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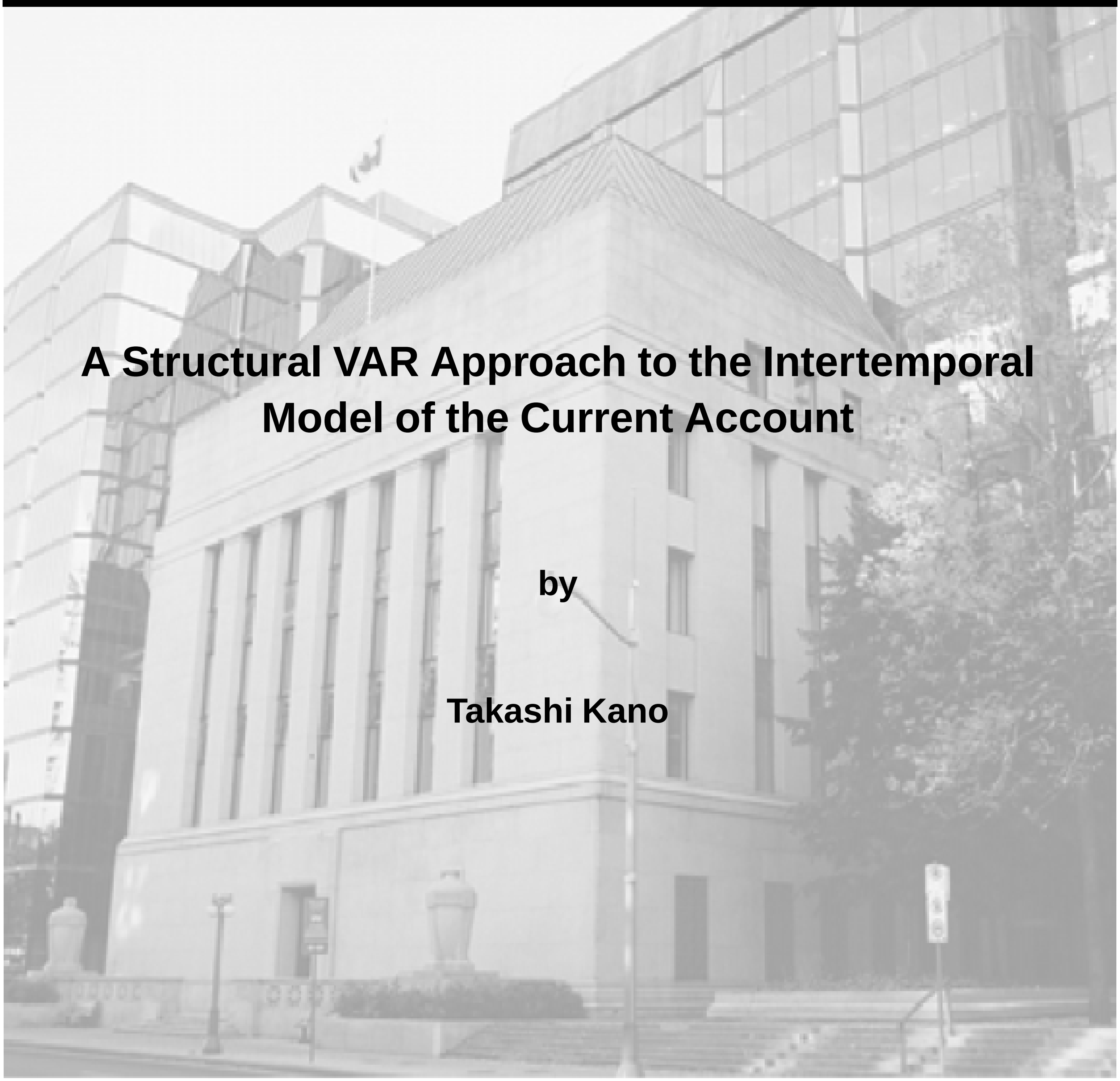

A Structural VAR Approach to the Intertemporal Model of the Current Account

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Takashi Kano

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Takashi Kano

International Department
Bank of Canada
Ottawa, Ontario, Canada K1A 0G9
tkano@bankofcanada.ca

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Abstract

The intertemporal current account approach predicts that the current account of a small open economy is independent of global shocks, and that responses of the current account to country-specific shocks depend on the persistence of the shocks. The author shows that these predictions impose cross-equation restrictions (CERS) on a structural vector autoregression (SVAR). To test the CERs, the author develops identification schemes of the SVAR that exploit the orthogonality of the world real interest rate to country-specific shocks as well as the lack of a long-run response of net output to transitory shocks. Tests of the SVAR reveal two puzzling aspects of the Canadian and U.K. current account: (i) the response of the current account to a country-specific transitory shock is too large, and (ii) the fluctuations in the current account are dominated by country-specific transitory shocks that explain almost none of the fluctuations in net output growth.

JEL classification: F32, F41
Bank classification: Balance of payments and components

Résumé

Selon l'approche intertemporelle, la balance courante d'une petite économie ouverte n'est pas influencée par les chocs mondiaux et sa réaction aux chocs nationaux dépend de la persistance de ceux-ci. L'auteur montre que ces prédictions impliquent l'imposition de contraintes interéquations à un vecteur autorégressif structurel (VARS). Pour tester ces contraintes, il élabore des schémas d'identification qui présupposent l'orthogonalité du taux d'intérêt réel mondial aux chocs nationaux et l'absence d'une réaction à long terme de la production nette aux chocs passagers. L'auteur étudie l'évolution des balances courantes du Canada et du Royaume-Uni. Les tests qu'il effectue sur les VARS font ressortir deux illogismes : i) le solde de la balance courante de ces deux pays réagit de façon excessive aux chocs nationaux transitoires; ii) les fluctuations de ce solde sont principalement attribuables à des chocs nationaux transitoires qui n'expliquent à peu près aucune des variations de la croissance de la production nette.

Classification JEL : F32, F41
Classification de la Banque : Agrégats monétaires

1. Introduction

The intertemporal current account approach provides an analytical framework within which to study the current account movements of a small open economy by emphasizing the forward-looking behaviour of economic agents.[1] The key message of the intertemporal approach is that the current account reflects the behaviour of consumers in a small open economy who smooth consumption against country-specific shocks by borrowing and lending in international capital markets. A global shock, however, does not give consumers an opportunity to smooth consumption, given that all economies are assumed to be homogeneous and to react symmetrically to the shock. Thus, a global shock has no effect on the current account of a small open economy in this framework.

The present value model (PVM) of the current account clearly expresses this consumption-smoothing motive in current account fluctuations as a linear closed-form solution of the intertemporal model.[2] With the assumption of a constant, exogenous world real interest rate, the PVM predicts that the response of the current account to a country-specific shock depends on the persistence of the shock. For instance, when domestic consumers face a temporary rise in income due to a country-specific shock, they lend out to the rest of the world to smooth consumption, and therefore the current account moves into surplus. On the other hand, if a rise in income is expected to be permanent, the current account should not change, because a permanent shock to net output cannot be smoothed away.

This paper tests and evaluates the predictions of the intertemporal approach to the current account and the PVM regarding current account responses to three shocks to net output (i.e., output net of investment and government spending): global, country-specific permanent, and country-specific transitory. For this purpose, the paper provides its own identification schemes. The three shocks are identified by a structural vector autoregression (SVAR) with two restrictions. The first restriction stems from the assumption of a small open economy. This assumption restricts the world real interest rate to be orthogonal to any country-specific shock at all forecast horizons. Together with the assumption of a small open economy, allowing the world real interest rate to vary stochastically makes it possible to identify global and country-specific shocks. The second restriction stems from the assumption that transitory shocks have no long-

[1]The small open-economy optimal growth model of Hamada (1966) is an explicit precursor to the intertemporal approach to the current account. Obstfeld and Rogoff (1995) provide an excellent review of this approach.

[2]Sheffrin and Woo (1990), Otto (1992), Ghosh (1995), and Bergin and Sheffrin (2000) jointly test the cross-equation restrictions the PVM formula imposes on an unrestricted vector autoregression, by applying the methodology originally developed by Campbell (1987) and Campbell and Shiller (1987) to test theories of consumption and stock prices. Their tests statistically reject the basic PVM's cross-equation restrictions in the G-7 economies, except for the United States.

run effect on net output. This long-run restriction, based on Blanchard and Quah (1989), decomposes country-specific shocks into permanent and transitory components.

The assumption of a small open economy and the long-run restriction provide two identification schemes for an SVAR that contains the world real interest rate, the first difference of the log of net output, and the current account-net output ratio as the endogenous variables. The identified SVAR, in turn, makes it possible to test jointly the predictions of the current account responses to the three shocks — the cross-equation restrictions (CERs) that the intertemporal approach and the PVM impose on the SVAR. The CERs are derived by augmenting the basic PVM with the stochastic world real interest rate, as in Bergin and Sheffrin (2000).

These CERs are conditional on the identification of the SVAR. In that sense, the tests described in this paper differ from the traditional test of the PVM, which is conducted by Sheffrin and Woo (1990), Otto (1992), Ghosh (1995), and Bergin and Sheffrin (2000): they test the CERs of the PVM imposed on the reduced-form VAR. The SVAR approach used in this paper also differs from that of an influential study by Nason and Rogers (2002), in both the information set and the identification restrictions. In a bivariate SVAR with the first differences of investment and the current account, Nason and Rogers (2002) identify global and country-specific shocks by using one of the following empirical results of Glick and Rogoff (1995): a non-stationary global technology shock, a stationary country-specific technology shock, a causal ordering that investment is prior to the current account, and no effect of a global technology shock on the current account. On the other hand, the trivariate SVAR of this paper includes the stochastic world real interest rate in its information set. Because a couple of recent small open economy-real business cycle studies, by Blankenau, Kose, and Yi (2001) and Nason and Rogers (2003), claim that the stochastic real interest rate is important in explaining Canadian trade balance-current account movements, the information set examined in this paper potentially yields a better specification of the stochastic process of the current account. Furthermore, the trivariate SVAR allows the small open-economy assumption to be used explicitly as a restriction to identify global and country-specific shocks, and to jointly test the predictions of the intertemporal approach and the PVM regarding the responses of the current account to the shocks (i.e., the CERs imposed on the SVAR). To my knowledge, this is the first paper in this literature that jointly tests these CERs imposed on the SVAR.

This paper uses post-war quarterly data of two small open economies: Canada and the United Kingdom. The main results of this paper are summarized as follows. First, in the two economies, the directions of the impulse responses of the current account to the identified shocks are consistent with the corresponding theoretical predictions: no response to a global shock, no response to a country-specific permanent shock, and a positive response to a positive, country-specific transitory shock. This result supports the intertemporal current account approach and the PVM. Second, an asymptotic χ^2 test jointly rejects the CERs imposed on the SVAR. In particular, this test shows that the hypothesis that the current account does not respond to a global shock is sensitive to identification, as observed by Nason and Rogers (2002). As the third and fourth results, this paper reveals two puzzles that are hard to reconcile with canonical small open-economy models. The first puzzle is that, given the identification, the response of the current account-net output ratio to country-specific transitory shocks is found to be *greater* than implied by the PVM. This is a puzzle because it implies that consumption responds negatively to a positive income shock.[3] The second puzzle is that the forecast error variance decompositions (FEVDs) of the current account reveal that country-specific transitory shocks dominate current account fluctuations in both the short run and long run, as Nason and Rogers (2002) find using a different identification. At the same time, however, the FEVDs of this paper show that the country-specific transitory shocks explain almost none of the fluctuations in net output. This result violates the PVM, since the PVM predicts that current account fluctuations are explained by the shocks that dominate net output fluctuations in the short run as well as the long run.

