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ON THE EFFECTS OF STERILIZED INTERVENTION

An Analysis of Weekly Data

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As the recent empirical studies surveyed here illustrate, it is very difficult to demonstrate that the exchange rate risk premium depends (through a portfolio balance channel) on the currency composition of outside assets. The existence of a 'portfolio balance effect' is a necessary condition for sterilized intervention to be a genuinely independent tool of monetary policy. This paper studies U.S./Canadian data, and attempts to improve on earlier studies by using higher frequency (weekly) data and by implementing an appropriate instrumental variables technique (2S2SLS). However, we still fail to detect evidence of a portfolio balance effect.

1. Introduction

It is by now widely accepted that sterilized intervention – intervention which alters the currency composition of interest-bearing government debt but does not affect the path of the monetary base – has no significant long-term impact on the exchange rate. More controversial is the question of whether sterilized intervention can be used to temporarily offset disturbances, even if it cannot be used to alter long-run trends.[1]

In theory, sterilized intervention operates on the exchange rate either by altering public perceptions of future monetary policy or by affecting the exchange rate risk premium.[2] The present paper focuses entirely on the latter

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[1] How and when sterilized intervention should be used, provided that it is effective, is discussed in Henderson (1984).

[2] The exchange rate risk premium is defined here as the 'uncovered' interest differential on two bonds identical in all respects except for currency of denomination, that is, the interest differential adjusted for the expected rate of appreciation of the exchange rate.

'portfolio balance' channel, asking whether sterilized intervention can influence the exchange rate by shifting exchange rate risk between public and private sector portfolios. It may seem misguided to abstract from the effects of sterilized intervention on expectations, when this channel might well be of greater empirical significance than the portfolio balance channel, but there is a strong argument for doing so. If the *only* effect of sterilized intervention is that it changes the public's expectations about the government's targets for the growth rate of money, then sterilized intervention cannot be properly regarded as an independent tool of monetary policy.

Most of the recent empirical studies surveyed in section 2 conclude that it is very difficult to detect a statistically significant portfolio balance effect on the exchange rate risk premium. While one highly plausible explanation of these results is that there *is* no portfolio balance effect, they can also be explained by the fact that the relevant theoretical models are very difficult to implement empirically. The data problems and the aggregation problems which plague all macro-econometric work are especially severe when it comes to estimating portfolio balance exchange rate models.

One problem that this paper attempts to improve on is the treatment of time aggregation. Previous efforts to estimate portfolio balance equations have generally been based on monthly or quarterly data. Such data necessarily contain only limited information about the very short-run effects of intervention. Here we examine weekly data for the Canadian dollar/U.S. dollar exchange rate. The weekly data set also includes Canadian and U.S. interest rates, interest-bearing debts, and monetary bases, as well as the Canadian Exchange Fund (see the appendix). The present paper also improves on earlier flexible-exchange-rate, portfolio-balance studies by implementing an instrumental variables estimator which is appropriate for rational expectations models with serially-correlated and/or conditionally-heteroskedastic structural disturbance terms; estimation issues are discussed in section 3.

The results reported in section 4 are not supportive of the existence of a portfolio balance effect. I am unable to find any regression in which the portfolio balance variables enter significantly with the right sign. This failure persists across different model specifications, estimating techniques, data sources, and subsamples. Thus the results are no more encouraging than those reported elsewhere in the literature.

2. Previous efforts to detect a portfolio balance effect

The portfolio balance model of exchange rate determination identifies the currency composition of outside nominal assets as a key influence on both the exchange rate risk premium and the exchange rate itself.[3] Obviously there are other (perhaps less easily observed) factors which, in theory, should also affect the risk premium.[4] But if the uncovered interest differential is solely a function of these other factors and does not depend on the relative supplies of outside assets, then it is difficult to argue that sterilized intervention constitutes an independent instrument of macroeconomic policy. As will be evident from the discussion below, strong and robust evidence of the existence of a 'portfolio balance effect' is hard to come by.

