exchange rate due to Britain and the U.S. leaving the Gold Standard in 1931 and 1933, the time-series properties of the data, non-stationarity, cointegration and estimated VAR results are qualititatively unchanged. Few qualitative changes arise in the innovation accounting exercises.

[20] The responses of the remaining six variables to the disturbances we identify will therefore reflect interest rate behaviour.

behaviour of the Canadian and U.S. economies during the interwar period. Although each pair of series display some different short-run movements, they appear to 'trend together' and the dip in outputs, money supplies and prices during the 1929-1933 era is synchronized across the two countries. Exchange rate adjustment of the U.S. data appears not to cause significant deviations from common movements in the data. The similar bivariate trend behaviour of the series suggests the possibility of cointegrating relations between outputs, prices, money stocks and velocities which is consistent with the model in Section 2 amended to allow for common stochastic output trends.

Table 2a shows positive average monthly output growth for the period 1925:1 to 1928:12 for both economies, and a high growth rate for Canada in particular, with 'business cycle peaks' occuring in the first half of 1929. The Depression sample trough for industrial production in the U.S. occurs before that in Canada (July 1932 and February 1933 respectively). Mean output growth rates are negative for both series during the Depression era (although positive in the other subsamples), mean levels are lowest and variablility highest. Additionally, the sample correlation of outputs is highest for this mid-sample period suggesting a peculiar strength of *common* factors during the Depression. Output in neither country recovers to its 1929 peak level by the end of 1939, nor does it fall to its 1934, recovery level during the recession of 1937-1938, reflecting the strong persistence of the Depression. Overall, the output data suggest very similar properties and timing of business cycle peaks, troughs and persistence during the interwar era for the U.S. and Canada.

M1 money stocks exhibit very similar patterns of behaviour in log levels and first differences to those of production, although the U.S. series attains its trough only in 1933:11. The timing of collapse and recovery is otherwise similar. Money stocks are strongly contemporaneously correlated, implying that the small open economy, fixed exchange rate implication for external determination of the Canadian money stock may be valid. The behaviour of prices mimics that for outputs and money stocks as expected; again, the two series exhibit strong similarities in their unconditional properties and in the timing of peaks and troughs. The Depression era is characterized by mean annual deflation rates of 6% for both price series, and the full sample estimate of their contemporaneous correlation is remarkably high, 0.97. These statistics illustrate common nominal properties in the two economies which, in the context of our model, may indicate that gold standard mechanisms functioned efficiently.

While these statistics suggest close links between the two economies during the interwar era and the Depression in particular, more formal analysis which studies conditional correlations in the data is required to identify the nature of these relations. Preceding Sections argue that evaluation of the appropriate time-series representation for each series, and of the presence and number of common stochastic trends in the data in particular, is an important pre-estimation specification test. We therefore apply standard tests for non-stationarity and cointegration which allow inference on whether the theoretical equilibrium constraints outlined in Section 2 are satisfied in the data.

4.2 Tests For Non-stationarity and Cointegration

Tables 3a and 3b present evidence that each of the variables can be represented as a unit root process; as containing a stochastic trend. Table 3a presents computed values for the Phillips (1987) Z_α and Z_t and the Dickey-Fuller (1976,1979 and 1981) t-statistics which test the null hypothesis of a unit root in the level of each series against the one-sided alternative that the series is stationary. The evidence is consistent with the null for all series we examine. Table 3b presents evidence *against* the null for the first difference of each series.[21] We therefore treat each series in the vector $[y_c, m_c, p_c, y_{us}, (m_{us}+e), (p_{us}+e)]$ as a univariate unit root process which requires first differencing to achieve stationarity.

This implies that all series are subject to permanent shocks. We cannot uncover the sources of these permanent shocks using univariate methods. However, cointegration tests inform on the data's consistency with the model's implications for structural long-run equilibrium relations reflected in common sources of stochastic trends in the data. We use the same Phillips and Dickey-Fuller statistics to test the null hypothesis that the residual series from each cointegrating regression is non-stationary or, equivalently, that there is no cointegration between variables in the regression. Table 4a presents results of univariate tests of cointegration applied to the residuals from the cointegrating regressions of the dependent variable on the regressor specified.

Consistent with the long-run equilibrium conditions (16) and (18), we cannot reject the null of non-cointegration for money and prices for either country (rows 5 and 6 of Table 4a). This implies that prices in the rest of the world absorb permanent output shock components additional to those reflected in the money stock, and that while long-run PPP determines prices in the small open economy, the domestic money stock will also reflect long-run asset market equilibrium conditions. The Phillips' test statistics in the first three rows of Table 4a provide strong evidence to favour bivariate cointegrating relations for Canadian and U.S. outputs, prices and money stocks. Weaker support is supplied by the Dickey-Fuller test results for these hypothesized equilibrium relations. Cointegration of outputs implies there is a common stochastic trend in outputs which, under the maintained hypothesis that only aggregate supply shocks matter for production in the long run,

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[21] The evidence conflicts with findings of non-stationarity in *post-war* inflation rates. Estimates of the autoregressive coefficients for inflation rates in Canada and the U.S. in the ADF(4) test regression are 0.54 and 0.57 respectively. This suggests that inflation rates are stationary. Since there is also no evidence of non-stationarity in M1 or output growth rates, this seems an appropriate 'structural' conclusion.

reflects common aggregate supply conditions. The common trend in prices reflects, under the maintained model, an unconstrained long-run PPP relation with common trend generated by aggregate supply shocks and money supply shocks in the U.S. economy. Finally, cointegrated nominal money stocks is an implication of the first two results and reflects the international monetary equilibrium condition, (20). The common trend in money stocks is generated by permanent money supply shocks in the U.S. and the common permanent real shock.

There is *no* evidence to support cointegration of domestic real money balances with domestic output for either country; of long-run domestic money market equilibrium of the form (4). Notably, the addition of nominal interest rates to the money market equilibrium relations had no qualitative effect on this result, so our omission of interest rates is not important for this conclusion. Non-cointegration of domestic money demand functions implies that *both* economies are subject to permanent money demand or 'independent velocity' shocks in asset markets.[22] Since nominal money stocks and prices *do* cointegrate, these permanent money demand shocks must be common to the two economies. If the money demand shocks are non-stationary processes and do not 'disappear' in long-run equilibrium, the long-run U.S. price level is given by $p_{us} = m_{us} - c_1\theta^{us} - \eta^{md^{us}}$ and the long-run Canadian money stock by $m_c = p_{us} + e + c_1\theta^c + \eta_c^{md}$. Given common θ's, $m_c = m_{us} + e + \eta^{md^c} - \eta^{md^{us}}$ and so cointegration of nominal money stocks requires cointegration of the money demand processes; common money demand shocks. Long-run prices in both economies must contain a component due to this permanent asset market shock which provides additional rationalization for the non-cointegration of money and prices in each economy.

In Table 4b, we impose some coefficient constraints implied by theory. We assume that the common aggregate supply shock has an equal long-run impact on the logarithms of output, or a proportional effect on the levels. We assume a constant, proportional relationship between prices in the U.S. and Canadian economies in the long-run, or impose relative long-run PPP, as predicted by (17), and also impose the (1,-1) coefficient vector in the money stock (and real balance and velocity) cointegrating regression implied by the condition for international monetary equilibrium, (20). These restrictions allow us to apply simple non-stationarity tests to the log-differences of outputs, prices, and money stocks. Tests for non-stationarity of real balances confirm non-cointegration of money and prices for each country in rows 5 and 6. The results document strong support for the coefficient restrictions at the 5% level for all but the long-run PPP relation, which is favoured at the 10% and 15% levels, as shown in the first three rows of Table 4b.

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[22] In general, this result will reflect any misspecification of the equilibrium conditions for asset markets. However, there is sufficient evidence from contemporary and historical data to support cointegration in such simple money demand specifications to warrant our labeling this result an outcome of permanent 'money demand' shocks.

In Table 4c, we use Johansen's maximum-likelihood multivariate cointegration test statistics to confirm our inference from the univariate results that there are three, independent common stochastic trends in the data. These use rank conditions to evaluate the dimension of a multivariate system. Specifically, they test the null of no more than r-cointegrating vectors in a given system against the alternative of more than r cointegrating vectors, and provide unnormalized maximum-likelihood estimates of the space of cointegrating vectors. We evaluate the number of independent cointegrating vectors in the six variable system $[y_c, m_c, p_c, y_{us}, (m_{us}+e), (p_{us}+e)]$. Univariate tests imply that there are three such vectors in the system; one in the two output series, which reflects purely the common stochastic supply trend, one in the two money stock series, which additionally reflects the nominal money stock trend, and one in the two price series, which incorporates additional permanent components due to aggregate supply and money demand shocks. The system should therefore be three-dimensional, have 'rank three' or contain three independent unit roots.

The first line of Table 4c shows that although we firmly reject the null of no cointegration in the system, we cannot reject the null of three independent cointegrating vectors. Tests of hypotheses about intermediate numbers of vectors suggest that there are no fewer than two independent cointegrating relations in the system. This is consistent with a three unit root specification. The Johansen procedure also rejects the null of no cointegration for the bivariate systems in outputs, money stocks and prices at least at the 15% level for all cases but cannot reject the null of no cointegration between money and prices or real balances and output (no long-run money demand) for either country's data.

The bivariate systems imply normalized cointegrating vectors given in Table 4d. These are consistent with theoretical priors in the output, money supply, real balance and velocity equations and there appears to be a long-run PPP relation with a coefficient close to but not equal to unity. Point estimates of the cointegrating vectors are also provided by the Phillips-Hansen Fully Modified procedure which shows some deviation from unit vectors. Subsequent sensitivity analysis showed that imposition of these alternative cointegrating vectors generates no significant differences in the reduced form or structural model results compared to a system in which unit vectors are imposed for all three cointegrating relations. Consequently, we report results only for the model in which all three unit coefficient restrictions are imposed.[23]

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[23] We also find that real balances and velocities of the two economies cointegrate, in Table 4a, which is implied by bivariate cointegration of outputs, money stocks and prices. Further, they cointegrate strongly with unit coefficient restrictions, supporting our coefficient restriction results for the underlying variables, in Table 4b. Johansen tests support these univariate results, in Tables 4c and 4d.

5 Identification of the Empirical Model

Our data analysis suggests the existence of three independent common stochastic trends in this data set consistent with the following interpretations. First, there is a permanent output shock which is common to the two economies and interpretable as a world aggregate supply process. Second, there is a permanent nominal shock which is common to the two economies and interpretable as a U.S. policy driven money supply process inherited by an endogenous money stock in the small open economy. Third, (and not predicted by the model), there is a permanent shock to real money demand, and so prices, which is common to the two economies and interpretable as a velocity or money demand process. While the money supply shock can be assumed imported from the U.S. through the fixed exchange rate regime, and the aggregate supply shock to either affect both economies simultaneously or to be rapidly diffused across geographic and economic boundaries, interpretation of the commonality in money demand shocks is not unambiguous. It may represent permanent shocks to the demand for North American currency or assets relative to those in Europe.

In addition to the three permanent shocks we can identify three transitory disturbances in the six variable system. The class of Keynesian small open economy models illustrated by our presentation in Section 2 suggest the transitory component will incorporate a uniquely U.S. transitory demand shock, a uniquely Canadian transitory demand shock and, under less than perfect capital market integration, possibly a uniquely Canadian transitory money supply shock. Since our interest is primarily in separately identifying international and idiosyncratic shocks we attempt only to isolate the U.S. and Canadian elements of the transitory component and not to disentangle individual sources of purely transitory disturbances. Consequently, while we exactly identify six disturbances in our system, we can place structural interpretation only on five; shocks to the three, common stochastic trends, an aggregate U.S. transitory component and an aggregate Canadian transitory component.

We identify these disturbances with both long and short-run restrictions. Exact identification requires estimation of 36 elements in $\Gamma(0)$. The covariance condition, $\Gamma(0)\Gamma(0)' = \Sigma_\epsilon$, provides 21 of these. As noted in Section 3, theory often suggests more restrictions for the structural empirical model than are needed for exact identification and we select a subset that provides close correspondence with the small open economy interpretations desired of the six disturbances. Other behavioural restrictions implied by the model (and by history) for the impulse responses and identified disturbances are used to evaluate the model's predictions (as overidentifying restrictions).

Given the unit root and cointegration test results, and the shock interpretations implied by our model, we specify and estimate the following empirical system which is the analogue to the triangular system of Section 3 ;

$$\begin{bmatrix} \Delta y_{c_t} \\ \Delta m_{c_t} \\ \Delta p_{c_t} \\ (y_{c_t} - y_{us_t}) \\ (m_{c_t} - m_{us_t} - e_t) \\ (p_{c_t} - p_{us_t} - e_t) \end{bmatrix} = \Gamma(L) \begin{bmatrix} \eta_t^{s} \\ \eta_t^{ms^{us}} \\ \eta_t^{md} \\ \eta_t^{d^{us}} \\ \eta_t^{d1^c} \\ \eta_t^{d2^c} \end{bmatrix} \tag{27}$$

Subscripts now denote country of origin and date, respectively, and superscripts denote shock type and country of origin respectively. Where shocks are common to the two economies a single superscript appears. This system is identified by applying the following restrictions.

First, in the hypothetical long-run with no new disturbances, the variables are assumed to be generated by the stochastic trend representation:

$$\begin{bmatrix} \Delta y_{c_t} \\ \Delta m_{c_t} \\ \Delta p_{c_t} \\ (y_{c_t} - y_{us_t}) \\ (m_{c_t} - m_{us_t} - e_t) \\ (p_{c_t} - p_{us_t} - e_t) \end{bmatrix} = \begin{bmatrix} \Gamma_{11}(1) & 0 & 0 & 0 & 0 & 0 \\ \Gamma_{21}(1) & \Gamma_{22}(1) & 0 & 0 & 0 & 0 \\ \Gamma_{31}(1) & \Gamma_{32}(1) & \Gamma_{33}(1) & 0 & 0 & 0 \\ \Gamma_{41}(1) & \Gamma_{42}(1) & \Gamma_{43}(1) & \Gamma_{44}(1) & \Gamma_{45}(1) & \Gamma_{46}(1) \\ \Gamma_{51}(1) & \Gamma_{52}(1) & \Gamma_{53}(1) & \Gamma_{54}(1) & \Gamma_{55}(1) & \Gamma_{56}(1) \\ \Gamma_{61}(1) & \Gamma_{62}(1) & \Gamma_{63}(1) & \Gamma_{64}(1) & \Gamma_{65}(1) & \Gamma_{66}(1) \end{bmatrix} \begin{bmatrix} \eta_t^{s} \\ \eta_t^{ms^{us}} \\ \eta_t^{md} \\ \eta_t^{d^{us}} \\ \eta_t^{d1^c} \\ \eta_t^{d2^c} \end{bmatrix} \tag{28}$$

where the last three rows of $\Gamma(1)$ are all zeros (by cointegration) which imply stationarity of the three log-level variables. The long-run zero constraints in the first three rows comprise 12 of 15 restrictions we impose on the system. We have uniquely identified three permanent disturbances, by assuming that each has a unique influence on the system, using only long-run restrictions in a lower triangular long-run multiplier matrix.[24] These restrictions, in accordance with the interpretations placed on the shocks by the model of Section 2, imply that only aggregate supply shocks matter for Canadian and U.S. outputs in the long-run, that only aggregate supply and money supply shocks matter for Canadian and U.S. money stocks in the long-run, and that all three permanent disturbances are absorbed by prices in Canada and the U.S..