Section 2 introduces the model and develops the predictions of the intertemporal approach and the PVM as cross-equation restrictions on a structural vector moving average (SVMA) process. Identification issues are discussed in section 3. Section 4 reports the empirical results. Section 5 concludes.

2. The Model and Its Predictions

This paper considers a world that consists of many small open economies. Following Glick and Rogoff (1995), this paper assumes that all the economies are homogeneous with respect to preferences, endowments, and technologies. Furthermore, international financial markets are assumed to be incomplete, in that no household in a small open economy can buy state-contingent claims to diversify away country-

[3] Glick and Rogoff (1995) find, using G-7 data, that the impact response of the current account to the identified country-specific technology shock is smaller in absolute terms than that of investment. Based on augmented Dickey-Fuller (ADF) tests, they infer that the country-specific technology shock is permanent. This is puzzling, however, because if the identified country-specific technology shock is permanent, the intertemporal approach predicts that the current account should respond to the shock more than investment does in absolute terms. Glick and Rogoff resolve this puzzle by mentioning the possibility that the country-specific technology shock is highly persistent but not permanent. This paper finds a similar puzzle, in that the impact response of the current account to a country-specific transitory shock is greater than implied by the PVM, even when a country-specific shock is decomposed into permanent and transitory components.

specific shocks. Only riskless bonds, which are denominated in terms of the single consumption good, are traded internationally.[4]

2.1 An intertemporal, small open-economy model

Consider an infinitely lived representative consumer in a small open economy. The assumption behind the small open economy is that it faces the world real interest rate, r_t, determined in international financial markets. The standard PVM of the current account (for example, Sheffrin and Woo 1990; Otto 1992; and Ghosh 1995) assumes that the world real interest rate is exogenous and constant. This paper, because it exploits stochastic variations in the world real interest rate to identify global and country-specific shocks, allows the world real interest rate to vary stochastically, as in Bergin and Sheffrin (2000). In addition, this paper assumes that the world real interest rate is covariance stationary.

Let C_t be consumption at period t, $u(C)$ the period utility function of the consumer, and β the subjective discount factor taking a value between 0 and 1, respectively. The consumer's expected lifetime utility function at period t is then given as

$$E_t \sum_{i=0}^{\infty} \beta^i u(C_{t+i}), \tag{1}$$

where E_t is the conditional expectation operator upon the information set at period t. Further defining B_t, Q_t, I_t, and G_t to be international bond holdings, output, investment, and government expenditure at period t, respectively, gives the following consumer's budget constraint:

$$B_{t+1} = (1 + r_t)B_t + Q_t - I_t - G_t - C_t. \tag{2}$$

The optimization problem of the representative consumer is to maximize equation (1) subject to equation (2). The first order-necessary conditions of this optimization problem comprise the budget constraint (2), the Euler equation,

$$u'(C_t) = \beta E_t(1 + r_{t+1})u'(C_{t+1}), \tag{3}$$

and the transversality condition,

$$\lim_{i\to\infty} E_t R_{t,i} B_{t+i} = 0, \tag{4}$$

[4]Incompleteness in international financial markets is one of the maintained assumptions in the intertemporal approach (see, for example, Obstfeld and Rogoff 1995 and Glick and Rogoff 1995) and in small open-economy real business cycle models (see, for example, Mendoza 1991 and Cardia 1991). By contrast, two-country real business cycle models (see, for example, Backus, Kehoe, and Kydland 1992 and Baxter and Crucini 1993) assume complete financial markets. In this literature, agents in the two countries can pool all idiosyncratic risks by trading contingent claims.

where $R_{t,i}$ is the ex-post market discount factor at period t for period $t+i$ consumption, which is defined as

$$R_{t,i} \equiv \begin{cases} 1/\left(\prod_{j=t+1}^{t+i}(1+r_j)\right) & \text{if } i \geq 1, \\ 1 & \text{if } i = 0. \end{cases} \tag{5}$$

For simplicity, let NO_t denote net output at period t: $NO_t \equiv Q_t - I_t - G_t$. Taking the infinite future sum of the consumer's budget constraint (2) and using the transversality condition (4) yields the ex-ante intertemporal budget constraint of the consumer:

$$\sum_{i=0}^{\infty} E_t R_{t,i} C_{t+i} = (1+r_t)B_t + \sum_{i=0}^{\infty} E_t R_{t,i} NO_{t+i}. \tag{6}$$

To derive the present value model of the current account measure, this paper takes a log-linear approximation of the Euler equation (3) and a linear approximation of the intertemporal budget constraint (6).[5] The approximation begins by dividing the intertemporal budget constraint (6) by NO_t. After several steps of algebra, equation (6) can be rewritten as:

$$\begin{aligned} \frac{C_t}{NO_t}\left[1 + \sum_{i=1}^{\infty} E_t \exp\left\{\sum_{j=t+1}^{t+i} (\Delta \ln C_j - \ln(1+r_j))\right\}\right] \\ = \exp\{\ln(1+r_t) - \Delta \ln NO_t\}\frac{B_t}{NO_{t-1}} \\ + \left[1 + \sum_{i=1}^{\infty} E_t \exp\left\{\sum_{j=t+1}^{t+i} (\Delta \ln NO_j - \ln(1+r_j))\right\}\right]. \end{aligned}$$

Let c, b, γ^c, γ, and μ denote, respectively, the unconditional means of the consumption-net output ratio, C_t/NO_t; the net foreign asset-net output ratio, B_t/NO_{t-1}; the first difference of the log of consumption, $\Delta \ln C_t$; the first difference of the log of net output, $\Delta \ln NO_t$; and the log of the gross world real interest rate $\ln(1+r_t)$. Equation (6) is then linearly approximated by taking a first-order Taylor expansion around these means. For any variable X_t, let $\tilde{X}_t$ denote the deviation from its unconditional mean. The

[5] Bergin and Sheffrin (2000) also conduct a linear approximation of the intertemporal current account model, to incorporate stochastic variations of both world real interest rates and real exchange rates into the standard PVM. Although they follow Huang and Lin's (1993) log-linear approximation, this paper develops an alternative linear approximation, to derive a closed-form solution of the optimal current account-net output ratio.

linear-approximated intertemporal budget constraint is given as

$$\begin{aligned}\widetilde{\frac{C_t}{NO_t}} \approx \frac{1-\alpha}{\kappa}\widetilde{\frac{B_t}{NO_{t-1}}} + \frac{1-\alpha}{\kappa} b\widetilde{\ln(1+r_t)} - \frac{1-\alpha}{\kappa} b\Delta\widetilde{\ln NO_t} \\ - c\sum_{i=1}^{\infty}\alpha^i\, E_t\left\{\Delta\widetilde{\ln C_{t+i}} - \widetilde{\ln(1+r_{t+i})}\right\} \\ + \frac{1-\alpha}{1-\kappa}\sum_{i=1}^{\infty}\kappa^i\, E_t\left\{\Delta\widetilde{\ln NO_{t+i}} - \widetilde{\ln(1+r_{t+i})}\right\}, \quad (7)\end{aligned}$$

where $\alpha = \exp(\gamma^c - \mu) < 1$ and $\kappa = \exp(\gamma - \mu) < 1$.[6]

Note that equation (7) makes the consumption-net output ratio depend on the expected future path of consumption growth. To characterize the process of consumption growth, the Euler equation (3) is approximated log-linearly. Suppose that the period utility function is given as a power function $u(C) = C^{1-1/\sigma}/(1-1/\sigma)$, where σ is the elasticity of intertemporal substitution. This specification of the utility function yields the Euler equation $1 = \beta\, E_t\left\{\left(\frac{C_{t+1}}{C_t}\right)^{-\frac{1}{\sigma}}(1+r_{t+1})\right\}$. As Campbell and Mankiw (1989) and Campbell (1993) show, when the world real interest rate and consumption are jointly conditionally homoscedastic and log-normally distributed, the above Euler equation can be rewritten as

$$E_t\Delta\ln C_{t+1} = \delta + \sigma(\ln\beta + \mu) + \sigma E_t[\ln(1+r_{t+1}) - \mu], \quad (8)$$

where δ is a constant term that includes the variances of $\Delta\ln C_{t+1}$ and $\ln(1+r_{t+1})$ and the covariance between the two terms.[7]

Finally, to derive an approximate solution of the current account-net output ratio, recall the current account identity:

$$CA_t \equiv r_t B_t + NO_t - C_t. \quad (9)$$

[6] The conditions $\alpha < 1$ and $\kappa < 1$ are required to satisfy boundedness of the expected present discounted value terms of equation (7). Through the following analysis, this paper assumes these conditions: the mean growth rates of consumption and net output are lower than the mean of world real interest rates, respectively. These conditions imply that, on the balanced growth path, the economy is *dynamically efficient*.

[7] It is important to note from the log-linearized Euler equation (8) that perfect consumption smoothing, which was common in previous studies, is not the case in this model. First, unless $\delta + \sigma(\ln\beta + \mu) = 0$, the log of consumption has a deterministic trend, as shown by the first two constant terms in the right-hand side (RHS) of equation (8). Second, the last term shows the substitution effect of variations of the world real interest rate on the consumption profile. A rise in the world real interest rate makes current consumption more expensive in terms of future consumption. Hence, the representative consumer is induced to shift consumption toward the future with elasticity σ. These two effects together produce a consumption profile that deviates from a perfectly smoothed one. Furthermore, a caveat of the log-linearized Euler equation (8) is that only the first moments of the logs of consumption and the world real interest rate enter the equation. Higher moments of the two series are assumed to be constant.

Assuming that the economy possesses a balanced growth path, $\alpha = \kappa$, and using the approximation $\ln(1 + r_t) \approx r_t$, equations (7), (8), and (9), together, give the present value representation of the current account-net output ratio:

$$\frac{\widetilde{CA_t}}{NO_t} = b\widetilde{r}_t + [(\sigma - 1)c + 1]\sum_{i=1}^{\infty} \kappa^i \, E_t \, \widetilde{r}_{t+i} - \sum_{i=1}^{\infty} \kappa^i \, E_t \, \Delta \widetilde{\ln NO}_{t+i}. \tag{10}$$

Equation (10) is the optimal path of the current account-net output ratio, which is represented as a linear present value relation among the current account-net output ratio, the first difference of the log of net output, and the world real interest rate.