One line of empirical investigation is exemplified in Frankel (1982a), who estimates an equation for the uncovered interest differential between deutsche mark denominated and dollar denominated bonds. Frankel assumes that market participants have rational (unbiased) expectations and constructs the 'ex-post' uncovered interest differential by using the actual rate of exchange rate appreciation in place of its unobservable expected value. For explanatory variables, he employs portfolio balance variables such as the relative supplies of central government bonds (or alternatively bonds and high-powered money) denominated in deutsche marks versus dollars. Frankel finds that the portfolio balance variables do not enter significantly in his quarterly equations, and indeed the key coefficients are of the wrong sign. In a subsequent paper, Frankel (1982b) attempts to increase the power of his test by (a) using monthly data, (b) jointly estimating equations for six currencies (the U.S. dollar, deutsche mark, pound sterling, yen, French franc, and the Canadian dollar), and (c) imposing theoretical restrictions based on a model in which investors in each country maximize a function of the mean and variance of end-of-period wealth. Although the coefficients then have the right sign, they remain jointly insignificant. Frankel's work follows that of Dooley and Isard (1983), who do not perform formal hypothesis tests but instead estimate a regression subject to a grid of prior constraints. They conclude that the exchange rate risk premium can account at most for only a small percentage of quarterly mark/dollar movements.

[3] Outside nominal assets are those nominal assets which do not net out when aggregating across the private sector; that is, non-indexed government bonds and the monetary base. The distinction between inside and outside bonds is meaningless in models where infinitely-lived homogeneous agents have rational expectations about their future tax liabilities, or in models in which finitely-lived agents leave bequests to their infinitely-lived family units. Obstfeld (1982) and Stockman (1979) rigorously demonstrate the impotence of sterilized intervention in such models, even where bonds denominated in different currencies are imperfect substitutes due to exchange rate risk.

[4] Other factors which theoretically affect the exchange rate risk premium include the diversifiability of exchange rate risk, and the characteristics of investors' utility functions. Hansen and Hodrick (1983) and Hodrick and Srivastava (1984) point out how difficult it is to test intertemporal asset pricing theory models in which the risk premium depends on the covariation between intertemporal marginal rates of substitution on monies and the nominal returns on assets.

The Dooley–Isard–Frankel risk premium approach may be viewed in the context of the exchange market efficiency literature.[5] Most efficiency studies involve a joint test of two hypotheses: (a) there is no exchange rate risk premium, and (b) exchange markets are efficient. The joint null hypothesis is rejected in almost every recent study, and some authors specifically attribute rejection to a (time-varying) risk premium. But what one can learn from these efficiency studies is limited by the fact that their specifications seldom embody any particular theoretical model of the risk premium.[6] The Dooley–Isard–Frankel 'efficiency test' differs because it embodies the portfolio balance model, a model in which sterilized intervention is effective.

In a comprehensive recent study, Danker, Haas, Henderson, Symansky and Tryon (1984) attempt to detect a portfolio balance effect in separate bilateral equations for the mark/dollar, yen/dollar, and Canadian dollar/U.S. dollar uncovered interest rate differentials.[7] Danker et al. devote considerable effort to constructing monthly data series for Germany and Japan, and quarterly series for Canada. For example, they succeed in constructing data which separate out net German and foreign holdings of assets by currency of denomination,[8] and are able to do the same for Japan (but not for Canada). Danker et al. derive their risk premium equations by inverting bond demand equations which are disaggregated between the bank and non-bank private sectors. (Unlike the previous studies, they treat state and local debt as outside assets.) Despite these refinements, Danker et al.'s estimated risk premium equations (estimated under both static and rational expectations) provide little evidence in support of their model. The portfolio balance variables are jointly and individually insignificant for the Canadian dollar/U.S. dollar and yen/dollar equations. And although the portfolio balance variables are jointly significant in the mark/dollar equations, many of the individual coefficients are of the wrong sign. Danker et al. obtain somewhat more positive results for the mark, but not for the Canadian dollar and the yen, when they estimate equations with bond holdings as left-hand side variables. Danker et al. also report the results of an extensive specification search, in which they succeed in

[5]Examples of exchange market efficiency studies are Hansen and Hodrick (1980), Hakkio (1981), Longworth (1981), Cumby and Obstfeld (1981) and Meese and Singleton (1982). Huizinga (1983) discusses the small-sample properties of some standard efficiency tests.

[6]Hansen and Hodrick (1983), and Hodrick and Srivastava (1984) test specifications which loosely embody intertemporal asset pricing theory models. Domowitz and Hakkio (1983) model the risk premium as a function of conditional forecast error variances.