In addition, we impose three short-run restrictions to just identify the empirical system. The first two of these identify the aggregate of the last two disturbances as being of uniquely Canadian origin. The third places an additional short-run restriction to identify the money supply shock as an 'exogenous' monetary policy disturbance in the U.S.. These are imposed as linear restrictions on the impact multiplier matrix, $\Gamma(0)$. The first two

$$(\Gamma_{15}(0) + \Gamma_{16}(0)) - (\Gamma_{45}(0) + \Gamma_{46}(0)) = 0 \tag{29}$$

$$(\Gamma_{25}(0) + \Gamma_{26}(0)) - (\Gamma_{55}(0) + \Gamma_{56}(0)) = 0 \tag{30}$$

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[24] See, for other lower triangular long-run identifying schemes, King, Plosser, Stock and Watson (1991) and Ahmed et al (1993).

impose a zero impact effect of the (aggregate) Canadian transitory disturbance for U.S. output and money. There should be no significant feedback from the Canadian to any variable in the U.S. economy of shocks that originate in Canada at any lag, according to our traditional small open economy model. Our identifying restrictions impose no immediate feedback to output and money. If we uncover the true Canadian component the theoretical restriction should also hold.

Finally, we assume that

$$\Gamma_{24}(0) - \Gamma_{54}(0) = 0 \tag{31}$$

This just identifies the system by imposing zero impact effect of domestic real demand disturbances for the domestic money stock in the U.S.. This is the most controversial of our identifying restrictions, although entirely consistent with our model. There are other alternative plausible restrictions that could be used to help identify the second permanent disturbance as an exogenous policy shock to the money stock implied by our model.[25] These are used as overidentifying information (see Section 2) to evaluate the model.

Our empirical model forces the data to satisfy strong long-run constraints. In particular, our specification implies that the Canadian economy is determined by international stochastic trends at the infinite horizon. However, the model also admits a significant explanatory role for purely transitory shocks of both Canadian and U.S. origin in generating short-run output fluctuations during the inter-war period. Quah (1992) shows that our multivariate permanent/transitory decomposition of macroeconomic flcutuations has sufficient structure to generate meaningful measures of the relative size of these two components. Our short-run restrictions also allow us to identify a purely domestic transitory component. We can therefore assess the relative importance both of permanent and transitory *and* of domestic and international disturbances for Canadian output fluctuations during the Great Depression.

6 Estimation Results

6.1 The Reduced Form Triangular VAR

We estimate the triangular cointegrated VAR. Standard criteria select a four lag specification and a constant term is included in each equation.[26] Some selected statistics are shown in Table 5. F-tests of the hypothesis that given blocks of lags in an equation are zero reveal that Canadian money

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[25] The U.S. money stock should not respond also to money demand disturbances (a zero short-run restriction could be imposed) at any lag, and the money supply shock should have an equal long-run impact on money and prices.

[26] Time trends are insignificant in each equation of the VAR and make no significant difference to our reduced form or structural model results.

growth responds significantly to all variables in the model, suggesting that the small open economy assumption of money supply elasticity well represents the reduced form behaviour of this variable. Inflation in Canada, moreover, is not significantly predicted by domestic money growth which also implies endogeneity of the domestic money stock. Also notable is the significance of some block of lags of the error-correction terms, $X_{2_t} - \alpha X_{1_t}$ for all of the Canadian growth rate variables.

'Quah' tests applied to the reduced form VAR confirm the F-test results; the computed value of the $\chi^2(36)$ statistic for the null hypothesis that the set of error-correction terms $[(y_c - y_{us}), (m_c - m_{us} - e), (p_c - p_{us} - e)]$ do not help predict $[\Delta y_c, \Delta m_c, \Delta p_c]$ is 103.02 which is significant at less than 1%. Similarly, the integrated part of the system helps predict the error-correction component with a test statistic computed value of 85.32. This system therefore does capture a permanent/transitory decomposition for the integrated Canadian variables.[27]

6.2 Computation of the Structural MAR

We invert the VAR, using 180 reduced form moving average coefficients as the cut off point for the reduced form moving average, and identify the structural MAR as described above using the estimated reduced form coefficients and our identifying restrictions.[28] We derive the structural moving average for the *levels* of the Canadian variables by inverting the difference operator in the difference-stationary component, X_{1_t}, of the MAR. We then generate impulse responses for each of the U.S. variables by taking linear combinations of the estimated parameters of the system $[y_c, m_c, p_c, (y_c - y_{us}), (m_c - m_{us} - e), (p_c - p_{us} - e)]$.

We calculate confidence intervals for the point estimates of the structural moving average parameters and structural innovations, and so the impulse responses, forecast error variance decompositions and historical decompositions, using Monte Carlo integration to compute the empirical distributions of these statistics. These one-standard error bands are based on specific distributional assumptions about the parameter estimates of the reduced form.[29] We report bias adjusted estimates when the bias, measured as the difference between the mean of the Monte Carlo draws and the point estimate, is large and significantly alters the results. All standard errors and biases reported have been generated from 2500 Monte Carlo draws.

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[27] This result is invariant to the presence of a time-trend in the VAR equations and to the use of the non-exchange rate adjusted U.S. money supply and price variables.

[28] The solution to $\Gamma(0)$ is derived using a non-linear system solution algorithm available in GAUSS386 (with the default program settings.

[29] Specifically, we assume that the OLS estimate of the VAR variance-covariance matrix, Σ_ϵ, is generated by an inverted-Wishart distribution, and construct a sequence of Σ_ϵ's from which we generate a sequence of the VAR parameter vector in B(L). These two sequences are then used to compute the structural model parameters using the usual identification techniques for each draw in the sequence.

6.3 The Identified Innovations

The shocks that we identify, and their one standard error bands, are shown in Figures 2a-2e. We can infer nothing about the relative importance of each in the Depression without also accounting for the estimated values and significance of the impulse response functions, however, investigating these plots helps evaluate our interpretation of the structural innovations. In particular, we can judge whether remarkable values of the point estimates are consistent with known historical events that can be associated with specific macroeconomic disturbances. In general, the identified disturbances are at least consistent with interpretations implied by the structural model.

The 1929 recession which precipitated the Depression is preceded by and coincident with several significant events. First, there is a run of significant and negative common supply shocks to output, the η_t^s, from 1929:7 onwards culminating in a large negative supply shock in November of 1929, the month following the Stock Market Crash. These are consistent with Fisher's (1933) hypothesis that negative actual and expected productivity shocks drove the U.S. economy to financial market disaster and into Depression. Second, there is a run of significant, negative autonomous money supply shocks, the $\eta_t^{ms^{us}}$, in late 1928 and early 1929 with a large negative realization in December 1929 which may represent the monetary base contraction initiated by the Federal Reserve stressed by Hamilton (1987) and Friedman and Schwartz (1963).[30] Third, there is a significant negative run of 'velocity' shocks, the η_t^{md}, during late 1928 which represent positive money demand disturbances and could reflect the rising demand for transactions balances in U.S. stock markets.[31] Finally, we identify a series of negative U.S. transitory demand shocks, the $\eta_t^{d^{us}}$, during 1929, which can be associated with Temin's (1976) autonomous demand shocks. The Canadian transitory component, captured by the aggregate $\eta^{d1^c}+\eta^{d2^c}$, is too imprecisely estimated for us to draw inference about its behaviour during 1928 and 1929.

The persistence of the Depression from 1930 to early 1933 is associated with a series of significant, negative aggregate supply shocks over that period, with some large negative autonomous money shocks in early 1930 and in early and late 1932, and with large positive velocity shocks of late 1931 and early 1933. The supply shocks are consistent with Bernanke's hypothesis about the supply effects of financial crises during this period. Similarly, the money shocks in 1930 are consistent with Hamilton's (1987) and Friedman and Schwartz's (1963) assertions that the Federal

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[30] While point estimates are also negative during the earlier deflation era in the first half of 1928, only the later realizations are significantly different from zero.

[31] While this is a permanent money demand disturbance we identify it only with the long-run restriction that it can permanently affect prices but not the money stock or output. Consequently, it has a long-run positive price effect and behaves like a 'negative' money demand disturbance ; the structural covariance Choleski decomposition is unique up to sign changes.

Reserve pursued contractionary policy during this period. We interpret the velocity shocks as speculative runs against the U.S. dollar during periods of withdrawal from the Gold Standard of key participants.

We also note the identification of significant positive supply, money supply and velocity shocks in September 1939 with the onset of World War II. These are consistent with priors about North American output, monetary policy and money demand responses to the announcement of the outbreak of war in Europe.

6.4 Results: Impulse Responses

Figures 3-8 show the response of each variable to a one standard deviation innovation to aggregate supply, money supply, and velocity, and to one standard deviation transitory shocks in the U.S. and Canada respectively. One-standard error bands are also plotted.

The response of Canadian output to the supply shock is somewhat unstable during the first few months following the innovation in contrast to the smooth response of U.S. output which rises steadily to its new permanent level. This may be attributable to different dynamic responses of Canadian and U.S. output and prices to the common shock and the consequent impact for export demand and the terms of trade. The overall response for both variables is as anticipated; large, positive, significant and increasing over a one-year period. The initially negative response of production to the money supply shock disappears rapidly.[32] Production in both countries subsequently rises within four months of the money supply shock. However, the responses are insignificant at all lags for both countries except for the very small, significant response at the very first lag for the U.S. economy. A positive velocity shock has a very small, barely significant negative effect for Canadian output at the first lag but otherwise has no significant effect on either output series at any lag. Despite large point estimates, the output responses to the transitory shocks are insignificant.

These results suggest that the data exhibit some, but not all of the dynamic implications of our structural model. For outputs, there are two (sets of) overidentifying restrictions. The first is that there should be no significant response at *any* lag of U.S. output to the uniquely Canadian shock, and this is (essentially) satisfied. Second, the model predicts that impact, and short-run dynamic, responses should significantly differ for all shocks in the two economies. This is also satisfied for the three permanent shocks in the model but not for the transitory shocks, for which short-run responses are zero.[33]

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[32] This negative output response is rationalized by transitory expected inflation effects dominating liquidity effects in nominal interest rates in some models with temporary monetary non-neutralities.

[33] The overidentifying restriction that Canadian output does not respond to domestic asset market shocks is eliminated by the finding of permanent, common money demand disturbances which affect Canadian output through

The effect of all shocks on the Canadian money stock is quite unstable at short lags which contrasts with the U.S. responses (Figures 5 and 6). The supply shock has a small, significant and positive permanent effect on both money stocks. The money supply shock has an immediate, significant positive effect on the money stocks, the permanent effects of which are almost fully realized within six months. The U.S. money stock responds insignificantly to all other shocks at all horizons. There is a very small, barely significant negative response of the money stock in Canada to the velocity shock and a positive response to the U.S. transitory shock.

The structural model's testable predictions for money stock behaviour are largely satisfied in the data. The U.S. money stock responds insignificantly to all but the domestic money supply and common real supply shocks at *all* lags, suggesting that we have successfully identified a policy driven, exogenous money supply shock. In particular, its impact response to the velocity shock is zero though unrestricted. This satisfies one set of overidentifying restrictions for U.S. money stock behaviour. Moreover, the estimated impact responses for the Canadian and U.S. money stocks *do* significantly differ in at least three cases, implying satisfaction of a second subset of testable restrictions that impact (and short-run) responses should differ across the two economies. The Canadian money stock exhibits significant short-run reponses to two of the three disturbances which do *not* affect the U.S. money stock at any lag. Furthermore, the signs of the money stock impact responses are consistent with those indicated by the model. These results imply that the predicted short-run adjustment of the Canadian money stock to all disturbances holds in the data at least for external and asset market disturbances. The model successfully replicates this implication of the small open economy model.

The price responses are illustrated in Figures 7a-7e and 8a-8e for Canada and the U.S. respectively. Prices in both economies respond positively and significantly to aggregate supply shocks at all but the first lag, and positively and significantly to the autonomous money supply and velocity shocks at all lags, but not to the transitory disturbances. The positive impact of the supply shock on the price levels is, perhaps, counterintuitive but consistent with our model in which the sign of the long-run price response to permanent output shocks depends on the relative size of money supply and money demand reponses to the disturbance. The price responses to money supply shocks have the expected sign and significance. The positive impact effect of the 'velocity' shock on price levels identifies this as a negative money demand shock; the long-run effect is significant and positive, driving the wedge between money and prices identified in the data analysis. Prices in neither economy respond significantly to the two transitory demand disturbances.

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relative price movements.

Recall that both the model and the data imply a positive, significant long-run money stock response to the supply shock, which should induce an *equal* long-run price effect. Here, while estimated short-run price effects are barely significant, the long-run price impact is positive and insignificantly different from the long-run money stock response. Moreover, accounting for confidence intervals, the long-run neutrality restriction (16) for autonomous money shocks holds. Consequently, price responses satisfy the overidentifying restrictions that shocks to money stocks have equal long-run effects for prices and, further, this neutrality result is attained well within a twelve month period.[34] U.S. prices satisfy the overidentifying restriction that there is no significant reponse of any U.S. variable to the transitory Canadian shock at any lag, with the exception of a small, significant response at lag 3.

Overall, the data fail to indicate significant short-run non-neutralities of outputs in response to each shock. The largest significant output movements derive from aggregate supply shocks implying a more classical representation than anticipated. In fact, many of these estimated impulses imply real effects for outputs, the output ratio, the terms of trade and real money balances which are quantitively limited and short-lived.

The economic model implies that one of the most important sources of transitory deviations from trend in domestic output is shifts in the terms of trade. The economic history of the global Depression has recently posed terms of trade movements as a primary mechanism for transmission of disturbances from the U.S. economy under the Gold Standard. Figure 9 plots impulse response functions and standard error bands for the terms of trade to each disturbance and shows that only permanent velocity disturbances generate significant short-run deviations of the terms of trade from its (zero-mean) equilibrium value. This reflects both the failure of prices to respond signficantly to the two transitory shocks *and* remarkable symmetry in the price responses across the two economies at all leads and lags to permanent U.S. and common shocks. The impulses imply insignificance of this mechanism for transmission of all but common velocity shocks, and such rapidity and completeness of price transmission for permanent monetary and real shocks across national boundaries that there is little support in this empirical representation for the idea the Gold Standard promoted real transmission of these shocks.