Equation (10) states that the optimal current account-net output ratio is determined by three factors. The first term of the RHS of equation (10) is a consumption-tilting factor. A variation in the world real interest rate changes the net interest payment from abroad. The direction of the change in the net interest payment is determined by the economy's net international asset position; for example, a rise in the world real interest rate increases the net interest payment from (to) abroad if the economy is a net creditor (debtor). This change in the net interest payment prompts the consumer to alter the current account-net output ratio from its consumption-smoothing level. The second term represents an additional consumption-tilting factor due to expected variations in the world real interest rate. The coefficient $(\sigma - 1)c + 1$ on the second term captures the intertemporal substitution effect, the income effect, and the wealth effect, respectively. If the world real interest rate is expected to change in the future, the representative consumer wants to deviate consumption from its smoothed path through the three effects. Finally, the third term of the RHS of equation (10) captures a consumption-smoothing motive. It implies that the representative consumer changes the current account-net output ratio to smooth consumption in response to expected changes in the future path of net output growth.

2.2 Derivation of the predicted responses

This subsection derives the testable restrictions that the PVM (10) imposes on responses of the current account measure to three orthogonal shocks to net output: global, country-specific permanent, and country-specific transitory. Let ϵ_t^g, ϵ_t^{cp}, and ϵ_t^{cs} denote global, country-specific permanent, and country-specific transitory shocks, respectively, all orthogonal to each other. This paper assumes that the first difference of the log of net output is linearly decomposed into three infinite-order moving average (MA) components attributed to the three orthogonal shocks:

$$\Delta \widetilde{\ln NO}_t = \Gamma_g^{no}(L)\epsilon_t^g + \Gamma_{cp}^{no}(L)\epsilon_t^{cp} + \Gamma_{cs}^{no}(L)\epsilon_t^{cs}, \tag{11}$$

where $\Gamma_i^{no}(L)$ for $i = \{g, cp, cs\}$ is an invertible, infinite-order polynomial with respect to the lag operator, L, in which the impact coefficient, $\Gamma_i^{no}(0)$, is not restricted to one.[8] Similarly, the process of the world real interest rate is linearly decomposed into three infinite-order MA components attributed to the three orthogonal shocks:

$$\widetilde{r}_t = \Gamma_g^r(L)\epsilon_t^g + \Gamma_{cp}^r(L)\epsilon_t^{cp} + \Gamma_{cs}^r(L)\epsilon_t^{cs}, \tag{12}$$

where $\Gamma_i^r(L)$ for $i = \{g, cp, cs\}$ is an invertible, infinite-order polynomial with respect to the lag operator, L.

Given the processes of the first difference of the log of net output and the world real interest rate, equations (11) and (12), the PVM (10) yields the predictions on the impulse responses of the current account-net output ratio to the three shocks through the *Wiener-Kolmogorov formula*, which is well-known as Hansen and Sargent's (1980) *distributed predicted leads formula*. As explained in Appendix A, the following structural moving average (SMA) representation of the current account-net output ratio yields the predictions:

$$\widetilde{\frac{CA_t}{NO_t}} = \Gamma_g^{ca}(L)\epsilon_t^g + \Gamma_{cp}^{ca}(L)\epsilon_t^{cp} + \Gamma_{cs}^{ca}(L)\epsilon_t^{cs}, \tag{13}$$

where $\Gamma_i^{ca}(L)$ for an index $i \in \{g, cp, cs\}$ is an invertible, infinite-order polynomial with respect to the lag operator. The testable hypotheses examined in this paper are based on the SMA (13).

The first hypothesis is that a global shock does not affect the current account at any forecast horizon. Under the homogeneity assumption across economies, every economy has the same excess demand for international riskless bonds. In this case, as argued by Razin (1993) and Glick and Rogoff (1995), no economy can alter its net foreign asset position following a global shock, because all the other economies react to the shock symmetrically. Therefore, a global shock has no effect on the current account at any forecast horizon. All that occurs is that the world real interest rate adjusts. Let $\mathcal{H}_g^i$ denote the impulse response of CA_t to ϵ_{t-i}^g. Then, the first null hypothesis is given as

$$H_0: \quad \mathcal{H}_g^i = \frac{\partial CA_t}{\partial \epsilon_{t-i}^g} = 0 \quad \text{for any } i \geq 0. \tag{Hypothesis 1}$$

To test this hypothesis, this paper estimates the impulse-response functions (IRFs) of the *level* of the current account to a global shock from the IRFs of the current account-net output ratio and the log of net output.[9]

[8]Note that equation (11) is a structural moving average (SMA) representation of the process $\Delta \ln NO_t$, rather than the Wold representation with the impact coefficient equal to one. Instead of being restricted to one, the impact coefficient is estimated.

[9]On the other hand, the response of the current account-net output ratio to a global shock is ambiguous. For example,

Next, consider the impact responses of the current account-net output ratio to the country-specific shocks ϵ_t^{cp} and ϵ_t^{cs}: $\Gamma_{cp}^{ca}(0)$ and $\Gamma_{cs}^{ca}(0)$ in equation (13). To derive the second and third hypotheses, recall the small open-economy assumption of the intertemporal approach. This assumption requires that a small open economy have no influence on the world real interest rate: a country-specific shock does not matter for the world real interest rate at any forecast horizon. In other words, this assumption implies that zero restrictions are imposed on the coefficients of the infinite-order polynomials related to the two country-specific shocks in the world real interest rate process (12). For any $i \geq 0$,

$$\Gamma_{cp,i}^{r} = \Gamma_{cs,i}^{r} = 0 \qquad \text{(small open-economy assumption)}, \tag{14}$$

where $\Gamma_{cp,i}^{r}$ and $\Gamma_{cs,i}^{r}$ are the i-th coefficients of the infinite-order polynomials $\Gamma_{cp}^{r}(L)$ and $\Gamma_{cs}^{r}(L)$ in equation (12), respectively.

As shown in Appendix A, under the small open-economy assumption (14), $\Gamma_{cp}^{ca}(0)$ and $\Gamma_{cs}^{ca}(0)$ should satisfy the following CERs, respectively:

$$\Gamma_{cp}^{ca}(0) = \Gamma_{cp}^{no}(0) - \Gamma_{cp}^{no}(\kappa), \tag{$\mathcal{R}_{cp}$}$$

and

$$\Gamma_{cs}^{ca}(0) = \Gamma_{cs}^{no}(0) - \Gamma_{cs}^{no}(\kappa), \tag{$\mathcal{R}_{cs}$}$$

where, for an index $i \in \{cp, cs\}$, $\Gamma_{i}^{no}(\kappa)$ is the infinite polynomial $\Gamma_{i}^{no}(z)$ evaluated at $z = \kappa$.

The CERs $\mathcal{R}_{cp}$ and $\mathcal{R}_{cs}$ state that the impact response of the current account ratio to a country-specific shock should be given as the difference between the impact and the discounted long-run responses of $\Delta \widetilde{\ln NO_t}$ to the shock. The current account identity (9) implies that the current account-net output ratio is negatively related to the consumption-net output ratio. Therefore, if a country-specific shock raises net output above (below) consumption, the current account-net output ratio rises (falls). $\Gamma_{cp}^{no}(0)$ in $\mathcal{R}_{cp}$ captures the impact effect of the shock ϵ_t^{cp} on net output, while $\Gamma_{cp}^{no}(\kappa)$ shows the impact effect of the shock on consumption.[10] Hence, the impact effect of the shock on the current account-net output ratio, $\Gamma_{cp}^{ca}(0)$, is given as the difference $\Gamma_{cp}^{no}(0) - \Gamma_{cp}^{no}(\kappa)$. The same explanation is applicable for $\mathcal{R}_{cs}$.

Define the statistics $\mathcal{H}_{cp}$ and $\mathcal{H}_{cs}$ as $\mathcal{H}_{cp} \equiv \Gamma_{cp}^{ca}(0) - \Gamma_{cp}^{no}(0) + \Gamma_{cp}^{no}(\kappa)$ and $\mathcal{H}_{cs} \equiv \Gamma_{cs}^{ca}(0) - \Gamma_{cs}^{no}(0) + \Gamma_{cs}^{no}(\kappa)$, respectively. The CERs $\mathcal{R}_{cp}$ and $\mathcal{R}_{cs}$ then provide the following null hypotheses:

$$H_0 : \mathcal{H}_{cp} = 0, \tag{Hypothesis 2}$$

if a global shock has a positive impact on $\ln NO_t$ and the mean value of CA_t/NO_t is positive, then the current account-net output ratio should respond negatively to the shock.

[10] The fact that consumption is determined by permanent income yields the result that the impact response of consumption is given as the discounted long-run response of the first difference of the log of net output. See, for example, Quah (1990).

and

$$H_0 : \mathcal{H}_{cs} = 0. \tag{Hypothesis 3}$$

By construction, if $\mathcal{H}_i \neq 0$ for $i \in \{cp, cs\}$, the prediction of the PVM on the impact response of the current account-net output ratio to the shock ϵ_t^i is rejected, because the observed response is considered to be greater or lesser than the prediction.

3. The SVMA and Identification Issues

Hypotheses 1 to 3 are constructed conditionally on identification of the three shocks. Testing the hypotheses discussed in the last section requires that the three shocks be identified. To do so, this paper exploits the SVAR methodology. In this paper, as implied by the small open-economy assumption, country-specific shocks are identified as shocks that are orthogonal to the world real interest rate in either the short run or the long run. Furthermore, country-specific shocks are decomposed into permanent and transitory components by Blanchard and Quah's (1989) long-run restriction.

To see this, consider a stationary column vector, $X_t = [\widetilde{r}_t \quad \widetilde{\Delta \ln NO_t} \quad \widetilde{CA_t/NO_t}]'$. Let the probability distribution of the vector, X_t, be characterized by a p-th order unrestricted VAR. Since the vector X_t is stationary, it has a Wold-vector moving average (VMA) representation, VMA(∞), $X_t = C(L)\upsilon_t$, where $C(L)$ is an invertible, infinite-order matrix polynomial with respect to the lag operator L and, in particular, the coefficient matrix of L^0 is the identity matrix. The reduced-form disturbance vector, υ_t, has a symmetric positive definite variance-covariance matrix, Σ.