[7]In an earlier study, Symansky, Haas and Hooper (1981) found that portfolio balance variables did not influence the risk premium under rational expectations for any of four currencies (the deutsche mark, yen, Canadian dollar and pound sterling) against the U.S. dollar.

[8]Obstfeld (1983) has employed similarly disaggregated data.

obtaining results for Germany and Japan (but not for Canada) which broadly conform to the theoretical predictions of the portfolio balance model.

Loopesko (1984) examines daily official intervention data for six major currencies.[9] She finds that lagged cumulated intervention variables are jointly significant in risk premium equations for about half the subperiods she investigates, and concludes that sterilized intervention may have affected the exchange rate through a portfolio balance channel. Loopesko's results must be interpreted with caution because (a) her reduced form approach does not allow one to determine whether the intervention variables enter with the theoretically expected signs, and (b) intervention in foreign exchange markets represents only a minor component of total changes in the relative supplies of outside assets denominated in different currencies. New government debt issues, data for which are not available on a daily basis, are typically much more significant; see section 5 below.

The studies discussed thus far have been based on bond demand or risk premium (inverted bond demand) equations. Another major strand in the portfolio balance literature involves estimating quasi-reduced-form equations with the exchange rate (in levels or rates of change) as the left-hand side variable. For example, Artus (1976, 1981) and Branson, Halttunen and Masson (1977, 1979) study the mark/dollar rate; Haas and Alexander (1979) examine the Canadian dollar/U.S. dollar rate; while Driskill (1981) and Driskill and Sheffrin (1982) analyze the Swiss franc/dollar rate. These studies typically report results supportive of the portfolio balance model. But in all cases, this support is based primarily on the explanatory power in exchange rate equations of either (cumulated) net private capital flows or the (cumulated) current account.[10] It is true that, to the extent current account surpluses and deficits reflect differences in national savings rates, the portfolio balance model predicts that a current account surplus will be accompanied by an appreciating exchange rate.[11] Holding the supply of outside assets constant, the exchange rate appreciates as the (relative) real wealth of a country's citizens

[9] Pippenger and Phillips (1973) analyse daily Canadian intervention and exchange rate data from the 1950's. Their analysis makes no distinction as to whether intervention affects the exchange rate through a portfolio balance effect, or by altering expectations about future monetary policy. Because so little relevant data is available daily, it is extremely difficult to use such data to analyse the effects of sterilized intervention. See Rogoff (1983).

[10] Driskill (1981) and Driskill and Sheffrin (1982) substitute out for the trade balance by assuming that it depends on real income and the real exchange rate; they base their support for the portfolio balance model on the estimated coefficients of these proxy variables. Hooper and Morton (1982) also demonstrate the explanatory power of the cumulated current account.

[11] This is a partial equilibrium effect. The correlation between the exchange rate and the current account depends on the source of the disturbance and may also depend on whether the disturbance is anticipated or unanticipated.

rises, since they prefer assets denominated in their own currency. But there are a number of reasons to be reluctant to embrace the empirical correlation between cumulated current accounts and exchange rates as solid evidence of a portfolio balance effect. One is that such a correlation can easily arise in models in which bonds denominated in different currencies are perfect substitutes.[12] Another reason is that the current account has not been the only source of changes in real wealth for the major industrial countries. A significant portion of savings goes into capital stock investment, and real wealth also changes due to real capital gains and losses. Small percentage changes in the market valuation of the capital stock (the stock and corporate bond markets) or in long-term interest rates on government bonds have effects on private sector wealth which swamp the effects of observed current account surpluses and deficits. Finally, the correlation between major industrial country cumulated current accounts and exchange rates has not been as pronounced over the past few years as it was during some earlier years. [See, for example, Meese and Rogoff (1983).]

The studies cited thus far have involved small-scale econometric models. Hooper et al. (1982) report on extensive efforts to try to implement the portfolio balance theory within the Federal Reserve Board's Multi-Country Model, a large-scale econometric model consisting of quarterly models of Canada, Germany, Japan, the United Kingdom and the United States as well as abbreviated OPEC and rest-of-world sectors. Hooper et al. explore numerous approaches, involving alternative econometric techniques, simplifying assumptions, data sets, and expectational hypotheses. The authors conclude that they are unable to find empirical evidence to confirm their strong priors that the portfolio balance approach has quantitative significance.