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[34] Notably, the price response to supply shocks implies that the long-run money demand response, c_1, to permanent output shocks is insignificantly different from zero. This suggests that the standard money demand function does not capture well properties of interwar data.

6.5 Results: Forecast Error Variance Decompositions

The relative effects of standardized shocks on the endogenous variables can be gauged from the forecast error variance decompositions which present the percentage of the total forecast error variance at each horizon attributable to each shock for a given variable. Again, some of the model's testable implications are unconstrained in identification and allow evaluation of the data's consistency with the model.

Table 6a shows that a high proportion of the variance in Canadian output can be accounted for by the two country-specific transitory shocks at short horizons, and by the supply shock. As the horizon increases, a rising fraction of the variance is attributable to supply, although the standard errors are large and the point estimates may overstate the rapidity of this rise. The money supply and velocity shocks play no significant role at any forecast horizon. The results are somewhat different in the U.S. case, where the two transitory shocks do not account for a significant fraction of the forecast error variance at any horizon, but the money supply shock accounts for a significant percentage at the one month horizon. These decompositions reassure us that the model's implications for exogeneity of the U.S. economy are satisfied. There is no feedback from the Canadian shock to the U.S. economy by this measure but there is a significant role for U.S. originating (transitory) shocks in Canadian output fluctuations. Additionally, by this criterion the two economies exhibit significant differences in output dynamics in response to all shocks.

The money stocks in the two countries also behave quite differently at short horizons, as shown in Tables 6c and 6d. The supply shock accounts for almost none of the Canadian money stock variance at short horizons, but a significant fraction of the U.S. money stock variance at all horizons. Its importance for Canadian money grows gradually over time, while its importance for the U.S. money stock is unambiguous at all horizons, despite large standard errors for both money stock decompositions. The standard errors do not hide the importance of autonomous money supply shocks at all horizons for both the U.S. and Canadian money stocks. Until the six month horizon a significant percentage of forecast error variance for the Canadian money stock derives from transitory Canadian shocks, suggesting that we are capturing some Canadian monetary disturbances in this component. All of the short-run forecast error variance of the U.S. money stock derives from the money supply and aggregate supply shocks.

The data therefore satisfy the short-run implication of the model that money stock behaviour differs across the two economies. They are consistent with our view that Canada is a small open economy in which the money stock adjusts endogenously to both domestic and foreign disturbances. The U.S. money stock responds only to domestic monetary policy shocks and 'endogenously' to permanent domestic output shocks. This latter characteristic of the U.S. money stock is not strongly reflected in Canadian money stock behaviour for several months suggesting there is short-run divergence between the variance of Canadian M1 and its long-run external determinants.

Tables 6e and 6f present the forecast error variance decompositions for Canadian and U.S. prices. At long forecast horizons the variance of prices in both countries is explained primarily by the velocity and money supply shocks respectively, with little signficant role for the supply shock. At short horizons the Canadian price level is also significantly influenced by the domestic transitory shock, although there is no significant role for the transitory U.S. shock, while the U.S. price forecast error variance is dominated by velocity shocks. The money supply shock plays a surprisingly small role for both variables at short horizons, however its share in price forecast error variance grows steadily as the forecast horizon is extended. In general, the price decomposition results reflect the same failure of prices to respond significantly to demand components as the impulse responses do.

Overall, these results reaffirm that our identifying assumptions have isolated a uniquely Canadian component which does not significantly impinge on fluctuations in the U.S. economy, and that the monetary implications of our small open economy model are satisfied. There is no significant component of any of the U.S. variables' forecast error variance attributable to the Canadian transitory shock at any forecast horizon although the forecast error variance of the Canadian output is significantly accounted for by both the Canadian and U.S. transitory disturbances. This suggests that while it has comparatively small importance for U.S. fluctuations, the U.S. disturbance can significantly affect the smaller, Canadian economy through export demand.

6.6 Results: Historical Error Decompositions

The preceding data analysis, estimated innovations, impulse responses and forecast error variance decompositions all reflect an empirical representation for the interwar data from Canada and the U.S. that reasonably captures the dynamics and long-run properties of a small open economy and a large external economy implied by standard Keynesian open economy models. The least satisfactory assumptions of the structural model for this data are that there will be significant non-neutralities for outputs in both economies from a wide variety of real and nominal disturbances and that terms of trade movements are a primary source of short-term transmitted output shocks for the small open economy. However, most importantly, the estimated innovations and responses appear to reflect quite well our interpretations of the shocks we identify. We therefore turn to evidence provided by the historical decompositions on the 'causes' of the Great Depression in Canada (and the U.S.) using these interpretations.

The historical decompositions shown in Figures 10-15 combine the information in the impulse response functions with the realized values of the shocks at each point in time. In particular, we depict the 12-month ahead total forecast error for the level of each variable, the forecast error due to each shock and the computed standard errors of the individual forecast error series.

In both Canada and the U.S. the total forecast error for industrial production is negative from early 1930 to early 1933, and again throughout 1938. In addition, the total forecast error for U.S. industrial production is negative in late 1927 and early 1928. In each of these cases, virtually all the forecast error can be explained by the permanent output (supply) shock (Figures 11a and 12a). With few exceptions, the other identified shocks have a relatively small and insignificant role in generating unpredictable output fluctuations. The transitory Canadian shocks appear to predict short-run domestic output dynamics well, but have no significant influence for the output collapse or recovery. However, in 1938 positive realizations of Canadian transitory shocks offset permanent output shocks, making the downturn of 1937/8 less severe in Canada than in the U.S.

Figures 16 and 17 show our decomposition results for output most starkly. These permanent/transitory decompositions plot the permanent and total transitory components of output at each date which are generated by the cumulative effects of aggregate supply shocks and the sum of money supply, velocity, and idiosyncratic shocks respectively. The time path of the total stochastic component of output is almost completely governed by the cumulative effects of aggregate supply disturbances for both countries for the sample period 1929:1-1936:12. Although transitory shocks can account for short-run fluctuations in Canada in the early part of the sample, and money supply shocks generate some pre-Depression fluctuations in the U.S., only permanent output shocks matter for output in both countries from the beginning of 1929.

The fall in output appears to be virtually monocausal, but the behaviour of money and prices is more complex. The total forecast error for money stocks in both countries is comparatively small, but is significantly negative in early 1929 and from early 1930 to early 1934 and especially large in late 1930 and late 1932. The U.S. forecast errors are entirely attributable to a combination of the permanent output and money supply shocks, while in Canada the effect of the transitory Canadian shock (which is an amalgam of both monetary and real idiosyncratic transitory shocks) is correlated with the total forecast error, although rarely significant. The unanticipated decline in money stocks reflects in part an endogenous response to the aggregate supply shocks that caused the output collapse, and in part an exogenous monetary contraction especially in the unanticipated monetary 'trough' of 1930-1931. However, as we argued above, autonomous money shock effects had no feed back into output fluctuations.

In Canada there were bouts of unanticipated deflation in early 1930 to mid-1932 and again in early 1933. On each occasion, unanticipated deflation began a few months earlier in the U.S. and, in addition, the U.S. experienced unanticipated deflation in 1938 which does not reflect in Canada. In the U.S., the monetary velocity and aggregate supply shocks contributed in roughly equal measure to the deflation of the early 30s while the hiatus from late 1931 to the end of 1932 reflected the effects of the positive velocity shock of late 1931. The story is similar for Canada with a greater, but insignificant, role for Canadian shocks.

6.7 A note on robustness

Our results proved robust to several changes in specification; most notably, inclusion of the non-exchange rate adjusted U.S. money supply and price series, of the estimated (Phillips-Hansen) error-correction terms rather than the unit valued error-correction vectors, and to the use of different price, output and money stock series for the U.S.. While small quantitative and qualitative changes do arise in the structural estimation results, the main result does not change; common, permanent shocks to output explain the onset, depth and duration of the Great Depression in Canada and the U.S..[35]

7 Conclusions

An extensive U.S. literature assumes that the global Depression of the 1930's reflected international transmission of the U.S. output collapse, initiated perhaps by Federal Reserve policy. To test this hypothesis we have estimated a small open economy model for Canada in which the U.S. represents the rest of the world. We exploit common stochastic trends in the U.S. and Canadian macroeconomies to identify international and domestically originating disturbances with standard macroeconomic interpretations and assess their relative contributions to interwar output fluctuations in both economies. We find that the onset, depth and duration of output collapse in both Canada and the U.S. can be attributed to a common, permanent output shock leaving little significant role for idiosyncratic disturbances originating in either economy. We conclude by contrasting our results with the hypotheses and empirical results reviewed in the Introduction.

We do identify the U.S. monetary contraction in late 1928 that Hamilton (1987) emphasized, and the attendant rise in transactions money demand, but these shocks are absorbed by prices and have an insignificant effect on output in both the U.S. and Canada. Similarly, while we find evidence of deflationary monetary policy in 1930 and a significant monetary contraction in 1931 and 1932 to which Friedman and Schwartz (1963) attribute the severity and persistence of the

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[35] Results available from the authors upon request.

Depression, the former has no significant output effects and the latter we find to be primarily an endogenous monetary contraction as Temin (1976) argued. Idiosyncratic U.S. demand shocks are significant during 1929, as Temin and Romer (1990) asserted, but equally have no output effects in either economy. Consequently, our results reject explanations of the global Depression which emphasize international transmission of autonomous monetary and real disturbances originating in the U.S.

Our evidence also is not supportive of the more general hypothesis that Canada imported the Depression through the collapse of export demand or of export prices. The symmetry of output behaviour in Canada and the U.S. and the insignificance of terms of trade movements in response to all but common asset market disturbances suggest that the Depression in Canada derived from the same sources as that in the U.S. economy rather than being transmitted through the collapse of export demand. These same symmetry results challenge the views of Temin (1991) and Eichengreen (1992) that the Depression was propagated worldwide from the U.S. through the Gold Standard. However, we cannot separately identify the purely domestic short-run effects of common disturbances from the effects due to transmission of short-run U.S. responses to the same disturbances. Consequently, while our results do not support it, we cannot *rule out* a significant role for a Gold Standard or export demand transmitted contraction originating in the aggregate supply collapse.

The implications of our results for Bernanke's (1983) hypothesis are unclear. Bernanke argued that bank failures, and financial crises more generally, caused a protracted 'monetary' non-neutrality due to the investment and consequent supply-side effects of the decline in efficient credit intermediation arrangements. Since we cannot isolate different sources of supply disturbances with our empirical model, any permanent output effects of credit market disruptions during the 1931-1933 era will be captured by our identified supply shocks. Our finding that there was significant unanticipated deflation in 1930-1931 which could engender bankruptcies and financial crises, as both Bernanke and Fisher (1933) have argued lends support to this interpretation.

Our results are also consistent with hypotheses, such as those of Fisher (1933), Bernstein (1987) and Safarian (1959) that emphasize secular factors in explaining the Depression. Moreover, they indicate that these factors were continent-wide, and potentially global, providing a rationalization for the synchronicity of the international output collapse.

References

[1] Ahmed, S., B.W. Ickes, P.Wang and B.S. Yoo (1993) 'International Business Cycles' *American Economic Review*, **83** : pp. 335-359

[2] Barro, R. (1979) 'Money And The Price Level Under The Gold Standard' *Economic Journal*, **89** : pp. 13-33

[3] Bernanke, B.S. (1983) 'Nonmonetary Effects Of Financial Crises In The Propagation Of The Great Dpression' *American Economic Review*, **73** : pp. 257-276

[4] Bernanke, B.S. (1986) 'Alternative Explanations Of The Money - Income Correlation' *Carnegie-Rochester Conference Series On Public Policy*, **25**: pp.49-99

[5] Bernanke, B.S. and H. James (1991) 'The Gold Standard, Deflation And Financial Crises In The Great Depression: An International Comparison' in Hubbard, R.G. (ed.) *Financial Markets And Financial Crises* Chicago : University of Chicago Press

[6] Bernstein, M. (1987) *The Great Depression* New York : Cambridge University Press

[7] Blanchard, O.J. and D. Quah (1989) 'The Dynamic Effects of Aggregate Supply And Demand Disturbances' *American Economic Review*, **79** : pp.655-673

[8] Blanchard, O.J. and D. Quah (1993) 'The Dynamic Effects of Aggregate Supply And Demand Disturbances : Reply' *American Economic Review*, **83** : pp.653-658

[9] Bordo, M.D. and A. Redish (1990) 'Credible Commitment And Exchange Rate Stability : Canada's Interwar Experience' *Canadian Journal of Economics*, **23** : pp. 357-380

[10] Calomiris, C.W. (1993) 'Financial Factors In The Great Depression' *Journal of Economic Perspectives*, **7** : pp. 61-85

[11] Cecchetti, S.G. and G. Karras (1993) 'Sources Of Output Fluctuations During The Interwar Period: Further Evidence On The Causes Of The Great Depression' *Review of Economics and Statistics*: forthcoming.

[12] Dickey, D.A. and W.A. Fuller (1979) 'Distribution Of The Estimators For Autoregressive Time Series With A Unit Root' *Journal of The American Statistical Association*, **74**: pp.427-431

[13] Dickey, D.A. and W.A. Fuller (1981) 'Likelihood Ratio Statistics For Autoregressive Time Series With A Unit Root' *Econometrica*, **49** : pp.1057-1072

[14] Eichengreen, B. (1990) *Elusive Stability* Cambridge : Cambridge University Press

[15] Eichengreen, B. (1992) *Golden Fetters* Oxford : Oxford University Press

[16] Engle, R.F. and C.W.J. Granger (1987) 'Cointegration And Error-Correction : Representation, Estimation And Testing' *Econometrica*, **55** : pp. 251-276

[17] Fackler, J. and R. Parker (1990) 'Accounting For The Great Depression : An Historical Decomposition' Unpublished Working Paper

[18] Field, A. (1984) 'Asset Exchanges And The Transactions Demand For Money 1919-1929' *American Economic Review*, **74** : pp. 489-498

[19] Friedman, M. and A.J. Schwartz (1963) *A Monetary History of the U.S. 1867-1960* Princeton : Princeton University Press

[20] Friedman, M. and A.J. Schwartz (1970) *Monetary Statistics of the United States* New York : NBER

[21] Fuller, W.A. (1976) *Introduction to Statistical Time Series* New York : Wiley

[22] Gali, J. (1992) 'How Well Does The ISLM Model Fit Post-War U.S. Data?' *Quarterly Journal of Economics*, **107** : pp. 709-738

[23] Green, A. and G. Sparks (1988) 'A Macro Interpretation Of Recovery: Australia and Canada' in Gregory, R.G. and N.G. Butlin, (eds.) *Recovery From The Great Depression* Cambridge : Cambridge University Press

[24] Hamilton, J. (1987) 'Monetary Factors In The Great Depression' *Journal of Monetary Economics*, **22** : pp. 145-169

[25] Haubrich, J. (1990) 'Nonmonetary Effects Of Financial Crises: Lessons From The Great Depression' *Journal of Monetary Economics*, **25** : pp. 223-252

[26] Johansen, S. and K. Juselius (1990) 'Maximum Likelihood Estimation And Inference On Cointegration - With Applications To The Demand For Money' *Oxford Bulletin of Economics and Statistics*, **52** : pp. 169-210

[27] Kindleberger, C.P. (1984) *A Financial History of Western Europe* London : George Allen Unwin (Publishers) Ltd.