Stacking equations (11), (12), and (13) vertically implies that the vector X_t has the following structural VMA (SVMA) representation:

$$\begin{bmatrix} \widetilde{r}_t \\ \widetilde{\Delta \ln NO_t} \\ \widetilde{CA_t/NO_t} \end{bmatrix} = \begin{bmatrix} \Gamma_g^r(L) & \Gamma_{cp}^r(L) & \Gamma_{cs}^r(L) \\ \Gamma_g^{no}(L) & \Gamma_{cp}^{no}(L) & \Gamma_{cs}^{no}(L) \\ \Gamma_g^{ca}(L) & \Gamma_{cp}^{ca}(L) & \Gamma_{cs}^{ca}(L) \end{bmatrix} \begin{bmatrix} \epsilon_t^g \\ \epsilon_t^{cp} \\ \epsilon_t^{cs} \end{bmatrix} \quad \text{or} \quad X_t = \Gamma(L)\epsilon_t, \tag{15}$$

where ϵ_t is the structural shock vector given as $\epsilon_t = [\epsilon_t^g \ \epsilon_t^{cp} \ \epsilon_t^{cs}]'$. In particular, following the standard exercise in the SVAR literature, this paper assumes that the variance-covariance matrix of the structural shock vector is given as the identity matrix: $E\epsilon_t\epsilon_t' = I$.[11]

The SVMA (15) is identified as follows. The small open-economy assumption (14) implies that $\Gamma_{cp}^r(L) = \Gamma_{cs}^r(L) = 0$ in the SVMA (15). Furthermore, to decompose country-specific shocks into perma-

[11] That is, the structural shocks are orthogonal at all leads and lags and each shock has a unit variance. Therefore, in this paper, the IRF of a variable is interpreted as the response to a unit standard error shock.

nent and transitory components, this paper imposes on the SVMA (15) a restriction that the country-specific transitory shock ϵ_t^{cs} has no long-run effect on the log of net output. This long-run restriction is given as

$$\Gamma_{cs}^{no}(1) = 0 \quad \text{(long-run restriction).} \tag{16}$$

Hence, the small open-economy assumption (14) and the long-run restriction (16) make the impact and long-run matrices, $\Gamma(0)$ and $\Gamma(1)$, of the SVMA (15) be

$$\Gamma(0) = \begin{bmatrix} \Gamma_g^r(0) & 0 & 0 \\ \Gamma_g^{no}(0) & \Gamma_{cp}^{no}(0) & \Gamma_{cs}^{no}(0) \\ \Gamma_g^{ca}(0) & \Gamma_{cp}^{ca}(0) & \Gamma_{cs}^{ca}(0) \end{bmatrix} \quad \text{and} \quad \Gamma(1) = \begin{bmatrix} \Gamma_g^r(1) & 0 & 0 \\ \Gamma_g^{no}(1) & \Gamma_{cp}^{no}(1) & 0 \\ \Gamma_g^{ca}(1) & \Gamma_{cp}^{ca}(1) & \Gamma_{cs}^{ca}(1) \end{bmatrix}.$$

The SVMA with the impact and long-run matrices $\Gamma(0)$ and $\Gamma(1)$ is overidentified. To see this, note that the small open-economy assumption (14) and the long-run restriction (16) impose an infinite number of restrictions on the coefficients in the SVMA (15): two impact restrictions, three long-run restrictions, and an infinite number of restrictions on IRFs. On the other hand, comparing the reduced-form VMA with the SVMA provides the relation $\Sigma = C(1)^{-1}\Gamma(1)[C(1)^{-1}\Gamma(1)]^T$. Given estimates of Σ and $C(1)$, if one does not impose any restriction on the long-run matrix $\Gamma(0)$, there are six linear independent equations and nine unknowns in the above relation. Therefore, only three restrictions, instead of an infinite number of theoretical restrictions, are needed for the SVMA (15) to be just-identified. Following the identification strategy examined by King and Watson (1997) and Nason and Rogers (2002), this paper investigates two different identification schemes consisting of three restrictions from all the overidentifying restrictions to just-identify the system, collect sample information conditional on the identification, and check the robustness of the empirical results by comparing the two identification schemes.

The first identification exploits the lower triangularity of the long-run matrix $\Gamma(1)$. The maintained assumptions in this paper provide three long-run restrictions. The zero restrictions on the (1, 2)th and (1, 3)th elements of $\Gamma(1)$ reflect the small open-economy assumption that requires country-specific permanent and transitory shocks to have no *long-run* effect on the world real interest rate, respectively. The zero restriction on the (2, 3)th element of $\Gamma(1)$ implies that a country-specific transitory shock has no *long-run* effect on the log of net output, which is explicitly shown as the long-run restriction (16). Therefore, the lower triangular long-run matrix $\Gamma(1)$ is just-identified and the impact matrix can be recovered through the relation $\Gamma(0) = C(1)^{-1}\Gamma(1)$. Hereafter, this Blanchard and Quah (1989)-style identification is called *identification scheme I*.

The other identification scheme exploits two impact restrictions in $\Gamma(0)$ and the long-run restriction (16). The zero restrictions on the (1, 2)th and (1, 3)th elements of $\Gamma(0)$ reflect the small open-economy assumption that requires country-specific permanent and transitory shocks to have no *instantaneous* effect on the world real interest rate. The zero restriction on the (2, 3)th element of $\Gamma(1)$ implies that a country-specific transitory shock has no long-run effect on the log of net output.

The long-run restriction (16) can be rewritten as an impact restriction. To show this, let $A_{i,j}$ denote the (i, j)th element in any matrix A. The zero restriction on the $(2, 3)$th element in $\Gamma(1)$, together with the zero restriction on the (1, 3)th element in $\Gamma(0)$, implies the restriction $C(1)_{2,2}\Gamma(0)_{2,3} + C(1)_{2,3}\Gamma(0)_{3,3} = 0$. Since $C(1)_{2,2}$ and $C(1)_{2,3}$ are estimated, this restriction can be considered as the impact restriction that makes it possible to just-identify $\Gamma(0)$ together with the two impact restrictions shown in $\Gamma(0)$. Hence, the second identification scheme of this paper follows Galí's (1992) method that exploits the impact and long-run restrictions in concert. Hereafter, this identification is referred to as *identification scheme II.* Table 1 summarizes the two identification schemes of this paper.

4. Empirical Results

This section describes the data, estimation methods, tests, and empirical results of this paper.

4.1 Data, estimation of RFVAR and SVAR, and test statistics

This paper studies quarterly data of two prototype small open economies: Canada and the United Kingdom. All data used in this paper are real, seasonally adjusted at annual rates, and span the period 1960Q1-1997Q4.[12] The estimation is based on the 1963Q2-1997Q4 sample, with the data prior to 1963Q2 used to construct lags. The world real interest rate is a weighted average of ex-ante real interest rates across the G-7 economies. This follows the way in which Barro and Sala-i-Martin (1990) and Bergin and Sheffrin (2000) construct r_t. Net output and the current account are generated from the appropriate national accounting data. Appendix B provides information on the source and construction of the data.

The standard ADF tests provide evidence that the vector X_t follows a stationary process.[13] Since the VMA is invertible, it has an infinite-order VAR representation. The infinite-order VAR is approximated by truncating at a finite lag length. To select an optimal lag length, both the AIC and BIC criteria are

[12]This sample period is close to those of related papers: it almost overlaps that of Bergin and Sheffrin (2000)(1960Q1 to 1996Q2) and includes that of Nason and Rogers (2002)(1973Q1-1995Q4).

[13]This paper constructs the demeaned series of the world real interest rate, the change in the log of net output, and the current account-net output ratio (i.e., $\widetilde{r}_t$, $\Delta\widetilde{\ln NO_t}$, and $\widetilde{CA_t/NO_t}$), and performs unit root tests for them based on the ADF τ-test. The ADF tests reject the unit-root null in all series at least at the 5 per cent significance level. From this evidence, the series $\widetilde{r}_t$, $\Delta\widetilde{\ln NO_t}$, and $\widetilde{CA_t/NO_t}$ are considered to be stationary in the following analysis.

calculated with a maximum lag length of fifteen. Both criteria select the first lag length for each economy. Therefore, the first-order reduced-form VAR (RFVAR), $X_t = BX_{t-1} + v_t$, is estimated by ordinary least squares (OLS).[14] Let $\hat{B}$, $\hat{\Sigma}$, and $\hat{C(1)}$ denote the OLS estimates of the RFVAR coefficient matrix, B, the variance-covariance matrix, Σ, and the infinite sum of the VMA coefficient matrices, $C(1) \equiv [I_3 - B]^{-1}$, through the following analysis. The estimates $\hat{\Sigma}$ and $\hat{C(1)}$ then make it possible to identify the impact matrix $\Gamma(0)$ with each of the identification schemes. This paper recovers the impact matrix $\Gamma(0)$ by the full-information maximum-likelihood (FIML) procedure.[15]

The correlations among the identified structural shocks are consistent with prior ones, thus suggesting that the identification scheme in this paper is appropriate and successful. Note that the global shocks identified with the SVARs of the two economies should be highly positively correlated with each other, and this is in fact the case: the estimate of the correlation coefficient between the identified global shocks of Canada and the United Kingdom is 0.802 in identification scheme I and 0.975 in identification scheme II. On the other hand, the identified country-specific permanent and transitory shocks should be uncorrelated across the two economies. This is also the case. In identification scheme I, the estimate of the correlation coefficient of the identified country-specific permanent shocks between Canada and the United Kingdom is -0.019, while it is -0.022 in identification scheme II. The estimate of the correlation coefficient of the identified country-specific transitory shocks between Canada and the United Kingdom is -0.020, while it is 0.146 in identification scheme II. Therefore, the identification of this paper is fairly successful with respect to the correlations among the identified structural shocks.

Tests of Hypotheses 1, 2, and 3 are constructed as the Wald statistics. Let $\mathcal{W}_1$, $\mathcal{W}_2$, and $\mathcal{W}_3$ denote the Wald statistics for the nulls $\mathcal{H}_g^0 = 0$, $\mathcal{H}_{cp} = 0$, and $\mathcal{H}_{cs} = 0$. In addition, let $\mathcal{W}_4$ and $\mathcal{W}_5$ be the Wald statistics for the joint nulls $\mathcal{H}_g^0 = \mathcal{H}_{cp} = \mathcal{H}_{cs} = 0$ and $\mathcal{H}_g^0 = \mathcal{H}_g^1 = \mathcal{H}_g^2 = \mathcal{H}_g^3 = 0$. In particular, $\mathcal{W}_5$ is based on the hypothesis that a global shock does not matter for the current account up to a year after impact. For example, the Wald statistic $\mathcal{W}_1$ for Hypothesis 1 is constructed as $\mathcal{W}_1 = \hat{\mathcal{H}}_g^0 \left[\frac{\partial \mathcal{H}_g^0}{\partial \hat{B}} \hat{V} \frac{\partial \mathcal{H}_g^0}{\partial \hat{B}}' \right]^{-1} \hat{\mathcal{H}}_g^0$, where $\hat{\mathcal{H}}_g^0$ is the point estimate of the statistic $\mathcal{H}_g^0$. The asymptotic theory states that $\mathcal{W}_1$ follows $\chi^2(1)$.[16] To derive

[14] This paper conducts the portmanteau test for the autocorrelations of the residual vector v_t, as discussed in Lütkepohl (1991, chapter 4). In both Canada and the United Kingdom, the χ^2 test cannot reject the hypothesis that the autocorrelations of the residual vector up to 8 lags (i.e., 2 years) are jointly zero at the 5 per cent significance level. This provides evidence that the residual vector follows a white-noise process.

[15] Because of the lower triangular long-run matrix, a numerical maximization procedure is not needed to recover the impact matrix in identification scheme I. In identification scheme II, the impact matrix is numerically recovered through the FIML procedure. See Amisano and Giannini (1997) and Hamilton (1994, chapter 11) for the FIML estimation of the SVAR models.