A major deficiency in the empirical portfolio balance literature (including the present paper) is the focus on nominal assets. One justification for this focus is that real assets, such as the capital stock, do not bear any risk from purely nominal price and exchange rate movements (tax considerations aside). But in fact, a large part of exchange rate variation is real, and future empirical research should address the hard problem of incorporating capital into the portfolio decision. Another issue which is not yet (and probably cannot be) fully resolved, is the question of what types of government debt should be treated as outside debt. It is conventional to assume that developing-country governments, in deciding how to denominate their hard-currency debt, consider the same risk/return factors as private sector agents. Dooley (1982), however, suggests that developing-country debt might be treated as outside debt. Similar questions arise with state and local debt. In countries such as Canada, provincial and local governments issue considerable quantities of

[12] Dornbusch and Fischer (1980) develop a relationship between the exchange rate and the current account in a model in which all bonds are real.

foreign-currency debt, and it may not be appropriate to assume they have the same portfolio preferences as the federal government. (Some might also argue that the future tax liabilities on local debt are more likely to be anticipated by private agents.)

Indeed, the broader issue is that it is tempting to separately model the portfolio behavior of different sectors of the economy, and there are limitless plausible disaggregations. Unfortunately, the data limitations become severe even at modest levels of disaggregation; Hooper et al. discuss this problem. Yet another issue is how to incorporate political risk (fear of tax changes, capital controls, etc.). See Dooley and Isard (1980) and Obstfeld (1983).

3. Tests using weekly Canadian and U.S. data

Because the effects of sterilized intervention may be quite short-lived, it is natural to consider employing high-frequency data to construct a more powerful test of the portfolio balance effect. The empirical analysis below is thus based on weekly data, the shortest interval for which money supply and net new government bond sales data are available. In this section, we describe the model and appropriate estimation techniques.

When assets are perfect substitutes and there is no exchange rate risk premium, then uncovered interest rate parity holds,

$$r_t - r_t^* = s_{t+1}^{\mathrm{e}} - s_t, \tag{1}$$

where the t subscripts denote time, r_t is the interest rate on Canadian dollar bonds, r_t^* is the interest rate on U.S. dollar bonds, s_t is the logarithm of the Canadian dollar/U.S. dollar exchange rate, and s_{t+1}^{e} is the expected value of the logarithm of the exchange rate in period $t+1$, conditional on information available in period t. In the empirical analysis reported below, all interest rates and exchange rates within each regression are drawn from the same market (see the appendix). Thus any deviation from uncovered interest parity will presumably reflect exchange rate risk and not political risk. The portfolio balance model predicts that the exchange rate risk premium (the uncovered interest rate differential) on Canadian dollar denominated assets will be an increasing function of their relative supply,[13]

$$(r - r^* - \Delta s^{\mathrm{e}})_t = \alpha + \beta(A/SA^*)_t + \varepsilon_t, \tag{2}$$

[13]Frankel (1982a) uses this highly aggregative specification, though he also employs a specification which allows home and foreign residents to have different asset preferences. Eq. (2) can only be regarded as structural when all agents have identical portfolio preferences. Dooley and Isard (1983) include domestic and foreign wealth proxies in their equation, but these variables are difficult to measure, especially in weekly data. To account for wealth, a time trend is included in some of the regressions below.

where $\beta > 0$, $\Delta s_t^e = s_{t+1}^e - s_t$, A is the net supply of outside Canadian dollar denominated assets, A^* is the net supply of outside U.S. dollar denominated assets, S is the level of the exchange rate, and ε is a structural disturbance term, which may be serially correlated. In many versions of the portfolio balance model, the asset stocks A and A^* are postulated to include only interest-bearing debt. Fama and Farber (1979), however, stress that bonds and money are both nominal assets which bear the same degree of exchange rate risk. Their analysis suggests that net privately-held non-interest-bearing government debt – the monetary base – could also be included in A and A^*.[14]

The fact that eq. (2) assumes instantaneous asset market adjustment does not imply that unanticipated intervention has the same effect on the exchange rate (in magnitude or direction) as anticipated intervention. In the presence of slow goods market adjustment and/or slow accumulation of wealth towards target wealth, the general equilibrium effects of anticipated and unanticipated disturbances will typically be quite different.[15] Of course, if $\beta = 0$ in eq. (2), then sterilized intervention has no effect regardless of the degree to which it is anticipated.