[28] King, R.G., C.I.Plosser, J.H.Stock and M.W.Watson (1991) 'Stochastic Trends And Economic Fluctuations' *American Economic Review*, **81** : pp.819-840

[29] Lippi, M. and L. Reichlin (1993) 'The Dynamic Effects Of Aggregate Demand And Supply Disturbances : Comment' *American Economic Review*, **83** : pp.644-657

[30] McCallum, B.T. (1989) *Monetary Economics: Theory and Policy* New York : Macmillan

[31] McClosky, D.N. and J.R. Zecher (1976) 'How The Gold Standard Worked, 1880-1913' in J.A. Frenkel and H.G. Johnson (eds.) *The Monetary Approach to the Balance of Payments* London : Allen and Unwin

[32] Metcalf, C., A. Redish and R. Shearer (1993) 'New Estimates Of The Canadian M1 Supply' University of British Columbia, in progress

[33] Ouliaris, S. (1991) 'Gauss Procedures for Cointegrated Regression Models' Version 1.0

[34] Phillips, P.C.B. (1987) 'Time Series Regression With Unit Roots' *Econometrica*, **55** : pp. 277-302

[35] Phillips, P.C.B. (1991) 'Optimal Inference In Cointegrated Systems' *Econometrica*, **59** : pp. 283-306

[36] Phillips, P.C.B. and S. Ouliaris (1990) 'Asymptotic Properties Of Residual Based Tests For Cointegration' *Econometrica*, **58** : pp. 165-193

[37] Quah, D. (1992) 'The Relative Importance of Permanent and Transitory Components: Identification And Some Theoretical Bounds' *Econometrica*, **60** : pp.107-118

[38] Romer, C. (1990) 'The Great Crash And The Onset Of The Great Depression' *Quarterly Journal of Economics*, **105** : pp. 597-624

[39] Romer, C. (1993) 'The Nation In Depression' *Journal of Economic Perspectives*, **7** : pp. 19-39

[40] Safarian, E. (1959) *The Canadian Economy in the Great Depression* Toronto : University of Toronto Press

[41] Said, E. and D.A. Dickey (1984) 'Testing For Unit Roots In Autoregressive Moving Average Models Of Unknown Order' *Biometrika*, **71** : pp. 599-607

[42] Sims, C. (1980) 'Macroeconomics And Reality' *Econometrica*, **48** : pp. 1-48

[43] Temin, P. (1976) *Did Monetary Forces Cause The Great Depression?* New York : Norton

[44] Temin, P. (1991) *Lessons From The Great Depression* Cambridge, Mass. : MIT Press

[45] Temin, P. (1993) 'Transmission Of The Great Depression' *Journal of Economic Perspectives*, **7** : pp. 87-102

[46] Urquhart, M.C. and K.A. Buckley (1965) *Historical Statistics of Canada* Toronto : Macmillan

[47] United States Department of Commerce (1975) *Historical Statistics of the U.S.* Washington : Bureau of the Census

[48] Wright, G. (1990) 'The Origins Of American Industrial Success 1879-1940' *American Economic Review*, **80** : pp. 651-668

Table 1 : Data Sources and Notation

All series are monthly, and deterministically seasonally adjusted except the nominal exchange rate series which has no significant seasonal component. Logarithms are used throughout the analysis except in the data plots presented in Figures 1a-1f which employ an index number of the level of each series, setting 1935-1939=100. All series which are expressed as indexes in *raw* form (industrial production and price variables) are re-indexed to a 1935-1939 =100 base prior to application of the logarithmic transformation.

- y_c is the log of industrial production index, Canada, (1935-1939=100) from the *Monthly Review of Business Statistics*, published in various issues by the Dominion Bureau of Statistics, Canada
- y_{us} is the log of industrial production index, U.S., (1935-1939=100) from the Federal Reserve Board of Governors, U.S.
- m_c is the log of M1 money stock, Canada, from Metcalfe, Redish and Shearer (1993)
- m_{us} is the log of M1 money stock, U.S., from Friedman and Schwartz (1970), Table 1
- p_c is the log of wholesale price index, Canada, (1935-1939=100), published in various issues of *Prices and Price Indexes* by the Dominion Bureau of Statistics
- p_{us} is the log of wholesale price index, U.S., (1935-1939=100), from various issues of *Statistical Abstract of the U.S.*, published by the U.S. Department of Commerce
- e is the log of (noon) nominal spot exchange rate in $C / $U.S., from various issues of *Prices and Price Indexes*, published by the Dominion Bureau of Statistics. Specifically, the monthly average of closing rates in Montreal.
- v_c is the log of velocity in Canada, computed as $y_c+p_c-m_c$ with data sources as above
- v_{us} is the log of velocity in Canada, computed as $y_{us}+p_{us}-m_{us}$ with data sources as above

Table 2 : Descriptive Statistics

Table 2a : Descriptive Statistics (Log Levels)

Series	Sample	Date of Minimum Value	Date of Maximum Value	Standard Deviation	Mean	Correlation with y_c
y_c	25:01-39:12	33:02	29:01	0.182	4.479	1.000
	25:01-28:12	25:04	28:05	0.132	4.452	1.000
	29:01-33:12	33:02	29:01	0.233	4.395	1.000
	34:01-39:12	34:02	39:12	0.122	4.566	1.000
y_{us}	25:01-39:12	32:07	39:12	0.192	4.484	0.857
	25:01-28:12	25:06	28:10	0.044	4.542	0.792
	29:01-33:12	32:07	29:05	0.235	4.357	0.947
	34:01-39:12	34:11	39:12	0.160	4.550	0.865
m_c	25:01-39:12	33:01	39:12	0.139	6.535	0.843
	25:01-28:12	25:07	28:06	0.082	6.493	0.857
	29:01-33:12	33:01	29:12	0.144	6.468	0.907
	34:01-39:12	34:01	39:12	0.146	6.620	0.894
$(m_{us} + e)$	25:01-39:12	33:11	39:12	0.134	7.887	0.661
	25:01-28:12	28:04	25:01	0.017	7.868	0.611
	29:01-33:12	33:11	29:10	0.085	7.807	0.610
	34:01-39:12	34:01	39:12	0.164	7.966	0.899
p_c	25:01-39:12	33:02	25:02	0.150	4.669	0.352
	25:01-28:12	28:12	25:01	0.028	4.861	-0.741
	29:01-33:12	33:02	29:08	0.150	4.606	0.941
	34:01-39:12	34:01	37:07	0.055	4.592	0.730
$(p_{us} + e)$	25:01-39:12	33:01	25:03	0.121	4.656	0.325
	25:01-28:12	27:04	25:03	0.035	4.811	-0.771
	29:01-33:12	33:01	29:07	0.115	4.601	0.888
	34:01-39:12	34:03	39:12	0.055	4.600	0.720

Table 2b : Cross-Correlation Matrix (Log Levels)

Series	y_c	y_{us}	m_c	$(m_{us} + e)$	p_c	$(p_{us} + e)$
y_c	1.00	*	*	*	*	*
y_{us}	0.86	1.00	*	*	*	*
m_c	0.84	0.74	1.00	*	*	*
$(m_{us} + e)$	0.66	0.67	0.88	1.00	*	*
p_c	0.35	0.56	0.18	0.16	1.00	*
$(p_{us} + e)$	0.32	0.57	0.17	0.22	0.97	1.00

Table 2c : Descriptive Statistics (Log Differences)

Series	Sample	Date of Minimum Value	Date of Maximum Value	Standard Deviation	Mean
$\Delta\ y_c$	25:02-39:12	31:06	29:01	0.060	0.003
	25:02-29:01	26:12	29:01	0.072	0.012
	29:02-34:01	31:06	30:01	0.066	-0.008
	34:02-39:12	35:03	34:05	0.042	0.007
$\Delta\ y_{us}$	25:02-39:12	29:12	33:05	0.045	0.021
	25:02-29:01	27:11	29:01	0.025	0.004
	29:02-34:01	29:12	33:05	0.058	-0.007
	34:02-39:12	37:11	34:12	0.041	0.008
$\Delta\ m_c$	25:02-39:12	30:01	25:12	0.035	0.003
	25:02-29:01	28:01	25:12	0.036	0.004
	29:02-34:01	30:01	33:12	0.034	-0.004
	34:02-39:12	39:04	35:03	0.033	0.008
$\Delta\ (m_{us}+e)$	25:02-39:12	29:11	39:09	0.022	0.003
	25:02-29:01	28:06	28:12	0.011	0.001
	29:02-34:01	29:11	33:12	0.029	-0.004
	34:02-39:12	35:09	39:09	0.019	0.010
$\Delta\ p_c$	25:02-39:12	30:12	39:09	0.013	-0.001
	25:02-29:01	25:04	25:11	0.010	-0.002
	29:02-34:01	30:12	33:07	0.015	-0.005
	34:02-39:12	38:08	39:09	0.014	0.002
$\Delta\ (p_{us}+e)$	25:02-39:12	32:01	39:09	0.018	-0.001
	25:02-29:01	25:04	25:07	0.008	-0.002
	29:02-34:01	32:01	31:10	0.020	-0.005
	34:02-39:12	37:11	39:09	0.019	0.003

Notes :

All series in logarithms and deterministically seasonally adjusted except the nominal exchange rate which has no significant seasonal component. Data analysis for the U.S. price level and M1 money stock shows that these variables have properties qualitatively similar to their exchange rate adjusted counterparts, and so only the latter results are reported in the interest of clarity.

Table 3 : Non-Stationarity Test Results

Table 3a : Tests For Non-stationarity (Log Levels)

Series	$\hat{Z}_{\alpha_\tau}$	$\hat{Z}_{t_\tau}$	$\hat{T}_\tau(1)$	$\hat{T}_\tau(4)$	$\hat{T}_\tau$ (6)
y_c	-6.21	-1.72	-1.57	-1.53	-1.70
y_{us}	-5.53	-1.45	-1.66	-1.54	-1.13
m_c	-2.29	-0.72	-0.92	-0.36	-0.40
$(m_{us}+e)$	1.05	0.39	0.70	-0.06	-0.10
p_c	-1.28	-0.59	-0.73	-0.10	-1.25
$(p_{us}+e)$	-2.52	0.79	-0.97	-0.91	-1.02
v_c	-9.45	-2.23	-2.10	-1.69	-1.89
v_{us}	-8.23	-1.97	-2.13	-2.13	-1.57

Table 3b : Tests For Non-Stationarity (Log Differences)

Series	$\hat{Z}_{\alpha_\tau}$	$\hat{Z}_{t_\tau}$	$\hat{T}_\tau(1)$	$\hat{T}_\tau(4)$	$\hat{T}_\tau$ (6)
Δ y_c	-224.63***	-18.50***	-11.78***	-5.98***	-4.70***
Δ y_{us}	-123.97***	-9.780***	-8.18***	-6.56***	-4.97***
Δ m_c	-177.79***	-15.46***	-12.27***	-5.94***	-4.63***
Δ $(m_{us}+e)$	-203.51***	-13.72***	-7.270***	-5.61***	-4.13***
Δ p_c	-117.53***	-9.350***	-7.20***	-3.85**	-3.27*
Δ $(p_{us}+e)$	-138.74***	-10.67***	-8.20***	-5.55***	-3.94**
Δ v_c	-206.31***	-18.64***	-13.24***	-6.48***	-5.23***
Δ v_{us}	-129.87***	-10.10***	-7.990***	-6.32***	-4.83***

Notes :

* denotes significance at the 15% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level. $\hat{Z}_{\alpha_\tau}$ and $\hat{Z}_{t_\tau}$ are computed values of the Phillips (1987) statistics for the null hypothesis that the series is non-stationary around a first order polynomial time trend and constant term. Four autocovariance terms are used to compute the spectrum at frequency zero. $\hat{T}_{\tau(k)}$ is the computed value of the Said and Dickey (1984) (Augmented Dickey-Fuller (1979, 1981)) statistic for the same null hypothesis, where k is the number of lagged first difference terms included in the test regression. Critical values tabulated in Phillips and Ouliaris (1990), Fuller (1976) and from Ouliaris (1991). The time series properties of the U.S. money supply and price level series are qualitatively the same as those for their exchange rate adjusted counterparts and so only the latter are reported.

Table 4 : Cointegration Test Results

Table 4a : Univariate Cointegration Tests

Dependent Variable	Independent Variable	$\hat{Z}_{\alpha_\mu}$	$\hat{Z}_{t_\mu}$	$\hat{T}_\mu(1)$	$\hat{T}_\mu(4)$	$\hat{T}_\mu(6)$
m_c	$(m_{us}+e)$	-22.71**	-3.59**	-3.52**	-2.91	-3.18*
p_c	$(p_{us}+e)$	-22.39**	-3.25**	-3.17*	-3.28*	-2.78
v_c	v_{us}	-58.88***	-6.05***	-4.56***	-4.16***	-4.43***
m_c	p_c	-0.05	-0.02	-0.31	0.35	0.23
m_{us}	p_{us}	-2.20	-1.30	1.60	0.70	0.69
$(m_c - p_c)$	y_c	-2.75	-0.25	-1.38	-0.83	-1.07
$(m_{us} - p_{us})$	y_{us}	-2.75	-1.21	-0.21	-0.44	-0.16
$(m_c - p_c)$	$(m_{us} - p_{us})$	-26.33***	-3.96**	-3.76**	-2.90*	-2.96*

Table 4b : Univariate Cointegration Tests (Constrained Coefficients)

Series	$\hat{Z}_{\alpha_\mu}$	$\hat{Z}_{t_\mu}$	$\hat{T}_\mu(1)$	$\hat{T}_\mu(4)$	$\hat{T}_\mu(6)$
$(y_c - y_{us})$	-29.16***	-4.28***	-4.01***	-3.54***	-3.67***
$(m_c - m_{us} - e)$	-23.07***	-3.58***	-3.46**	-2.89**	-3.16**
$(p_c - p_{us} - e)$	-11.47*	-2.39*	-2.26	-2.80*	-2.41*
$(v_c - v_{us})$	-51.03***	-5.57***	-4.41***	-4.48***	-4.67***
$(m_c - p_c)$	-1.48	-0.81	-1.03	-0.63	-0.85
$(m_{us} - p_{us})$	0.43	0.25	0.34	-0.00	-0.21
$(m_c - p_c) - (m_{us} - p_{us})$	-23.83***	-3.85***	-3.70***	-2.89**	-2.99**

Table 4c : Multivariate Cointegration Tests

Series	$\hat{J}_{t_\mu}(0)$	$\hat{J}_{m_\mu}(0)$	$\hat{J}_{t_\mu}(3)$	$\hat{J}_{m_\mu}(3)$
$y_c, m_c, p_c, y_{us}, (m_{us}+e), (p_{us}+e)$	121.0***	54.80***	18.14	11.71
y_c, y_{us}	21.89**	20.00***	n/a	n/a
$m_c, (m_{us}+e)$	12.50*	11.50*	n/a	n/a
$p_c, (p_{us}+e)$	19.86**	16.94**	n/a	n/a
v_c, v_{us}	41.92***	18.37**	n/a	n/a
m_c, p_c	3.800	3.800	n/a	n/a
m_{us}, p_{us}	3.800	3.600	n/a	n/a
$(m_c - p_c), y_c$	5.200	4.700	n/a	n/a
$(m_{us} - p_{us}), y_{us}$	4.600	3.900	n/a	n/a
$(m_c - p_c), (m_{us} - p_{us})$	13.52*	13.50*	n/a	n/a

Table 4 cont.