[16] To obtain the estimates $\hat{\mathcal{H}}_g^i$, $\hat{\mathcal{H}}_{cp}$, and $\hat{\mathcal{H}}_{cs}$, this paper exploits the fact that all restrictions provided by the hypotheses

Wald statistic $\mathcal{W}_4$ for the joint null $\mathcal{H}_g^0 = \mathcal{H}_{cp} = \mathcal{H}_{cs} = 0$, construct a row vector $\lambda = [\hat{\mathcal{H}}_g^0 \quad \hat{\mathcal{H}}_{cp} \quad \hat{\mathcal{H}}_{cs}]$. Then the Wald statistic for the joint null is given as $\mathcal{W}_4 = \lambda \left[\frac{\partial\lambda}{\partial\hat{B}} \hat{V} \frac{\partial\lambda}{\partial\hat{B}}'\right]^{-1} \lambda'$. According to the asymptotic theory, $\mathcal{W}_4$ asymptotically follows $\chi^2(3)$. The same argument is applicable to the construction of Wald statistic $\mathcal{W}_5$.

As in the standard exercise of the SVAR literature, the IRFs and the FEVDs of the endogenous variables to the identified shocks are estimated. The empirical standard errors of the IRFs and the FEVDs are calculated by generating 10,000 non-parametric bootstrapping replications based on the reduced-form disturbances. The 10,000 replications of the statistics $\mathcal{H}_{cp}$ and $\mathcal{H}_{cs}$ that the bootstrapping exercise generates provide the empirical joint distribution of $\mathcal{H}_{cp}$ and $\mathcal{H}_{cs}$.

4.2 Joint test of the PVM's restrictions

Before the results of the SVAR exercise are reported, the traditional joint test of the CERs that the PVM (10) imposes on the RFVAR will be conducted by following Sheffrin and Woo (1990), Otto (1992), Ghosh (1995), and Bergin and Sheffrin (2000). Let a 1×3 vector, $\mathbf{e}_i$, be the ith row of the 3×3 identity matrix, I_3. The PVM (10) then implies the following CERs on the RFVAR coefficient matrix, $\hat{B}$, conditional on the parameters b, c, κ, and σ:

$$\mathbf{e}_3 = \mathbf{e}_1 \left\{ b + [(\sigma - 1)c + 1]\kappa\hat{B}[I_3 - \kappa\hat{B}]^{-1} \right\} - \mathbf{e}_2\kappa\hat{B}[I_3 - \kappa\hat{B}]^{-1}. \tag{17}$$

Then define a statistic $\mathbf{k}(B)$ such that $\mathbf{k}(B) \equiv \mathbf{e}_1 \left\{ b + [(\sigma - 1)c + 1]\kappa B[I_3 - \kappa B]^{-1} \right\} - \mathbf{e}_2\kappa B[I_3 - \kappa B]^{-1} - \mathbf{e}_3$. Under the null of $\mathbf{k}(B_0) = 0$, the Wald statistic $\mathcal{W} \equiv \mathbf{k}(\hat{B})[\mathbf{k}'(\hat{B})\hat{V}\mathbf{k}'(\hat{B})^T]^{-1}\mathbf{k}(\hat{B})^T$ asymptotically follows the $\chi^2(3)$.

Recall that the Wald statistic $\mathcal{W}$ is constructed conditional on the parameters κ, c, b, and σ. Following the definitions of the parameters, this paper calibrates κ, c, and b directly from the data: $\kappa = 0.993$,

can be rewritten as linear restrictions on the impact matrix $\Gamma(0)$. Let $[A]_i^r$ and $[A]_i^c$ denote the ith row and column vectors of matrix A, respectively. Furthermore, let R and R_i for an index $i \geq 0$ be the 1×3 row vectors such that $R_i = \frac{CA}{CA/NO}[C_i]_3^r + CA\sum_{s=0}^{i}[C_s]_2^r$ and $R = [C(\kappa)_{2,1} \quad C(\kappa)_{2,2} - 1 \quad C(\kappa)_{2,3} + 1]$, where C_i, CA/NO, CA and $C(\kappa)_{i,j}$ denote the coefficient matrix of L^i in the VMA, the mean of the current account-net output ratio, the mean of the current account, and the (i, j)th element of the matrix $C(\kappa)$, respectively. It can then be easily shown that the statistics $\mathcal{H}_g^i$, $\mathcal{H}_{cp}$, and $\mathcal{H}_{cs}$ are given as $\mathcal{H}_g^i = R_i[\Gamma(0)]_1^c$ for $i \geq 0$, $\mathcal{H}_{cp} = R[\Gamma(0)]_2^c$, and $\mathcal{H}_{cs} = R[\Gamma(0)]_3^c$. Note that the statistics $\mathcal{H}_g^i$, $\mathcal{H}_{cp}$, and $\mathcal{H}_{cs}$ are constructed from the IRFs recovered from the just-identified SVAR. Since the IRFs are non-linear functions of the RFVAR parameters, as shown in Hamilton (1994, section 11.4), the asymptotic standard errors of the estimates $\hat{\mathcal{H}}_g^i$, $\hat{\mathcal{H}}_{cp}$, and $\hat{\mathcal{H}}_{cs}$ are obtained by using the asymptotic standard errors of the RFVAR parameters and the Delta method. Similarly, the asymptotic χ^2 statistics for the hypotheses can be constructed from knowledge of the asymptotic distribution of the RFVAR parameters. Of course, the asymptotic χ^2 test depends on the identification.

$c = 0.983$, $b = -0.712$ for Canada; $\kappa = 0.990$, $c = 0.988$, $b = 0.377$ for the United Kingdom. The elasticity of intertemporal substitution, σ, is calibrated by matching the predictions of the PVM (10) on the current account-net output ratio with the actual series. The predictions $\mathcal{CA}/\mathcal{NO}_t^f$ are constructed as a function of σ by $\mathcal{CA}/\mathcal{NO}_t^f = \mathcal{F}(\sigma)X_t$, where

$$\mathcal{F}(\sigma) = \mathbf{e}_1 \left\{ b + [(\sigma - 1)c + 1]\kappa\hat{B}[I_3 - \kappa\hat{B}]^{-1} \right\} - \mathbf{e}_2\kappa\hat{B}[I_3 - \kappa\hat{B}]^{-1}.$$

The elasticity of intertemporal substitution σ is then calibrated by minimizing the mean squared error of the prediction: $T^{-1}\sum_{t=1}^{T}[CA/NO_t - \mathcal{F}(\sigma)X_t]^2$. The resulting σ is 0.001 for Canada, and 0.08 for the United Kingdom. The small values of the elasticity of intertemporal substitution are close to the estimates of Bergin and Sheffrin (2000) in their two-goods model. The first four rows of Table 2 summarize the calibrations in this paper.

The last two rows of Table 2 report the Wald statistics for the joint test of the CERs (17), and the corresponding p-values based on the χ^2 distribution for Canada and the United Kingdom. In the two economies, the Wald statistics are so large that the CERs are jointly rejected at any standard significance level. Figures 1(a) and (b) draw the actual series of the current account-net output ratio and the PVM's predictions $\mathcal{CA}/\mathcal{NO}_t^f$ for Canada and the United Kingdom, respectively. Even though σ is chosen to minimize the mean squared error, the PVM's predictions are much smoother than the actual series in Canada. The result is much better in the United Kingdom, but the PVM still cannot capture the large deficits that occurred through the end of the 1980s and the beginning of the 1990s.

In summary, the CERs that the PVM imposes on the RFVAR are jointly rejected across the two economies. The predicted series from the PVM closely tracks the U.K. series for the current account-net output ratio with the exceptional periods of the end of the 1980s and the beginning of the 1990s, but they are still too smooth to match the Canadian series. This result suggests that, particularly for the case of Canada, the source of the rejection of the PVM can be attributed to something other than the fluctuations in net output, as well as the world real interest rate: even if it is augmented with the stochastic world real interest rate, the PVM is still too simple to identify the factors that lead to a better explanation for the Canadian current account.

4.3 Impulse-response analysis

Figure 2 shows the IRFs of the current account across the two economies under identification scheme I. In each window, the dark line represents the point estimate and the dashed lines exhibit 95 per cent confidence bands constructed by a non-parametric bootstrapping exercise. The results of the impulse-response analysis are summarized as follows. For both Canada and the United Kingdom, this paper finds that

- The IRFs of the current account to a global shock are not significant across any of the 40 periods after impact.[17]
- The IRFs of the current account to a country-specific permanent shock are positive but insignificant.
- The IRFs of the current account to a country-specific transitory shock are positive and significant. The positive responses remain significant for at least three years.

These results support the basic predictions of the intertemporal approach and the PVM: no response of the current account to a global shock, no response to a country-specific permanent shock, and a positive response to a positive, country-specific transitory shock. Figure 3 shows the IRFs of the log of net output in Canada and the United Kingdom under identification scheme I. Note that, in each economy, the response of the log of net output to a country-specific permanent shock is almost flat after the jump at impact. This observation is consistent with the PVM's prediction that if a country-specific shock is random walk, the current account has no response to the shock.

The impulse-response analysis, therefore, *qualitatively* supports the basic predictions of the intertemporal approach and the PVM: the predicted shapes of the impulse responses of the current account to the three shocks are consistent with the data. Although not reported, the same results are also observed even under identification scheme II. Hence, this empirical result is robust to the two identification schemes.

4.4 Testing the hypotheses

The *qualitative* validity of the predictions does not necessarily mean that the *quantitative* requirements of the intertemporal approach and the PVM – the CERs imposed on the SVMA – are supported at the same time. Testing Hypotheses 1 to 3 provides information about the validity of the CERs.

Tables 3(a) and (b) report the results of the asymptotic Wald tests under identification schemes I and II, respectively. Each table shows the Wald statistics and the corresponding p-values generated by asymptotic χ^2 distributions under the null hypotheses. The following results are observed:

- The single null $\mathcal{H}_g^0 = 0$ is not rejected in Canada and the United Kingdom in identification scheme I, but it is rejected in the two economies in identification scheme II.

[17] A caveat is that the IRFs and the associated confidence bands are not a joint test statistic for Hypothesis 1. They provide pointwise information about the response of the current account to a global shock.

- The single null $\mathcal{H}_{cp} = 0$ is not rejected in Canada and the United Kingdom across the two identification schemes.
- The single null $\mathcal{H}_{cs} = 0$ is not rejected in Canada and the United Kingdom across the two identification schemes.
- The joint null $\mathcal{H}_g^0 = \mathcal{H}_{cp} = \mathcal{H}_{cs} = 0$ is rejected in Canada and the United Kingdom across the two identification schemes.
- In Canada, but not in the United Kingdom, the joint null $\mathcal{H}_g^0 = \mathcal{H}_g^1 = \mathcal{H}_g^2 = \mathcal{H}_g^3 = 0$ is rejected across the two identification schemes.

These results lead to the following inferences: (i) the validity of the hypothesis that the current account does not respond to a global shock is sensitive to the identification and the economy being studied, (ii) the PVM succeeds in making quantitative predictions on the impact responses of the current account to country-specific shocks, and (iii) the response predictions of the intertemporal approach and the PVM are jointly rejected.

Recall that the IRFs support the hypothesis that the current account does not respond to a global shock. From the two different tests (i.e., the IRFs and the Wald statistics), this paper observes no robust evidence for this hypothesis. This confirms the inference drawn by Nason and Rogers (2002) that the hypothesis is sensitive to identification. On the other hand, the IRFs and the asymptotic Wald tests consistently support the predictions of the PVM on the responses of the current account to the country-specific shocks. Finally, the observation that the predictions of the PVM on the impact responses of the current account to the three shocks are jointly rejected reinforces the rejection of the CERs that the PVM imposes on the RFVAR; see section 4.2.