It is impossible to estimate eq. (2) directly since the expected value of the future spot rate, s_{t+1}^e, is unobservable. Nor does it make sense to use the forward rate f_t as a proxy for s_{t+1}^e. As long as *covered* interest parity obtains,[16] f_t equals s_{t+1}^e if and only if uncovered interest parity holds [eq. (1)]. And the whole point of the portfolio balance model is that uncovered interest parity does not hold because of the exchange rate risk premium. So the approach taken here, following Dooley and Isard (1982) and Frankel (1982a, b), will be to assume rational expectations,

$$s_{t+1} = s_{t+1}^e + \theta_{t+1}, \tag{3}$$

where θ_{t+1} is a forecast error which is uncorrelated with any information dated period t or earlier. Substituting eq. (3) into eq. (2) yields

$$(r - r^* - \Delta s)_t = \alpha + \beta(A/SA^*)_t + \varepsilon_t - \theta_{t+1}. \tag{4}$$

[14]It is completely consistent to include the monetary bases in A and A^*, and at the same time posit standard money demand functions for each currency. Suppose all agents have identical attitudes towards exchange risk, but primarily use their own country's currency for transactions. The demand for money function would determine home residents' relative holdings of home money versus home bonds; the total share of home-currency denominated assets in their portfolios would depend on the uncovered interest differential [eq. (2)]; see Branson and Henderson (1984).

[15]See, for example, Henderson (1984) or Dornbusch and Fischer (1980).

[16]Covered interest parity implies that the forward premium equals the interest rate differential. Arbitrage ensures that covered interest parity holds exactly when all data are taken from the same trading room at the same time of day.

Estimation of eq. (4) is much simpler if one only worries about consistency under the null hypothesis that there is no exchange rate risk premium. Frankel (1982a, b) takes this approach; setting $\alpha = \beta = \varepsilon = 0$, eq. (4) collapses to

$$(r - r^* - \Delta s)_t = -\theta_{t+1}. \tag{5}$$

Treating $\alpha = \beta = \varepsilon = 0$ as the null hypothesis allows one to consistently estimate eq. (4) by ordinary least squares (OLS). One problem with Frankel's approach is that OLS is not necessarily consistent under the alternative hypothesis, $\beta > 0$, and therefore may lack power. As an extreme example, suppose sterilized intervention is used to fully offset all shocks to portfolio demand (ε) thereby perfectly stabilizing the exchange rate risk premium. The probability limit of the OLS estimate of β in eq. (4) would be zero regardless of the true size of β and in spite of the fact that sterilized intervention is effective. Even if the two asset stocks, A and A^*, are predetermined, the right-hand side variable in eq. (4) will be endogenous, in general, as long as the exchange rate S is endogenous. Thus there is a strong case for using an instrumental variables technique. An appropriate instrumental variables estimator for (4) should allow for possible serial correlation in the structural portfolio disturbance term, ε_t, and *must* allow for the moving average error which arises if $\mathrm{cov}(\varepsilon_t, \theta_t) \neq 0$. This covariance is unlikely to be zero since ε_t is almost certainly a component of the exchange rate forecast error θ_t. [Note also that if $\mathrm{cov}(\varepsilon_t, \theta_t) \neq 0$, then $(r - r^* - \Delta s)_{t-1}$ is definitely not a valid instrument.] For the above reasons, two-step, two-stage least squares (2S2SLS) is used below to estimate eq. (4).[17]

Before proceeding to the empirical results, we should prepare for the possibility that the ex-post risk premium will exhibit significant serial correlation and yet be insignificantly correlated with the portfolio balance variable. [The finding of serial correlation would not be surprising given the results of Longworth (1981), Cumby and Obstfeld (1981) or Dooley and Shafer (1983) for the Canadian dollar/U.S. dollar exchange rate.] One interpretation, which we should be extremely reluctant to embrace, is that exchange markets are inefficient. A more plausible interpretation would be that there is a time-varying exchange rate risk premium but one that cannot be affected by sterilized intervention.