Table 4d : Multivariate Cointegrating Vector Estimates

Series	FM Estimate	SJ Estimate
y_c, y_{us}	(1, -0.85)	(1, -0.96)
m_c, $(m_{us}+e)$	(1, -0.95)	(1, -1.06)
p_c, $(p_{us}+e)$	(1, -1.21)	(1, -1.26)
v_c, v_{us}	(1, -0.85)	(1, -0.93)
$(m_c\text{-}p_c)$,$(m_{us}\text{-}p_{us})$	(1, -1.11)	(1, -1.11)

Notes :

Notes for **Tables 4a** and 4b as for **Tables 3a** and **3b**. The test statistics for the unconstrained coefficient tests are applied to the residuals from the cointegrating regressions of the Dependent Variable on the Independent Variable in **Table 4a**, as in non-stationarity tests in **Table 4b**. We report results for the case in which a constant term, μ, is included in the test regressions. The cointegration results for the U.S. money supply and price level series are qualitatively similar to those for their exchange rate adjusted counterparts and so only the latter are reported. In **Table 4c**, $\hat{J}_{t_\mu}$(K) and $\hat{J}_{m_\mu}$(K) are computed values of the Johansen and Juselius (1990) trace and maximum eigenvalue test statistics for the null hypothesis that there are K cointegrating vectors in the specified system. Critical values from Johansen and Juselius (1990) and Ouliaris (1991). Column 2 in **Table 4d** gives the Phillips-Hansen Fully Modified estimates of the cointegrating vectors. Column 3 gives normalized estimates derived from those generated from the Johansen tests for **Table 4c**.

Table 4 cont.

Table 4d : Multivariate Cointegrating Vector Estimates

Series	FM Estimate	SJ Estimate
y_c, y_{us}	(1, -0.85)	(1, -0.96)
m_c, $(m_{us}+e)$	(1, -0.95)	(1, -1.06)
p_c, $(p_{us}+e)$	(1, -1.21)	(1, -1.26)
v_c, v_{us}	(1, -0.85)	(1, -0.93)
(m_c-p_c),$(m_{us}-p_{us})$	(1, -1.11)	(1, -1.11)

Notes :

Notes for **Tables 4a** and **4b** as for **Tables 3a** and **3b**. The test statistics for the unconstrained coefficient tests are applied to the residuals from the cointegrating regressions of the Dependent Variable on the Independent Variable in **Table 4a**, as in non-stationarity tests in **Table 4b**. We report results for the case in which a constant term, μ, is included in the test regressions. The cointegration results for the U.S. money supply and price level series are qualitatively similar to those for their exchange rate adjusted counterparts and so only the latter are reported. In **Table 4c**, $\hat{J}_{t_\mu}$(K) and $\hat{J}_{m_\mu}$(K) are computed values of the Johansen and Juselius (1990) trace and maximum eigenvalue test statistics for the null hypothesis that there are K cointegrating vectors in the specified system. Critical values from Johansen and Juselius (1990) and Ouliaris (1991). Column 2 in **Table 4d** gives the Phillips-Hansen Fully Modified estimates of the cointegrating vectors. Column 3 gives normalized estimates derived from those generated from the Johansen tests for **Table 4c**.

Table 5 : VAR Results (1925:1-1939:12)

Table 5a : VAR F-statistics

Variable/ Equation	Δy_c	Δm_c	Δp_c	(y_c-y_{us})	$(m_c-m_{us}-e)$	$(p_c-p_{us}-e)$	R^2
Δy_c	2.68**	2.35**	0.03	6.09***	2.98**	1.16	0.27
Δm_c	3.47***	2.52**	2.91**	5.05***	10.37***	5.72***	0.35
Δp_c	1.80*	2.00*	3.94***	1.63*	0.63	2.77**	0.22
(y_c-y_{us})	8.15***	1.92*	0.83	49.97***	1.98*	0.62	0.75
$(m_c-m_{us}-e)$	2.17*	2.26*	2.04*	4.69***	49.76***	4.80***	0.74
$(p_c-p_{us}-e)$	1.07	0.77	0.34	1.59*	1.26	180.34***	0.89

Notes :

The rows give value of F-statistics for each equation in the VAR system. This statistic evaluates the null hypothesis that the block of lags pertaining to the variable in each column is zero. * denotes rejection of the null at 20%, ** at 5% and *** at 1% . Final column gives adjusted R^2 for the equation.

Table 6 : Structural Model (1925:1-1939:12)

Table 6a : Forecast Error Variance Decomposition For Canadian Output (y_c)

Forecast Horizon	Supply Shock	Money Shock	Velocity Shock	U.S. Transitory Shock	Canadian Transitory Shock
1 month	28.7 (18.4)	7.3 (13.3)	2.3 (10.5)	33.1 (19.5)	28.7 (26.7)
3 months	49.0 (20.5)	5.4 (11.7)	2.2 (10.0)	23.3 (15.0)	24.1 (20.9)
6 months	71.1 (22.3)	3.0 (10.2)	1.5 (9.3)	12.0 (12.6)	12.4 (15.2)
12 months	86.6 (22.3)	1.4 (10.5)	0.8 (8.9)	5.4 (10.8)	5.8 (10.6)
24 months	93.9 (18.7)	0.6 (10.1)	0.4 (7.6)	2.5 (7.2)	2.6 (6.6)
36 months	96.0 (15.7)	0.4 (9.2)	0.2 (6.3)	1.6 (5.2)	1.7 (4.8)
120 months	98.9 (6.0)	0.1 (4.3)	0.1 (2.2)	0.5 (1.2)	0.5 (1.4)

Table 6b : Forecast Error Variance Decomposition For U.S. Output (y_{us})

Forecast Horizon	Supply Shock	Money Shock	Velocity Shock	U.S. Transitory Shock	Canadian Transitory Shock
1 month	62.9 (25.0)	20.0 (18.3)	0.3 (10.9)	16.8 (19.2)	0.0 (0.0)
3 months	77.4 (24.0)	7.4 (13.4)	0.2 (10.2)	13.4 (17.8)	1.6 (3.6)
6 months	87.9 (23.1)	3.2 (11.7)	0.2 (9.7)	7.8 (14.9)	0.9 (4.3)
12 months	92.4 (21.4)	1.6 (11.2)	0.2 (9.1)	5.4 (10.9)	0.4 (3.3)
24 months	95.3 (18.6)	0.9 (10.4)	0.1 (8.0)	3.4 (7.3)	0.2 (2.7)
36 months	96.6 (16.2)	0.6 (9.6)	0.1 (7.0)	2.4 (5.5)	0.2 (2.2)
120 months	98.8 (7.8)	0.2 (5.7)	0.0 (2.8)	0.8 (1.8)	0.1 (0.8)

Table 6 cont.

Table 6c : Forecast Error Variance Decomposition For Canadian Money (m_c)

Forecast Horizon	Supply Shock	Money Shock	Velocity Shock	U.S. Transitory Shock	Canadian Transitory Shock
1 month	11.3 (14.5)	31.7 (18.9)	3.8 (12.5)	5.4 (18.1)	47.9 (24.9)
3 months	12.3 (12.9)	59.6 (19.9)	1.8 (9.1)	3.8 (12.3)	22.5 (16.2)
6 months	22.1 (15.1)	61.9 (20.1)	1.2 (7.9)	2.4 (10.4)	12.4 (13.2)
12 months	26.7 (16.8)	65.3 (20.6)	0.6 (7.5)	1.2 (7.8)	6.2 (9.9)
24 months	29.2 (18.9)	66.8 (21.4)	0.3 (6.5)	0.6 (5.3)	3.1 (6.5)
36 months	29.8 (20.2)	67.5 (21.9)	0.2 (5.5)	0.4 (3.9)	2.1 (4.8)
120 months	30.6 (23.7)	68.6 (23.8)	0.1 (2.2)	0.1 (1.0)	0.6 (1.5)

Table 6d : Forecast Error Variance Decomposition For U.S. Money (m_{us}+e)

Forecast Horizon	Supply Shock	Money Shock	Velocity Shock	U.S. Transitory Shock	Canadian Transitory Shock
1 month	56.7 (26.3)	40.4 (25.7)	2.9 (18.6)	0.0 (0.0)	0.0 (0.0)
3 months	48.0 (23.7)	47.7 (24.4)	3.3 (17.1)	0.8 (1.8)	0.1 (3.1)
6 months	45.9 (22.6)	51.0 (24.0)	1.7 (15.4)	1.1 (2.7)	0.2 (4.5)
12 months	42.7 (21.8)	55.3 (23.5)	0.8 (13.0)	0.8 (2.9)	0.3 (4.9)
24 months	38.4 (20.9)	60.5 (22.4)	0.4 (9.3)	0.5 (2.9)	0.2 (3.9)
36 months	36.3 (21.1)	62.9 (22.3)	0.3 (7.2)	0.4 (2.5)	0.1 (3.2)
120 months	32.8 (23.8)	67.0 (23.9)	0.1 (2.3)	0.1 (0.8)	0.0 (1.0)

Table 6 cont.

Table 6e : Forecast Error Variance Decomposition For Canadian Prices (p_c)

Forecast Horizon	Supply Shock	Money Shock	Velocity Shock	U.S. Transitory Shock	Canadian Transitory Shock
1 month	1.4 (7.8)	16.5 (11.2)	34.3 (20.9)	9.8 (18.1)	38.0 (23.5)
3 months	11.2 (12.2)	20.5 (12.9)	32.2 (20.0)	9.3 (17.6)	26.9 (20.6)
6 months	20.1 (14.9)	26.7 (15.0)	23.6 (17.8)	10.6 (16.5)	18.3 (17.6)
12 months	31.4 (17.3)	26.6 (15.6)	23.6 (17.4)	10.3 (10.8)	8.0 (12.0)
24 months	35.7 (20.1)	25.9 (16.3)	28.1 (17.8)	7.1 (7.5)	3.2 (7.0)
36 months	35.1 (21.6)	26.5 (17.0)	31.3 (18.2)	5.1 (5.1)	2.0 (5.0)
120 months	29.9 (24.7)	29.2 (19.1)	38.9 (19.5)	1.4 (1.2)	0.5 (1.4)

Table 6f : Forecast Error Variance Decomposition For U.S. Prices ($p_{us}+e$)

Forecast Horizon	Supply Shock	Money Shock	Velocity Shock	U.S. Transitory Shock	Canadian Transitory Shock
1 month	17.6 (19.6)	4.5 (11.2)	75.1 (22.3)	0.4 (9.1)	2.3 (12.4)
3 months	21.9 (19.2)	13.4 (13.3)	63.2 (21.6)	0.7 (8.3)	0.8 (10.3)
6 months	28.0 (19.7)	19.8 (15.0)	50.1 (20.8)	1.6 (8.0)	0.4 (8.8)
12 months	30.9 (21.2)	24.3 (16.7)	43.0 (20.8)	1.5 (6.2)	0.3 (6.7)
24 months	31.2 (22.7)	26.7 (17.7)	41.0 (20.7)	1.0 (4.2)	0.1 (4.8)
36 months	30.5 (23.3)	27.7 (18.2)	40.9 (20.6)	0.8 (3.1)	0.1 (3.7)
120 months	28.1 (25.1)	29.8 (19.6)	41.9 (20.5)	0.2 (0.9)	0.0 (1.2)

Notes :

Table 7 presents the % forecast error variance attributable to each shock at the forecast horizons indicated. A 0.0 indicates a measured value of less than 0.05%. Standard errors are in parentheses, calculated by Monte Carlo procedures (described in Section 5) with results based on 2500 draws. Sensitivity analysis, involving the use of the Fully-Modified cointegrating vector estimates (see **Table 5b**) rather than the unit cointegrating vectors and of the non-exchange rate adjusted U.S. money supply and price series, indicates robustness of the model to minor specification changes and we report only structural results for the baseline model. Other results avaliable upon request from the authors.