A potential drawback of the test based on the Wald statistics is that it depends on the asymptotic χ^2 distribution, and with a small sample the Wald statistic does not necessarily follow the χ^2 distribution. Figure 4 shows the scatter plots of 10,000 pairs of the statistics $\mathcal{H}_{cp}$ and $\mathcal{H}_{cs}$ replicated by non-parametric bootstrapping resamples under identification scheme I. In each window, the darkest square represents the point estimate and the joint null is given by the origin. Observe that, in the two economies, the scatter plots have strikingly similar shapes and almost all replicated pairs are concentrated on the upper regions of the windows. Therefore, the empirical distributions of the statistics $\mathcal{H}_{cp}$ and $\mathcal{H}_{cs}$ provide evidence that the null hypothesis $\mathcal{H}_{cs} = 0$ is not satisfied.

By construction, the observation that the empirical joint distribution of $\mathcal{H}_{cp}$ and $\mathcal{H}_{cs}$ is concentrated in the upper region means that, in Canada and the United Kingdom,

$$\Gamma_{cs}^{ca}(0) > \Gamma_{cs}^{no}(0) - \Gamma_{cs}^{no}(\kappa). \qquad (*)$$

Under Hypothesis 3, the above equation (*) must be satisfied with equality. Hence, the data indicate that, *in Canada and the United Kingdom, the impact responses of the current account-net output ratio to a country-specific transitory shock are too large to support the PVM.* The same observation is obtained in identification scheme II.

Since the calibrated values of κ in the two economies are very close to one (Table 3), the long-run restriction (16) requires that the term $\Gamma_{cs}^{no}(\kappa)$ be almost zero. Hence, the above inequality (*) says that the impact response of the current account to a country-specific transitory shock is greater than that of net output. This observation is actually a puzzle. The current account identity requires that the impact response of the current account to a country-specific shock be the difference between the responses of net output and consumption. Hence, the fact that the response of the current account to a country-specific transitory shock is greater than the response of net output implies that *consumption responds negatively to a positive country-specific shock to net output.* This inference violates the basic intertemporal approach to the current account. This puzzle is a challenge for the current account literature.

4.5 Analysis of forecast error variance decomposition

Another way to examine the effects of the three shocks on the current account is to look at the forecast error variance decompositions (FEVDs) of the current account. The FEVD provides information about the share of current account fluctuations that can be explained by an identified shock.

Table 4(a) reports the FEVDs of the current account attributed to the three shocks in Canada and the United Kingdom under identification scheme I. The table shows that, a quarter after impact, a country-specific transitory shock can explain almost 70 per cent of fluctuations in the current account for the two economies. Even a year after impact, the shock can significantly explain 81 and 71 per cent of fluctuations in the current account in Canada and the United Kingdom, respectively. Therefore, the country-specific transitory shock can be considered as the dominant driving force of the current account in the short run.

A striking fact revealed by the FEVDs is that, *even in the long run, the country-specific transitory shock dominates fluctuations in the current account in the two small open economies.* For example, 40 quarters (10 years) after impact, about 80 per cent of fluctuations in the Canadian current account is attributed to the country-specific transitory shock. Similarly, at the same forecast horizon, the shock explains 72 per cent of fluctuations in the U.K. current account. Identification scheme II yields a similar observation.

The result that country-specific transitory shocks dominate current account fluctuations not only in the short but in the long run echoes the finding of Nason and Rogers (2002). In their SVAR approach to studying the joint dynamics of investment and the current account, they report the persistent dependence of the current account on country-specific transitory shocks across the G-7 economies. As they argue, there is no consensus intertemporal model that generates persistence in the current account to country-specific transitory shocks.

Table 4(b) shows the FEVDs of the log of net output. Note that, in the two economies, a country-specific transitory shock cannot significantly explain fluctuations in the log of net output at any forecast horizons. The second puzzle of this paper is that a country-specific transitory shock that has no significant effect on net output dominates fluctuations in the current account in the short and the long run. This observation violates the standard PVM as well as the augmented PVM with the stochastic world real interest rate, because in these models current account fluctuations need to be explained by a country-specific shock that dominates the fluctuations in net output; i.e., the consumption-smoothing behaviour of the consumer. Combined with the joint rejection of the full CERs that the PVM (10) imposes on the RFVAR, this puzzling observation suggests the importance of the consumption-tilting motive — which is induced by country-specific shocks but is not identified with the PVM (10) — in explaining current account movements in small open economies.

5. Conclusion

When the world real interest rate is allowed to vary stochastically, the intertemporal approach and its well-known closed-form solution, the PVM of the current account, jointly provide a new identification scheme for an SVAR. The small open-economy assumption of the intertemporal approach gives the SVAR a restriction to identify global and country-specific shocks, because the assumption requires any country-specific shock to be orthogonal to the world real interest rate. By exploiting this orthogonality condition as well as Blanchard and Quah's decomposition, this paper has developed two identifying schemes for the SVAR and recovered its global, country-specific permanent, and country-specific transitory shocks.

The identified SVAR based on Canadian and U.K. data yields tests of the predictions that the intertemporal approach and the PVM make on the current account responses to the three shocks. A part of the results of these tests have reaffirmed the results of past studies. Even though the test jointly rejects the PVM's CERs on the RFVAR, the intertemporal approach and the PVM are still useful in explaining some aspects of current account movements. In fact, the IRFs of this paper are consistent with the theoretical counterparts of the intertemporal approach and the PVM. Thus, this paper contributes to the current account literature by providing further evidence that small open-economy models based on forward-looking economic agents are useful in understanding current account dynamics.

This paper has also revealed two puzzles that challenge the intertemporal approach. First, the response of the current account-net output ratio to a country-specific transitory shock is too large to support the PVM. This observation, in turn, draws a puzzling inference that consumption responds negatively to a positive income shock. The second puzzling aspect is that current account fluctuations are dominated by country-specific transitory shocks that explain almost none of the fluctuations in net output in the short and the long run. This puzzle implies that the consumption-tilting motive induced by country-specific shocks, rather than the consumption-smoothing behaviour emphasized by past studies, is important in accounting for current account movements. These failures of the intertemporal approach to the current account suggest that more research into its theoretical structure is needed. For example, more general utility functions, non-tradable goods, and endogenous risk premiums may yield resolution of these puzzles. A future task of the current account literature is to seek valid modifications of the basic intertemporal approach.

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Table 1: Identification Schemes

(a) Identification scheme I

Economic meaning	Restriction
A country-specific permanent shock has no *long-run* effect on the world real interest rate	$\Gamma(1)_{1,2} = 0$
A country-specific transitory shock has no *long-run* effect on the world real interest rate	$\Gamma(1)_{1,3} = 0$
A country-specific transitory shock has no *long-run* effect on the log of net output	$\Gamma(1)_{2,3} = 0$

(b) Identification scheme II

Economic meaning	Restriction
A country-specific permanent shock has no *instantaneous* effect on the world real interest rate	$\Gamma(0)_{1,2} = 0$
A country-specific transitory shock has no *instantaneous* effect on the world real interest rate	$\Gamma(0)_{1,3} = 0$
A country-specific transitory shock has no *long-run* effect on the log of net output	$\Gamma(1)_{2,3} = 0$

Note 1: In addition to three restrictions, each identification scheme requires that the structural shocks be orthogonal and have unit variances.

Note 2: $\Gamma(0)$ and $\Gamma(1)$ are the impact and the long-run matrices of the SVMA, respectively. $A_{i,j}$ shows the (i, j)th element of the matrix A.

Table 2: Calibrated Parameters and Joint Test of the Present Value Restrictions

	Canada	U.K.
κ	0.993	0.990
c	0.983	0.988
b	-0.712	0.377
σ	0.001	0.080
$\mathcal{W}$	18.193	23.224
p-value	0.000	0.000

Note 1: To calibrate b requires the data of international bond holdings, B_t. For B_t, this paper uses the international net investment position (IIP) in the balance-of-payment statistics. Statistics Canada (http://www.statcan.ca) distributes the annual IIP for Canada from 1926 to 2001. This paper converts the annual series to quarterly series, divides the resulting series by nominal net output and takes the sample average from 1963Q1-1997Q4 to construct b. On the other hand, National Statistics (http://www.statistics.gov.uk) provides the annual IIP series of the United Kingdom only from 1966. Nevertheless, the value of b for the United Kingdom is calibrated by applying the same method as in the Canadian case for the whole sample period 1966-97.

Note 2: The elasticity of intertemporal substitution, σ, is calibrated by minimizing the mean squared error of the PVM prediction on the current account-net output ratio.

Note 3: The Wald statistic, $\mathcal{W}$, is calculated conditionally on the calibrated parameters κ, c, b, and σ. The corresponding p-value is based on the chi-squared distribution with the third degree of freedom.

Table 3: Asymptotic Wald Tests for the Cross-Equation Restrictions

(a) Identification scheme I			(b) Identification scheme II		
	Canada	U.K.		Canada	U.K.
$\mathcal{W}_1$	0.190	0.758	$\mathcal{W}_1$	10.416	24.100
p-value	*0.663*	*0.384*	*p-value*	*0.001*	*0.000*
$\mathcal{W}_2$	0.069	0.001	$\mathcal{W}_2$	0.782	1.297
p-value	*0.793*	*0.983*	*p-value*	*0.376*	*0.255*
$\mathcal{W}_3$	1.562	1.589	$\mathcal{W}_3$	1.827	3.212
p-value	*0.211*	*0.208*	*p-value*	*0.176*	*0.073*
$\mathcal{W}_4$	379.392	320.599	$\mathcal{W}_4$	14.603	34.944
p-value	*0.000*	*0.000*	*p-value*	*0.002*	*0.000*
$\mathcal{W}_5$	20.010	0.823	$\mathcal{W}_5$	14.809	24.809
p-value	*0.001*	*0.935*	*p-value*	*0.005*	*0.000*

Note 1: The nulls of $\mathcal{W}_1$, $\mathcal{W}_2$, and $\mathcal{W}_3$ are Hypotheses 1, 2, and 3, respectively.

Note 2: The null of $\mathcal{W}_4$ is that Hypotheses 1, 2, and 3 are jointly satisfied.

Note 3: The null of $\mathcal{W}_5$ is that Hypothesis 1 is satisfied up to a year.

Note 4: The p-values are constructed from asymptotic χ^2 distributions.