4. Results

In this section, we estimate the portfolio balance equation (4), first by ordinary least squares and then by two-step, two-stage least squares. To form

[17]Cumby, Huizinga and Obstfeld (1983) derive the 2S2SLS estimator, which may be viewed as a single-equation generalized method of moments estimator [see Hansen (1982)]. Hayashi and Sims (1983) develop an alternative estimator; Hansen and Singleton (1982) develop a more general procedure which extends to nonlinear environments.

the (ex-post) uncovered interest differential, we use end-of-week seven-day Euromarket time deposit bid rates (non-annualized), and the log difference between next Friday's and this Friday's spot exchange rate. An appendix describes these data as well as the data used in measuring A and A^*: net private holdings of Canadian direct and guaranteed securities, net private holdings of U.S. Treasury bills, notes and bonds, and both the U.S. and Canadian monetary bases. (Even though A and A^* are measured at midweek, it is quite possible that exchange market participants lacked full knowledge of these asset stocks by Friday, when making their exchange rate forecasts. This particular source of bias in the OLS estimates may not be severe, however, since week to week movements in the relative asset stock variable, A/SA^*, are dominated by movements in the exchange rate S, a variable which market participants observe exactly. Note also that the 2S2SLS estimates reported later in this section are obtained using lagged variables as instruments for A/SA^*.)

Table 1 reports OLS estimates of eq. (4), in which A/SA^* is constructed alternately using interest-bearing assets only, and interest-bearing assets plus

Table 1

OLS estimates of eq. (4), weekly data.[a]

	Const. ($\times 10^{-3}$)	A/SA^* ($\times 10^{-2}$)	$D.W.$
Full sample March 1973–December 1980[b]			
Bonds only	2.9 (1.10)	−6.4 (1.30)	1.4
Bonds plus the monetary base	4.1 (1.17)	−7.7 (1.32)	1.4
Subsample March 1973–November 1976			
Bonds only	10.8 (1.56)	−21.5 (1.58)	1.3
Bonds plus the monetary base	8.0 (1.08)	−14.3 (1.11)	1.3
Subsample December 1976–December 1980			
Bonds only	−0.9 (0.20)	0.0 (0.00)	1.4
Bonds plus the monetary base	−0.1 (0.02)	−1.1 (0.12)	1.4

[a] t-statistics are in parentheses below the estimated coefficients. The dependent variable is the (non-annualized) one-week ex-post uncovered interest rate differential (Canadian minus U.S.). A/SA^* is the relative supply of Canadian dollar denominated outside assets versus U.S. dollar denominated outside assets.

[b] 407 weekly observations.

the monetary base. Over the full sample period, the coefficients on A/SA^* are insignificant and of the wrong sign. This result holds up when a time trend and/or monthly seasonal dummies are included.[18] Similar results are obtained when the lagged value of A/SA^* is either included, or used in place of, A/SA^*. Table 1 also reports results over two subperiods, to allow for the possibility that a structural break occurred in November 1976. That date marks an important election in Quebec as well as the beginning of a period of sustained depreciation in the Canadian dollar/U.S. dollar exchange rate. But the subperiod regressions yield equally poor results. The coefficients on A/SA^* remain negative and insignificant. The low Durbin–Watson statistics for all the regressions in table 1 indicate the possible presence of serial correlation.

Recall from section 3 that while the OLS estimates are consistent under the null hypothesis of perfect substitutibility, they are inconsistent under the alternative hypothesis that there exists a portfolio balance effect. Table 2

Table 2

2S2SLS estimates of eq. (4), weekly data.[a]

	Const. ($\times 10^{-3}$)	Time ($\times 10^{-5}$)	A/SA^*	ρ
	Full sample[b] *March 1973–December 1980*			
Bonds only	7.0	0.3	−0.15	0.35
	(1.30)	(0.72)	(1.34)	(1.91)
Bonds plus the monetary base	12.1	0.4	−0.22	0.38
	(1.53)	(0.89)	(1.55)	(2.04)
	Subsample March 1973–November 1976			
Bonds only	18.0	1.7	−0.34	0.38
	(2.71)	(2.97)	(2.96)	(1.26)
Bonds plus the monetary base	16.3	0.3	−0.20	0.09
	(2.15)	(0.45)	(2.35)	(0.33)
	Subsample December 1976–December 1980			
Bonds only	9.0	1.9	−0.27	0.22
	(0.73)	(0.79)	(0.81)	(1.00)
Bonds plus the monetary base	15.2	1.9	−0.35	0.25
	(0.94)	(0.93)	(0.99)	(1.05)