Figure 1a: Industrial Production Indices

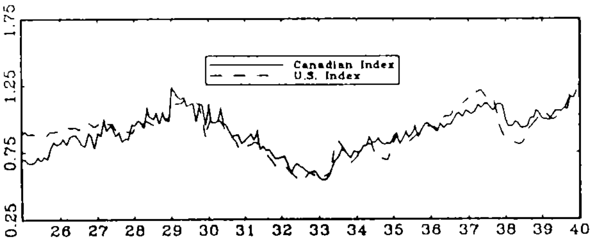


Figure 1b: M1 Velocity Indices

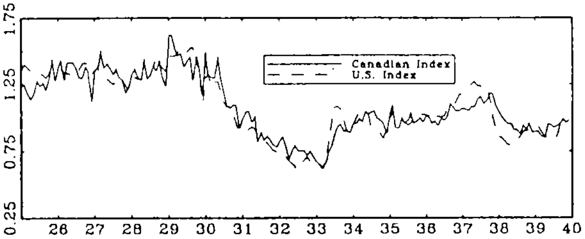


Figure 1c: Wholesale Price Indices

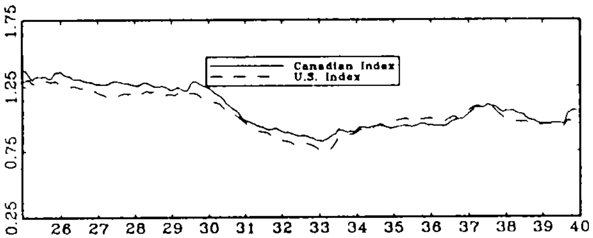


Figure 1d: M1 Money Stock Indices

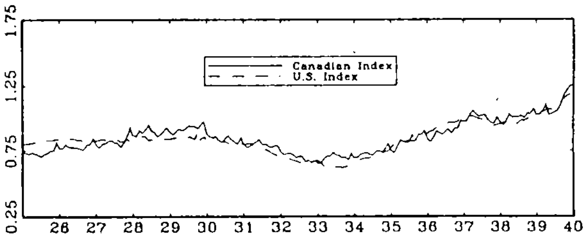


Figure 1e: Common Currency Price Indices

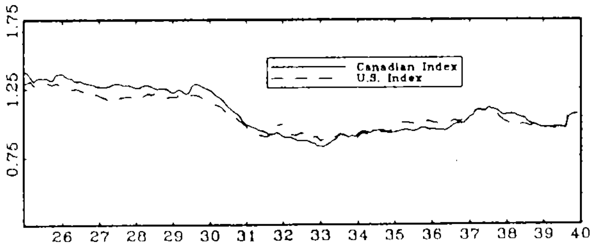


Figure 1f: Common Currency M1 Indices

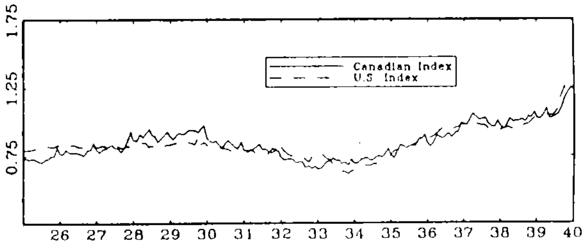


Figure 2a: Permanent Supply Shock

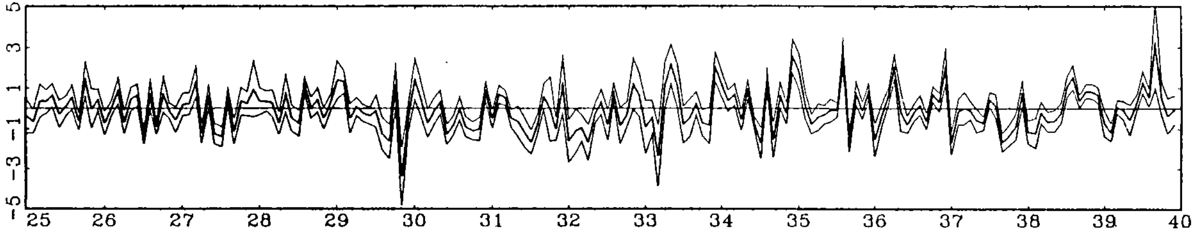


Figure 2b: Permanent Money Shock

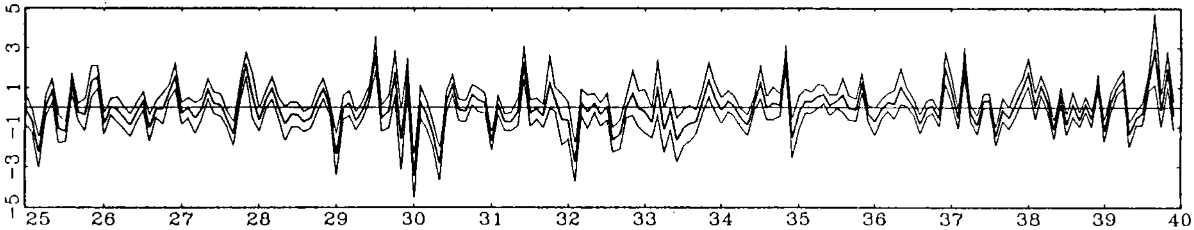


Figure 2c: Permanent Velocity Shock

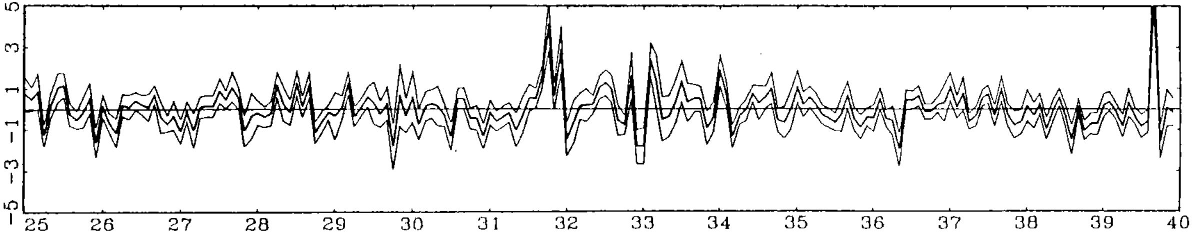


Figure 2d: Transitory U.S. Shock

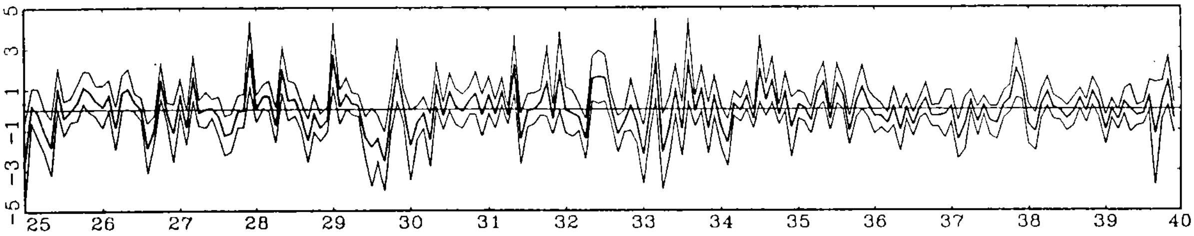


Figure 2e: Transitory Canadian Shock

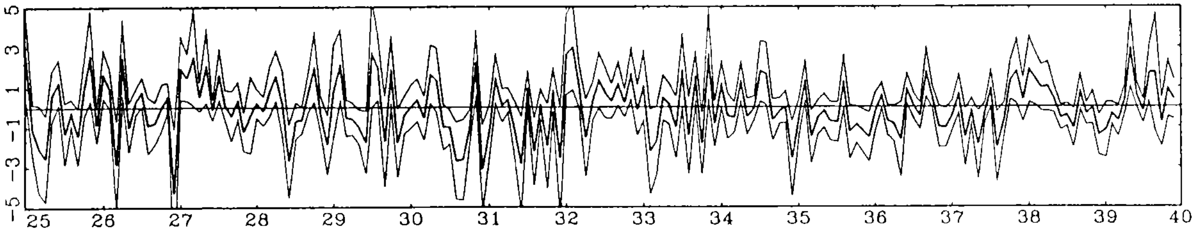


Figure 3a: Yc Response to Supply Shock

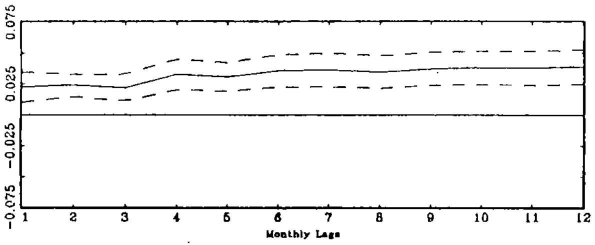


Figure 4a: Yus Response to Supply Shock

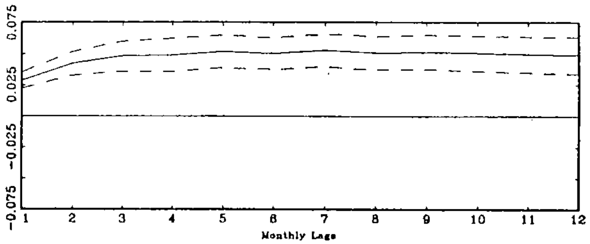


Figure 3b: Yc Response to Money Shock

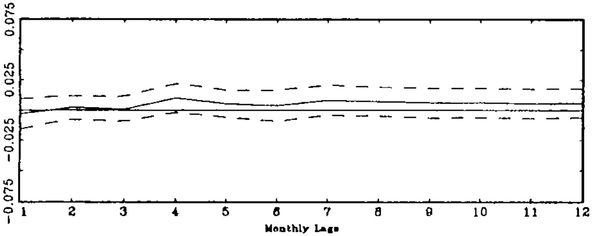


Figure 4b: Yus Response to Money Shock

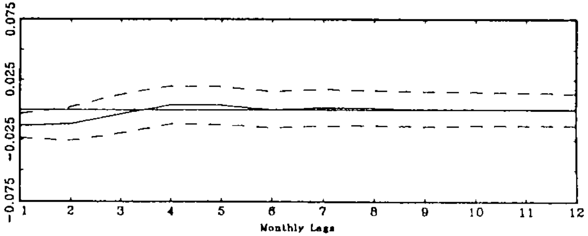


Figure 3c: Yc Response to Velocity Shock

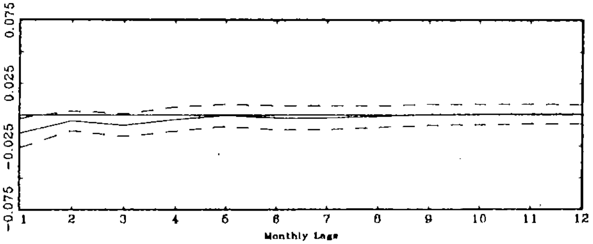


Figure 4c: Yus Response to Velocity Shock

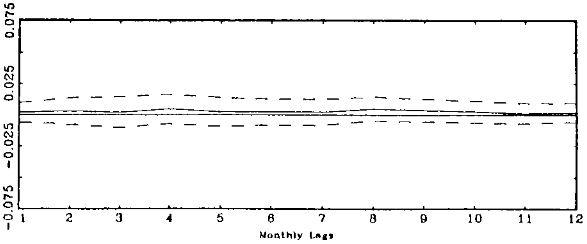


Figure 3d: Yc Response to U.S. Transitory Shock
(bias adjusted)

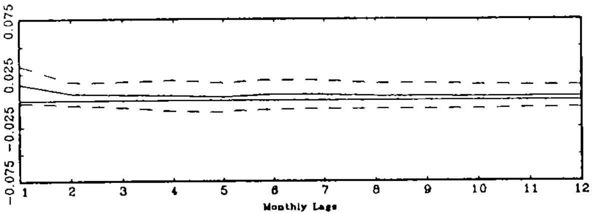


Figure 4d: Yus Response to U.S. Transitory Shock
(bias adjusted)

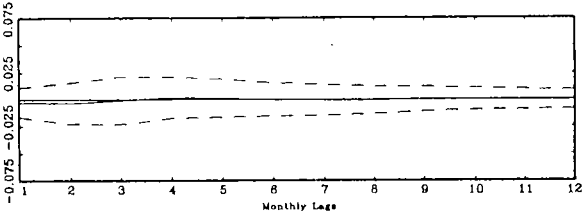


Figure 3e: Yc Response to Cdn. Transitory Shock
(bias adjusted)

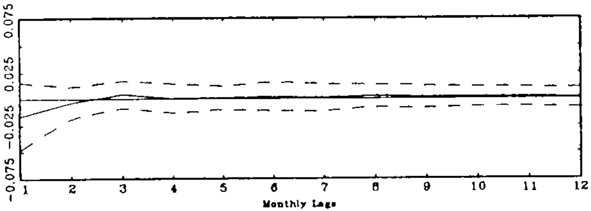


Figure 4e: Yus Response to Cdn. Transitory Shock
(bias adjusted)

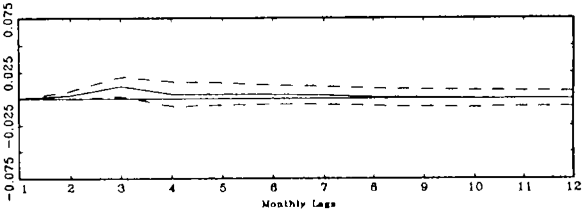


Figure 5a: Mc Response to Supply Shock

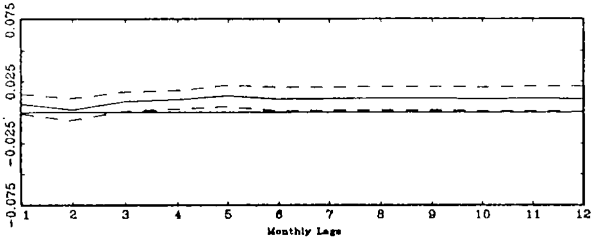


Figure 5b: Mc Response to Money Shock

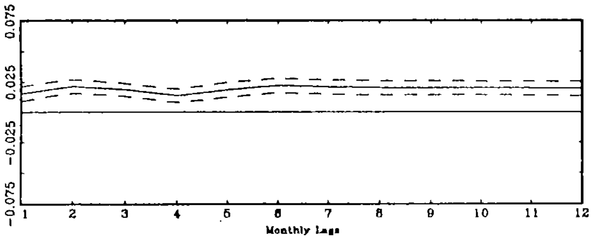


Figure 5c: Mc Response to Velocity Shock

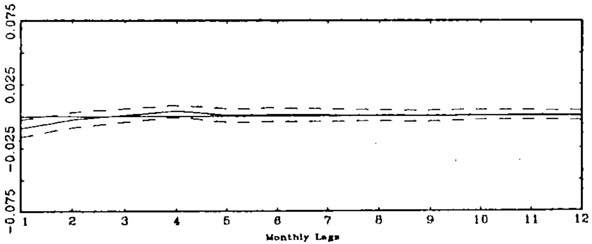


Figure 6a: Mus Response to Supply Shock

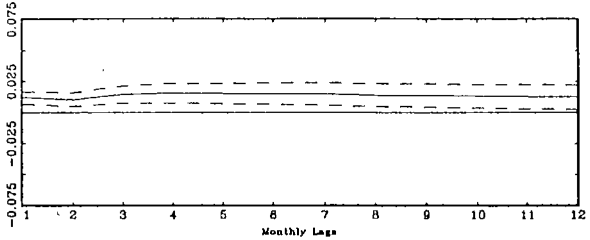


Figure 6b: Mus Response to Money Shock

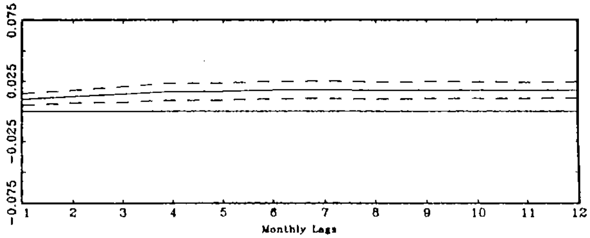


Figure 6c: Mus Response to Velocity Shock

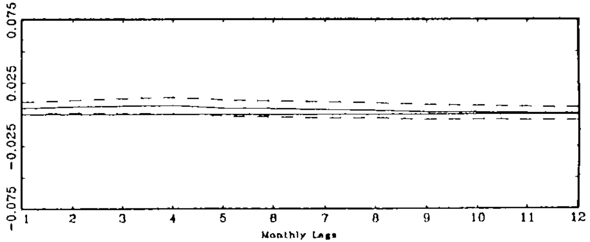


Figure 5d: Mc Response to U.S. Transitory Shock
(bias adjusted)