Table 4(a): The FEVDs of the Current Account under Identification Scheme I

Canada Periods	g	cp	cs
1	0.056	0.174	0.770
	(0.153)	(0.154)	(0.197)
2	0.054	0.154	0.792
	(0.152)	(0.144)	(0.189)
3	0.049	0.149	0.802
	(0.149)	(0.142)	(0.186)
4	0.046	0.146	0.809
	(0.147)	(0.141)	(0.184)
12	0.034	0.138	0.828
	(0.138)	(0.136)	(0.173)
20	0.039	0.136	0.825
	(0.139)	(0.134)	(0.171)
40	0.044	0.135	0.821
	(0.141)	(0.132)	(0.171)

U.K. Periods	g	cp	cs
1	0.242	0.059	0.698
	(0.214)	(0.113)	(0.218)
2	0.239	0.049	0.712
	(0.213)	(0.106)	(0.212)
3	0.238	0.047	0.715
	(0.211)	(0.105)	(0.211)
4	0.237	0.046	0.717
	(0.210)	(0.105)	(0.209)
12	0.232	0.046	0.722
	(0.206)	(0.105)	(0.204)
20	0.231	0.047	0.722
	(0.206)	(0.104)	(0.204)
40	0.231	0.048	0.721
	(0.208)	(0.104)	(0.204)

Table 4(b): The FEVDs of the Log of Net Output under Identification Scheme I

Canada Periods	g	cp	cs
1	0.010	0.852	0.138
	(0.108)	(0.327)	(0.321)
2	0.011	0.864	0.125
	(0.101)	(0.320)	(0.315)
3	0.011	0.876	0.114
	(0.095)	(0.311)	(0.307)
4	0.010	0.886	0.104
	(0.089)	(0.299)	(0.295)
12	0.006	0.939	0.054
	(0.098)	(0.193)	(0.158)
20	0.005	0.959	0.037
	(0.131)	(0.166)	(0.096)
40	0.007	0.973	0.020
	(0.187)	(0.189)	(0.044)

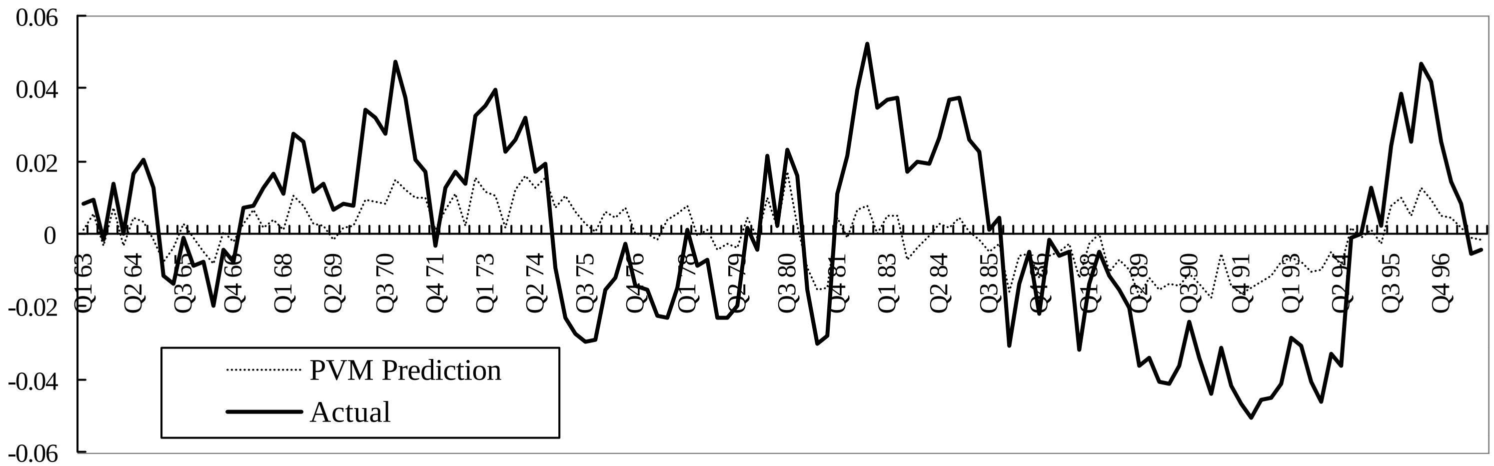
U.K. Periods	g	cp	cs
1	0.103	0.851	0.046
	(0.090)	(0.221)	(0.220)
2	0.111	0.851	0.039
	(0.089)	(0.208)	(0.209)
3	0.118	0.850	0.032
	(0.090)	(0.195)	(0.198)
4	0.125	0.848	0.027
	(0.093)	(0.184)	(0.187)
12	0.185	0.805	0.009
	(0.134)	(0.151)	(0.111)
20	0.225	0.769	0.006
	(0.166)	(0.169)	(0.075)
40	0.280	0.717	0.003
	(0.210)	(0.208)	(0.035)

Note 1: g, cp, and cs represent global, country-specific permanent, and country-specific transitory shocks, respectively.

Note 2: The numbers in parentheses denote the standard errors based on 10,000 non-parametric bootstrapping resamples.

Figure 1: PVM Predictions on Actual Current Account-Net Output Ratio

(a) Canada



(b) U.K.

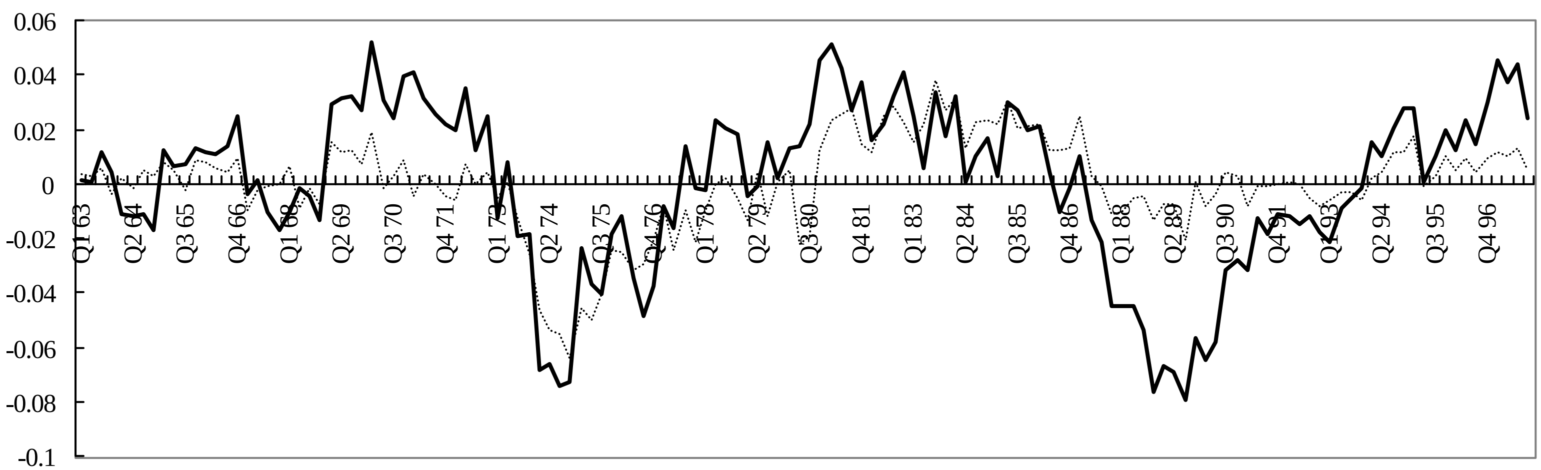
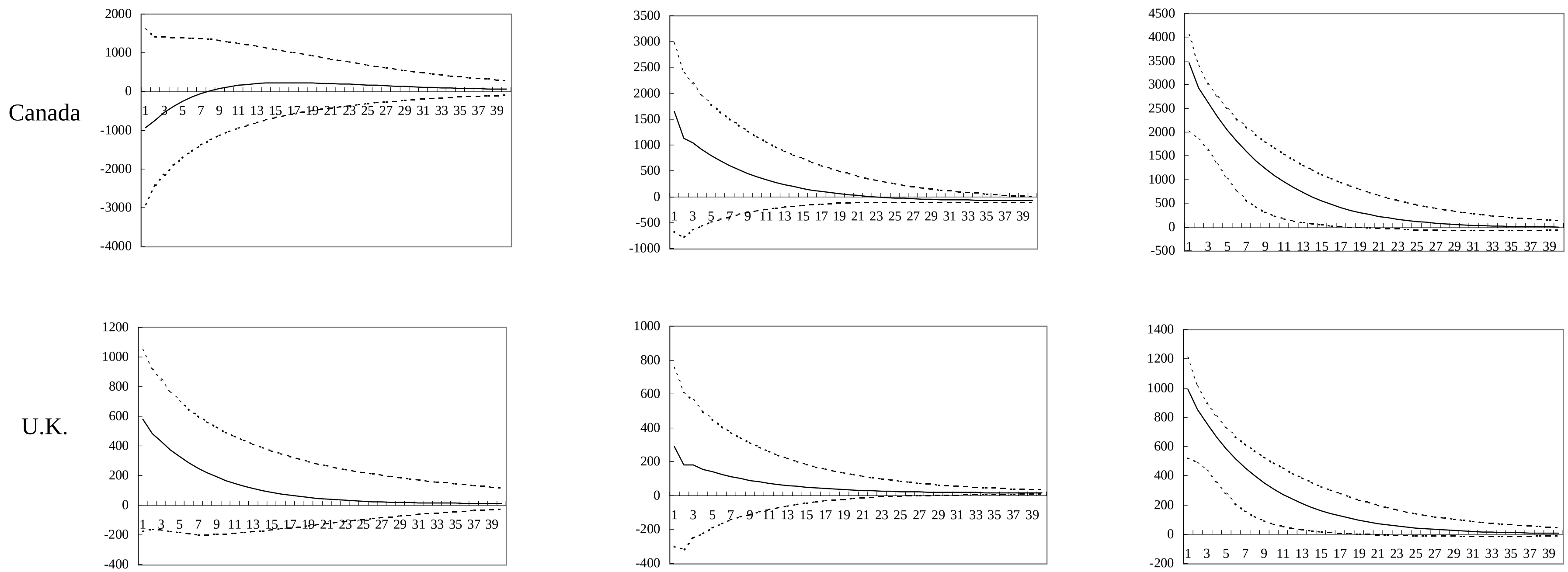