[a] t-statistics are in parentheses; ρ is the coefficient of the first-order autoregressive structural error process. The dependent variable is the (non-annualized) one-week ex-post uncovered interest rate differential (Canadian minus U.S.). A/SA^* is the relative supply of Canadian dollar denominated outside assets versus U.S. dollar denominated outside assets.

[b] 402 weekly observations.

[18] It may be useful to consider a more careful approach [see, for example, Plosser (1979)] to incorporating seasonality into portfolio balance models.

reports 2S2SLS estimates, with a correction for an ARMA (1,1) error term. The autoregressive component is assumed to arise from the structural error in eq. (2). The moving average component arises because we are using the realized value of the exchange rate as a proxy for its expected value. The estimates in table 2 are, of course, consistent whether or not assets are perfect substitutes. Nevertheless, the coefficients on A/SA^* are again of the wrong sign; this result continues to obtain when time is excluded from the regressions, and also when the square and cube of time are added as additional explanatory variables.[19] Aside from being of the wrong sign, the coefficient on A/SA^* is always insignificant except in the first subsample (though there the t-statistic is close to one when the square and cube of time are added to the regression). The persistence of a negative (albeit generally insignificant) slope coefficient, even in the instrumental variables regressions of table 2, is difficult to explain. Certainly, it is possible that eq. (4) is too aggregative to properly capture the portfolio balance effect. And we may have incorrectly modeled the serial correlation properties of the structural disturbance term ε, in which case the instrumental variables estimates in table 2 are not necessarily consistent.

These caveats are important, though our results can hardly be construed as positive evidence of a portfolio balance effect. Of course, the results are not entirely consistent with the joint hypothesis of perfect substitutability and market efficiency, either. The estimates of the autoregressive coefficient, ρ, are statistically significant over the full sample (though not over the subsamples).

For the results presented thus far, the (ex-post) uncovered interest rate differential has been constructed using seven-day Euromarket interest rates. A possible problem with these data is that the trading volume in very short-run Euromarket securities is considerably smaller than the volume in medium-term securities. To guard against any difficulties which may arise due to the thinness of the seven-day interest rate market, we shall now consider results based on one-month ex-post uncovered interest differentials. (These are constructed using one-month forward rate prediction errors under the assumption that covered interest parity holds exactly.) The disadvantage of using one-month interest differentials in a weekly regression is that it greatly complicates estimation. According to the portfolio balance model, the one-month uncovered interest rate differential should depend not only on this week's value of A/SA^*, but also on the expected value of A/SA^* for each of the following four weeks. (This is true even if portfolio adjustment is instantaneous.) The

[19]The results reported in table 2 are based on using time as well as lags of A/SA^* and $(r-r^*-\Delta s)$ as instruments. (Thus the first few observations are omitted.) Recall that $(r-r^*-\Delta s)$ must be lagged at least two periods to be a valid instrument. The results do not change when lagged values of r and r^* are added to the list of instruments. The computer program used was developed by Robert Cumby at the IMF. Cumby et al. (1983) explain how 2S2SLS implicitly allows for conditional heteroskedasticity, and provides an efficiency gain over nonlinear 2SLS if the model contains overidentifying restrictions.

above problem only compounds all the previously discussed estimation problems which arise when one tries to develop an estimator which remains consistent under the hypothesis of imperfect substitutability. Therefore, we will try only to achieve the more modest goal of ensuring that the one-month uncovered interest rate differential regressions are consistent under the null hypothesis that assets are perfect substitutes. Even so, we must take into account the fact that the error term will follow a fourth-order moving average process. [See, for example, Hakkio (1981).]