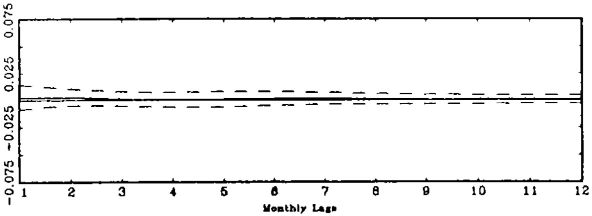


Figure 6d: Mus Response to U.S. Transitory Shock
(bias adjusted)

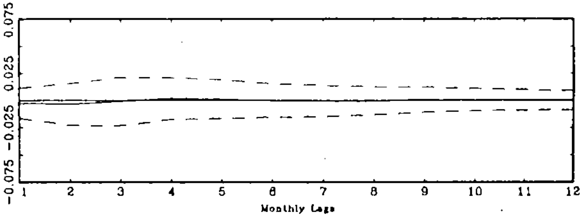


Figure 5e: Mc Response to Cdn. Transitory Shock
(bias adjusted)

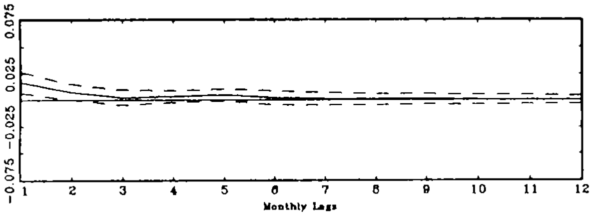


Figure 6e: Mus Response to Cdn. Transitory Shock
(bias adjusted)

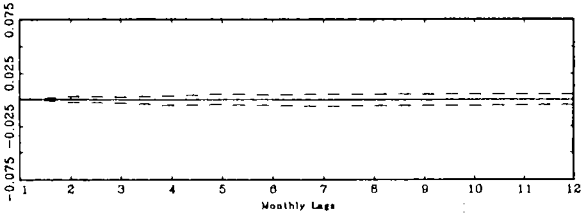


Figure 7a: Pc Response to Supply Shock

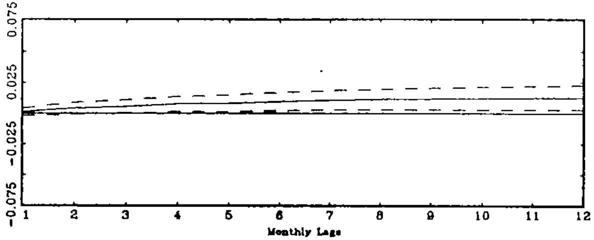


Figure 7b: Pc Response to Money Shock

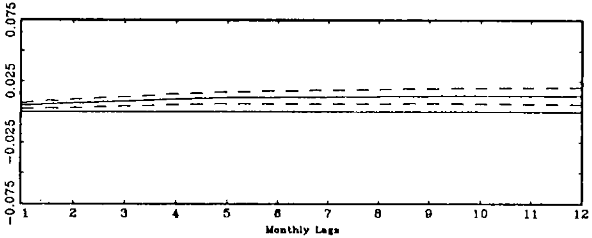


Figure 7c: Pc Response to Velocity Shock

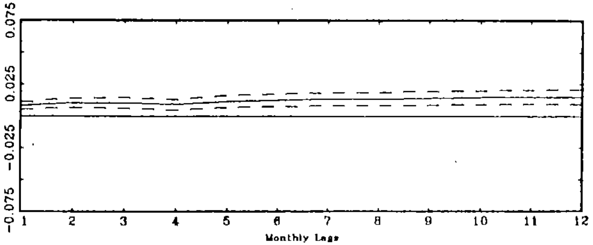


Figure 8a: Pus Response to Supply Shock

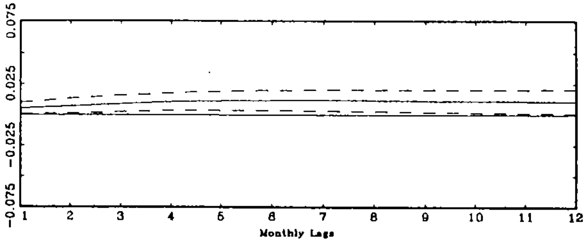


Figure 8b: Pus Response to Money Shock

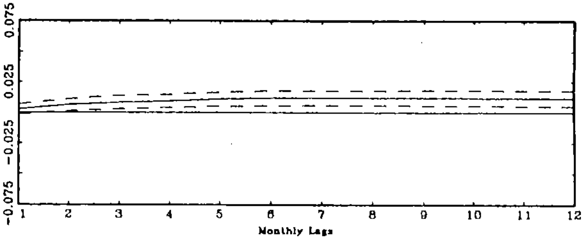


Figure 8c: Pus Response to Velocity Shock

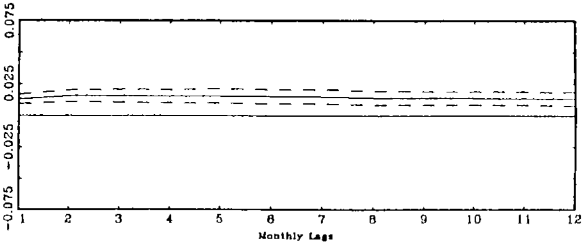


Figure 7d: Pc Response to U.S. Transitory Shock
(bias adjusted)

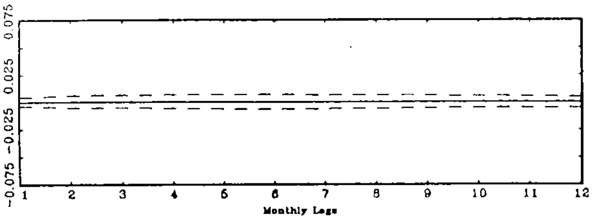


Figure 7e: Pc Response to Cdn. Transitory Shock
(bias adjusted)

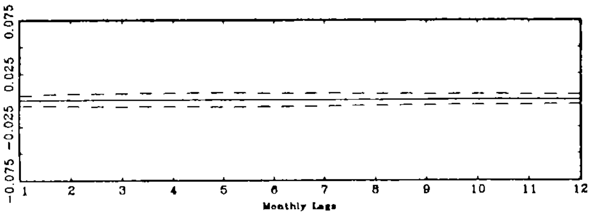


Figure 8d: Pus Response to U.S. Transitory Shock
(bias adjusted)

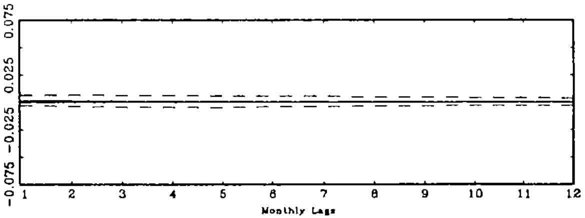


Figure 8e: Pus Response to Cdn. Transitory Shock
(bias adjusted)

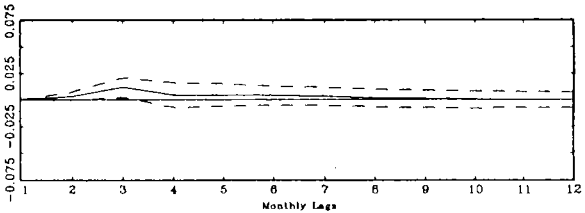


Figure 9a: (Pc−Pus−e) Response to Supply Shock
(bias adjusted)

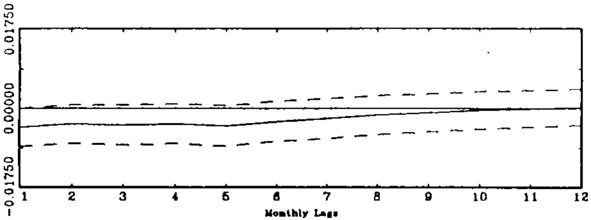


Figure 9b: (Pc−Pus−e) Response to Money Shock

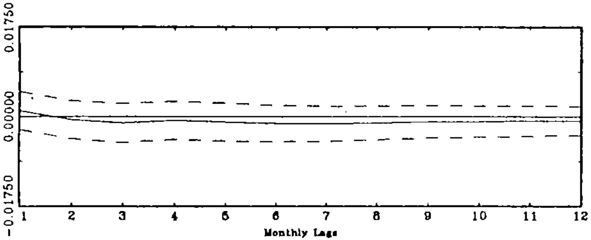


Figure 9c: (Pc−Pus−e) Response to Velocity Shock
(bias adjusted)

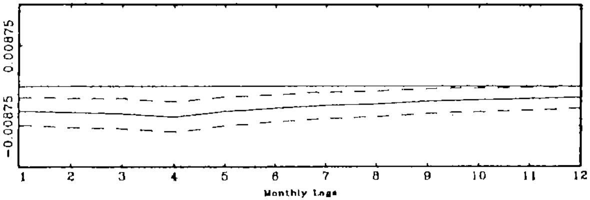


Figure 9d: (Pc−Pus−e) Response to U.S. Transitory Shock
(bias adjusted)

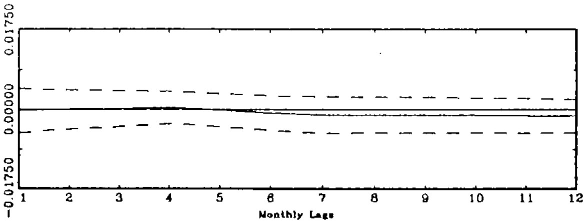


Figure 9e: (Pc−Pus−e) Response to Cdn. Transitory Shock
(bias adjusted)

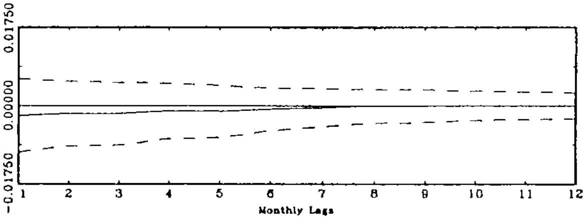


Figure 10a: Yc Historical Decomposition (Supply)

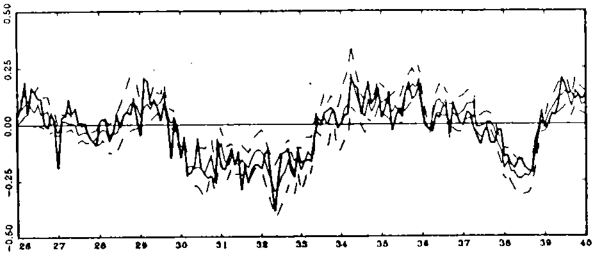


Figure 10b: Yc Historical Decomposition (Money)

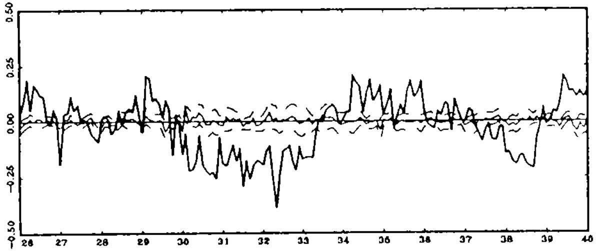


Figure 10c: Yc Historical Decomposition (Velocity)

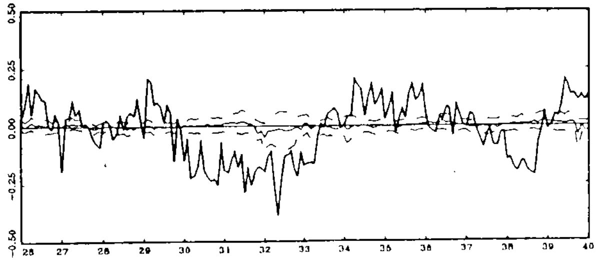


Figure 11a: Yus Historical Decomposition (Supply)

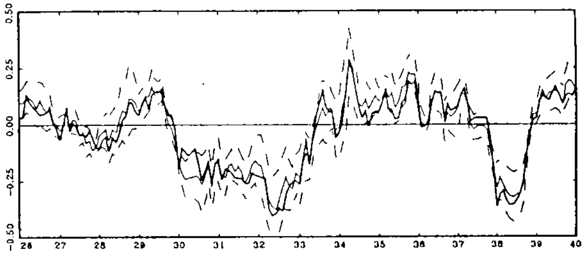


Figure 11b: Yus Historical Decomposition (Money)

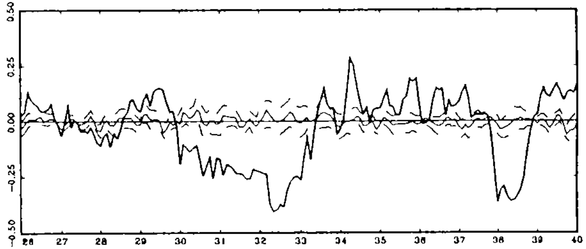
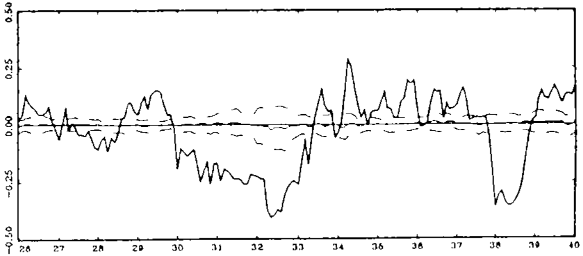


Figure 11c: Yus Historical Decomposition (Velocity)



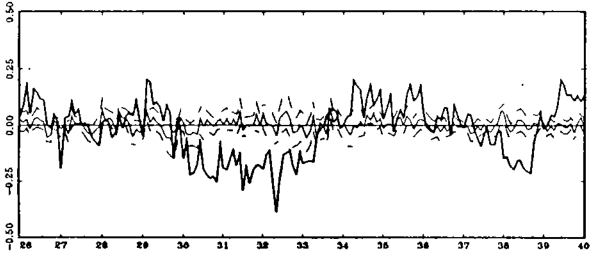


Figure 10d: Yc Historical Decomposition (US Transitory)

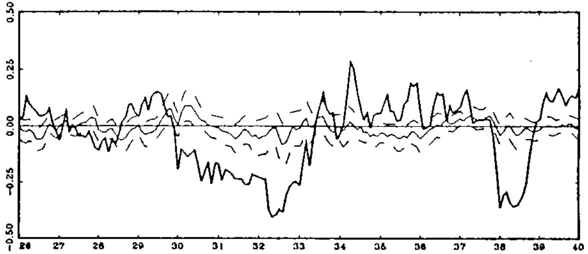


Figure 11d: Yus Historical Decomposition (US Transitory)