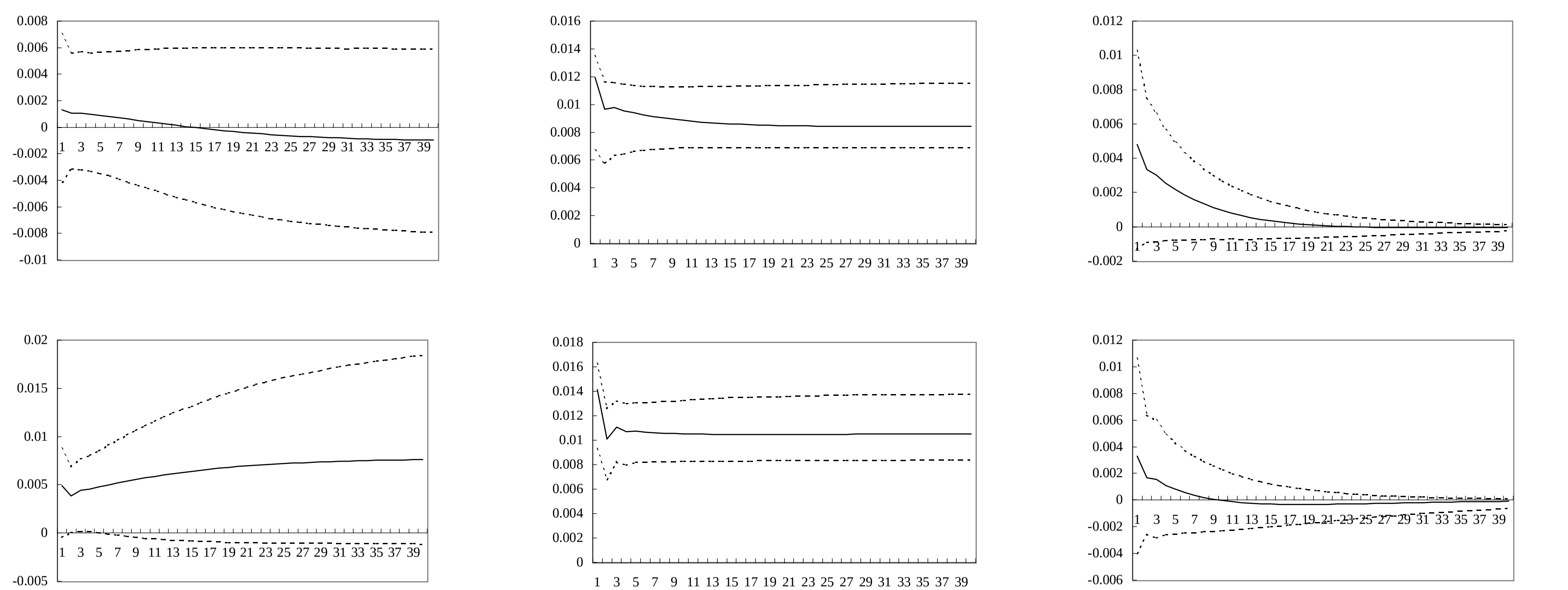
Figure 2: Impulse-Response Functions of the Current Account under Identification Scheme I

Responses to a Global Shock — *Responses to a Country-Specific Permanent Shock* — *Responses to a Country-Specific Transitory Shock*



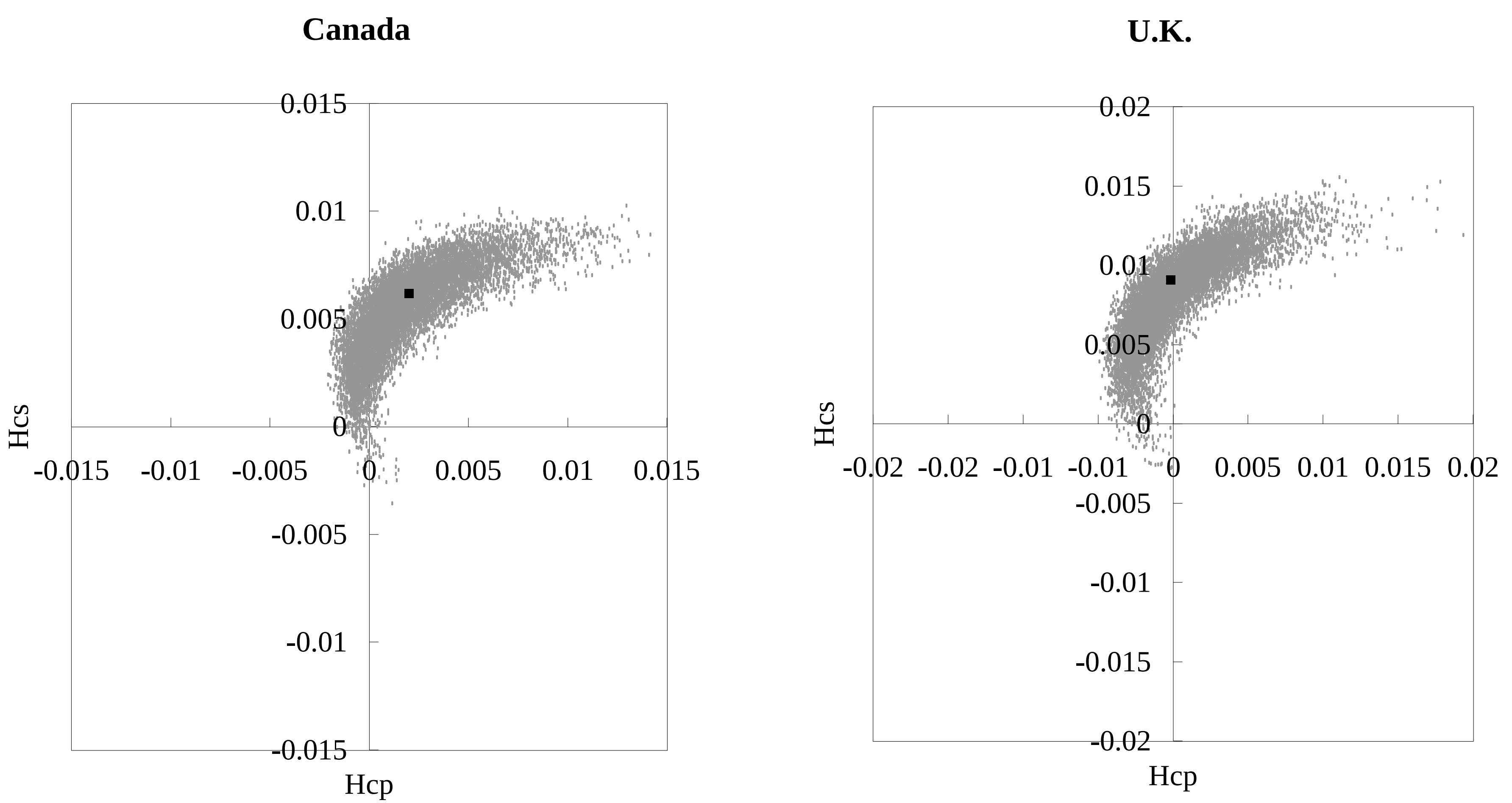
Note: The dark line shows the point estimates. The dashed lines represent 95 per cent confidence intervals based on 10,000 non-parametric bootstrapping resamples.

Figure 3: Impulse-Response Functions of the Log of Net Output under Identification Scheme I



Note: The dark line shows the point estimates. The dashed lines represent 95 per cent confidence intervals based on 10,000 non-parametric bootstrapping resamples.

Figure 4: Empirical Joint Distributions of the Statistics H_{cp} and H_{cs} under Identification Scheme I



Note 1: The scatter plots are based on 10,000 non-parametric bootstrapping resamples of the RFVAR residuals.
Note 2: The darkest squares are the ML point estimates.

Appendix A: Derivation of Cross-Equation Restrictions $\mathcal{H}_{cp}$ and $\mathcal{H}_{cs}$

To derive the CERs $\mathcal{H}_{cp}$ and $\mathcal{H}_{cs}$, this paper exploits the *Wiener-Kolmogorov formula*, which is well-known as Hansen and Sargent's (1980) *distributed predicted leads formula*. For exposition, this formula is given as the following lemma without proof.

Lemma (Hansen and Sargent 1980). *For a covariance-stationary process, X_t, with a Wold MA representation $X_t = A(L)\nu_t$ and $\beta \in (0,1)$, it is the case that*

$$\sum_{i=1}^{\infty} \beta^i E_t X_{t+i} = \beta \left[\frac{A(L) - A(\beta)}{L - \beta} \right] \nu_t.$$

By using the PVM (10), the maintained data-generating processes of the first difference of the log of net output and the world real interest rate, (11) and (12), and the above lemma, this paper derives a structural MA representation of the current account-net output ratio:

$$\frac{\widetilde{CA_t}}{NO_t} = \Gamma_g^{ca}(L)\epsilon_t^g + \Gamma_{cp}^{ca}(L)\epsilon_t^{cp} + \Gamma_{cs}^{ca}(L)\epsilon_t^{cs}, \tag{A.1.1}$$

where $\Gamma_g^{ca}(L)$, $\Gamma_{cp}^{ca}(L)$ and $\Gamma_{cs}^{ca}(L)$ are infinite-order polynomials, respectively, which satisfy

$$\Gamma_g^{ca}(L) = b\Gamma_g^r(L) + [c(\sigma - 1) + 1]\kappa \left[\frac{\Gamma_g^r(L) - \Gamma_g^r(\kappa)}{L - \kappa} \right] - \kappa \left[\frac{\Gamma_g^{no}(L) - \Gamma_g^{no}(\kappa)}{L - \kappa} \right], \tag{A.1.2}$$

$$\Gamma_{cp}^{ca}(L) = -\kappa \left[\frac{\Gamma_{cp}^{no}(L) - \Gamma_{cp}^{no}(\kappa)}{L - \kappa} \right], \tag{A.1.3}$$

and

$$\Gamma_{cs}^{ca}(L) = -\kappa \left[\frac{\Gamma_{cs}^{no}(L) - \Gamma_{cs}^{no}(\kappa)}{L - \kappa} \right], \tag{A.1.4}$$

under the assumption of a small open economy (14). Since the impact responses of the current account ratio to ϵ_t^{cp} and ϵ_t^{cs} are given as $\Gamma_{cp}^{ca}(0)$ and $\Gamma_{cs}^{ca}(0)$, respectively, $\mathcal{H}_{cp}$ and $\mathcal{H}_{cs}$ are obvious from (A.1.3) and (A.1.4).

Appendix B: Data Description and Construction

The data used in this paper span the sample period 1960Q1-1997Q4. All data are seasonally adjusted at annual rates.

To construct a measure of the world real interest rate, r_t, this paper follows the method of Barro and Sala-i-Martin (1990) and Bergin and Sheffrin (2000). It collects short-term nominal interest rates, three-month Treasury Bill rates, or money market rates of the G-7 economies from the International Financial Statistics (IFS) distributed by the IMF. The inflation rate in each economy is calculated by using the country's CPI and the expected inflation rate is constructed by regressing the inflation rate on its own eight lags. The nominal interest rate is then subtracted by the expected inflation rate to compute the ex-ante real interest rate. The world real interest rate is derived by taking the weighted average of the ex-ante real interest rates across the G-7 economies, with the time-varying weights for each economy based on its share of real GDP in the G-7 total.

To construct the net output and current account series of Canada and the United Kingdom, this paper uses each economy's national accounting data distributed by Datastream. All nominal series are converted to real series by using the GDP price deflators. The resulting real series are divided by population. Following the definition of net output, this paper constructs the net output series, NO_t, by subtracting gross fixed capital formation, change in stocks, and government consumption expenditure from GDP. Taking a log of the net output series and a first difference of the resulting logarithmic series provides the first difference of the log of net output, $\Delta \ln NO_t$. The current account series, CA_t, is constructed by subtracting gross fixed capital formation, change in stocks, government consumption expenditure, and private consumption expenditure from GNP. Dividing CA_t by NO_t provides the series of the current account-net output ratio, CA_t/NO_t.

Finally, the three series, r_t, $\Delta \ln NO_t$, and CA_t/NO_t, are demeaned to construct the series $\widetilde{r}_t$, $\Delta \widetilde{\ln NO_t}$, and $\widetilde{CA_t/NO_t}$.

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