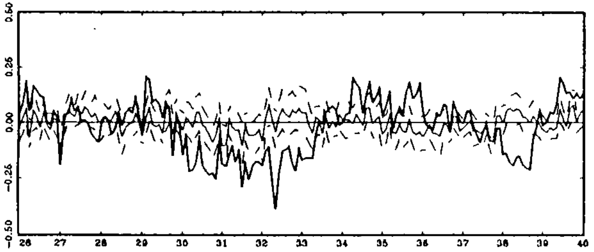


Figure 10e: Yc Historical Decomposition (Cdn Transitory)

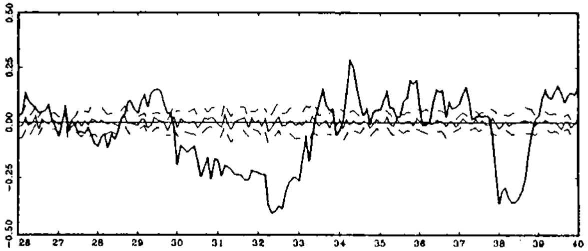


Figure 11e: Yus Historical Decomposition (Cdn Transitory)

Figure 12a: Mc Historical Decomposition (Supply)

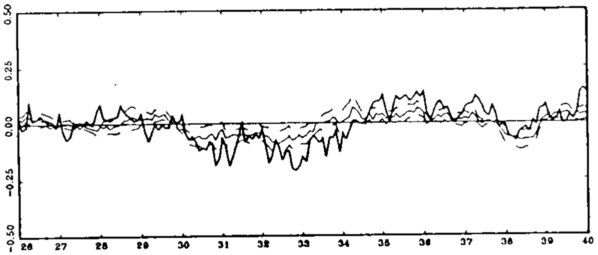


Figure 12b: Mc Historical Decomposition (Money)

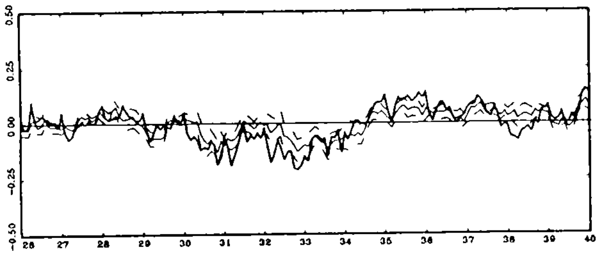


Figure 12c: Mc Historical Decomposition (Velocity)

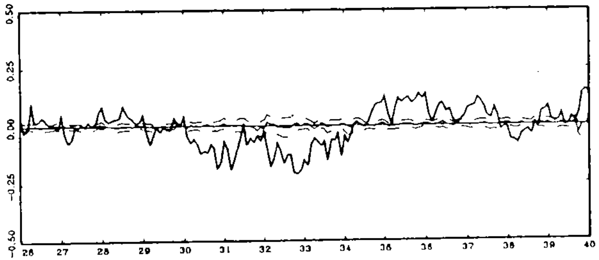


Figure 13a: Mus Historical Decomposition (Supply)

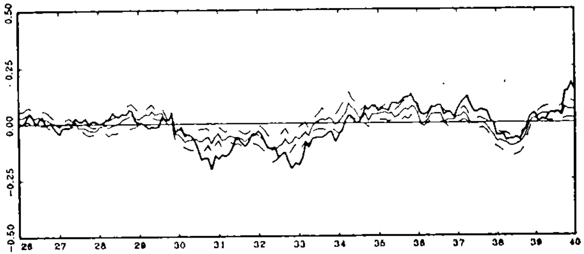


Figure 13b: Mus Historical Decomposition (Money)

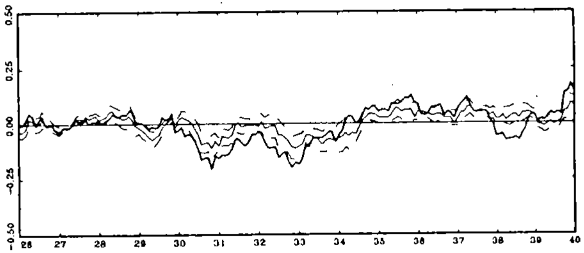


Figure 13c: Mus Historical Decomposition (Velocity)

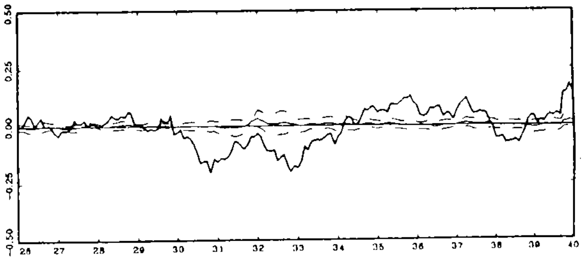


Figure 12d: Mc Historical Decomposition (US Transitory)

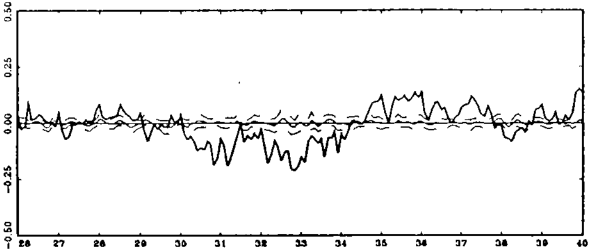


Figure 13d: Mus Historical Decomposition (US Transitory)

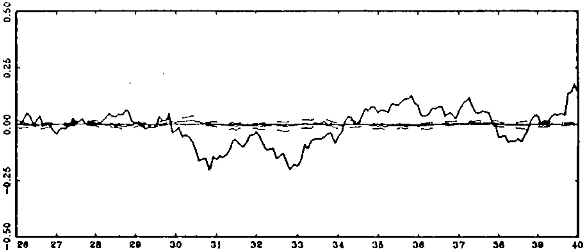


Figure 12e: Mc Historical Decomposition (Cdn. Transitory)

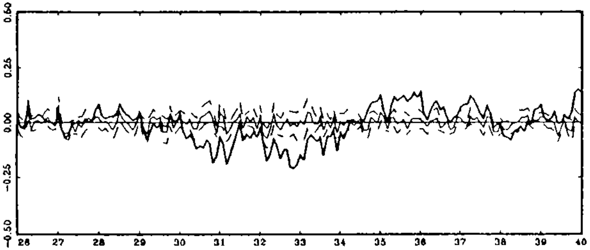


Figure 13e: Mus Historical Decomposition (Cdn. Transitory)

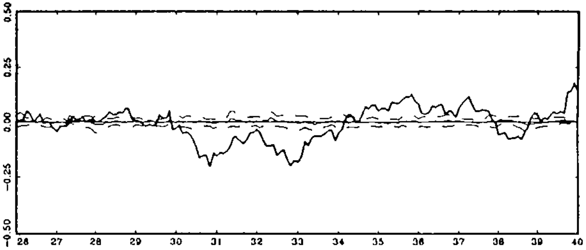


Figure 14a: Pc Historical Decomposition (Supply)

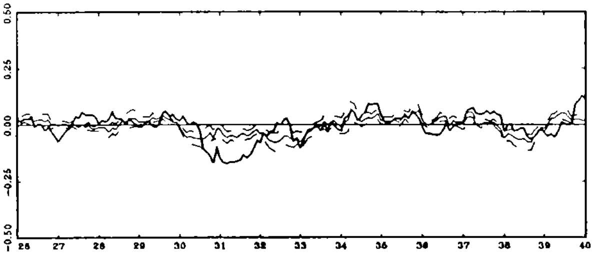


Figure 14b: Pc Historical Decomposition (Money)

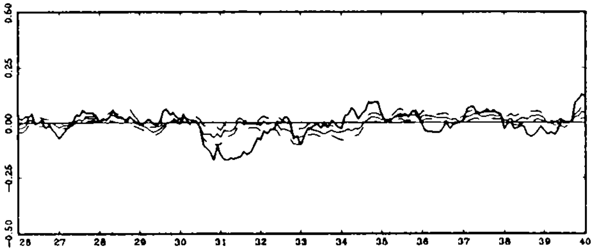


Figure 14c: Pc Historical Decomposition (Velocity)

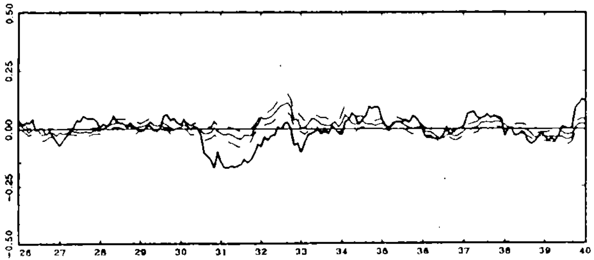


Figure 15a: Pus Historical Decomposition (Supply)

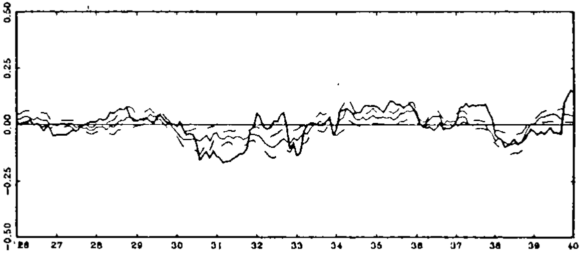


Figure 15b: Pus Historical Decomposition (Money)

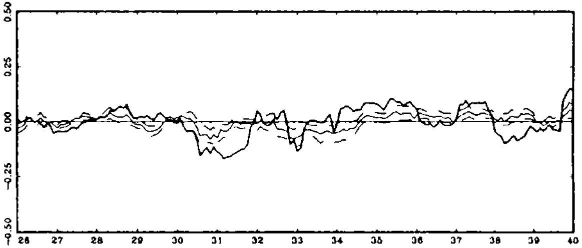
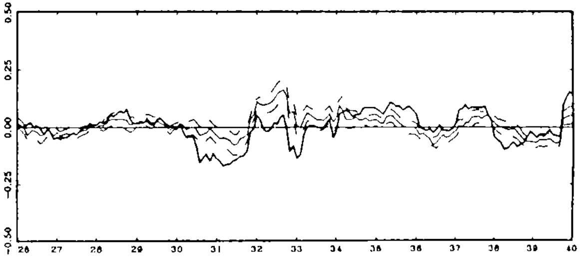


Figure 15c: Pus Historical Decomposition (Velocity)



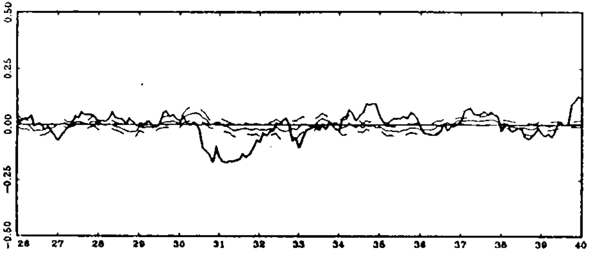


Figure 14d: Pc Historical Decomposition (US Transitory)

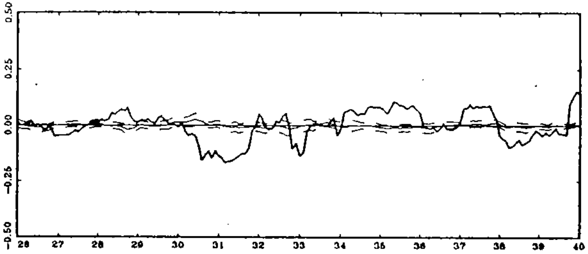


Figure 15d: Pus Historical Decomposition (US Transitory)

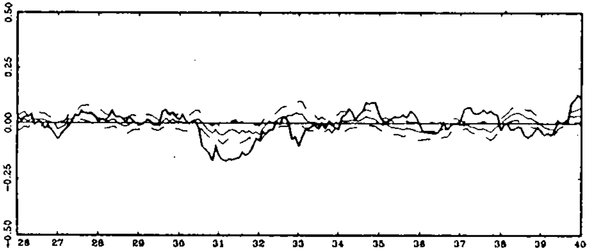


Figure 14e: Pc Historical Decomposition (Cdn. Transitory)

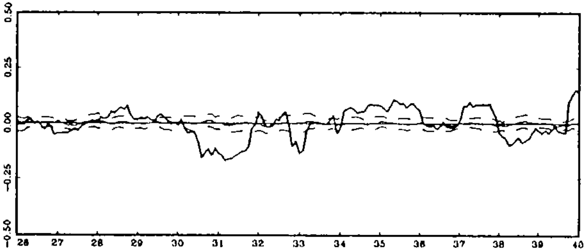


Figure 15e: Pus Historical Decomposition (Cdn. Transitory)

Figure 16a: Yc Permanent Component

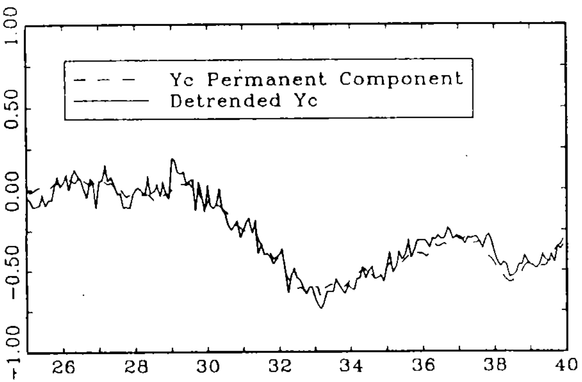


Figure 17a: Yus Permanent Component

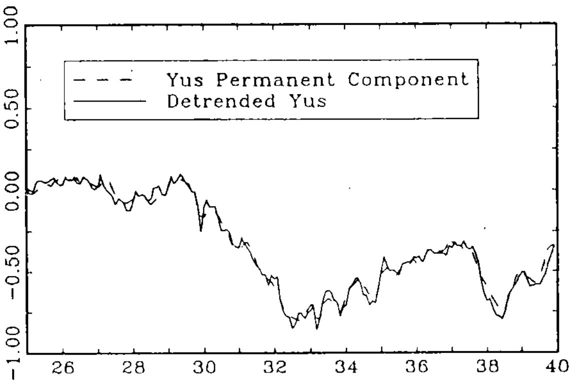


Figure 16b: Yc Total Transitory Component

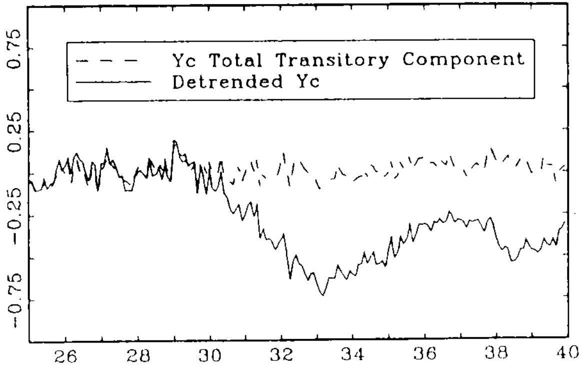


Figure 17b : Yus Total Transitory Component