In the equations reported below in table 3, the left-hand side variable is the logarithm of the one-month forward rate minus the logarithm of the matching realized future spot rate, $f_t - s(f_t)$. To correct for the moving average disturbance term, all the equations are estimated by 2S2SLS.[20] The first equation in table 3 confirms the standard result that forward rate prediction errors are serially correlated (see section 3). The low R^2 statistic is consistent with another standard result: forward rate prediction errors are in large part unforecastable. Adding the relative supply of Canadian dollar denominated bonds to U.S. dollar denominated bonds (or bonds and money) adds very little explanatory power. The coefficients on A/SA^* and its lagged value are insignificant both individually and jointly. Furthermore, the estimated coefficients are again of the wrong sign. (Strictly speaking, it is incorrect to draw strong inferences from the signs of the coefficients on A/SA^* in table 3, because we are not estimating structural equations as in tables 1 and 2.) The portfolio balance variables remain jointly insignificant when more lags of A/SA^* are included. Allowing for a structural break in November 1976 does not change the complexion of the results, either. When no lags are included, A/SA^* does enter significantly over the early sample period, though with the wrong sign. The above results are based on Friday forward rates; A/SA^* never enters significantly or with the proper sign when forward rates from the following Tuesday are used instead.

In tables 1–3, A and A^* are constructed from the components of total Canadian and U.S. dollar assets available on a weekly basis. This limitation probably does not explain the negative findings here. Danker et al. (1984) use more refined quarterly data. Despite experimenting with a wide variety of disaggregations and specifications, they too failed to find any support for the portfolio balance model in Canadian data.[21]

[20] The results reported in table 3 do not involve using additional instruments to allow for conditional heteroskedasticity. I tried using additional lags of the right-hand side variables as instruments, but did not obtain significantly different results.

[21] I experimented with constructing weekly series on broadly-defined outside debt by interpolating from monthly and quarterly data. The method of interpolation uses related data available weekly and avoids incorporating information unavailable at time t into the week t element of the interpolated series (to avoid correlation with the exchange rate forecast error). Results based on the interpolated series were no more positive than those presented here. A complete description of the data, interpolation techniques, and representative results, is available from the author on request.

Table 3

Regressions for the one-month forward rate prediction error, $f_t - s(f_t)$.[a]

Equation	Const.	Time ($\times 10^{-5}$)	$f_{t-5} - s(f_{t-5})$	$f_{t-6} - s(f_{t-6})$	$(A/SA^*)_t$	$(A/SA^*)_{t-1}$	R^2	Chi-squared test: All slope coefficients = 0	Chi-squared test: Coefficients on $(A/SA^*)_t$, $(A/SA^*)_{t-1} = 0$
Autoregression	0.001	−1.0	0.12	−0.20				8.2[b]	
	(0.27)	(1.00)	(1.17)	(2.30)			0.021		
Bonds only	0.01	−0.2	−0.12	−0.19	−0.02	−0.20		9.8	0.2[c]
	(0.47)	(0.12)	(1.30)	(2.34)	(0.02)	(0.24)	0.027		
Bonds only	0.01	−0.2	0.13	−0.20	−0.21			8.5	
	(0.47)	(0.13)	(1.22)	(2.18)	(0.46)		0.027		
Bonds plus the monetary base	0.03	0.4	0.12	−0.17	−0.06	−0.41		10.4	0.7
	(0.85)	(0.18)	(1.27)	(2.17)	(0.06)	(0.46)	0.027		
Bonds plus the monetary base	0.02	0.4	0.14	−0.18	−0.46			8.9	
	(0.84)	(0.17)	(1.28)	(2.16)	(0.83)		0.027		

[a] The dependent variable is the logarithm of the Canadian dollar/U.S. dollar one-month forward rate minus the logarithm of the realized future spot rate. A/SA^* is the relative supply of Canadian dollar denominated outside assets versus U.S. dollar denominated outside assets. 2S2SLS estimation is used to correct for a fourth-order moving average error term. The data is weekly, June 1973–December 1980 (390 observations). t-statistics are reported in parentheses below the estimated coefficients.

[b] Significant at the 95 percent level of confidence. The other chi-square statistics in this column are significant at the 90 percent level. (When time is not included as a regressor, all are significant at the 95 percent level.)

[c] Both entries in this column are highly insignificant.

5. The scale of intervention

Even if there does exist a portfolio balance effect, one must recognize that the typical sterilized intervention operation is very small relative to existing stocks of outside assets. At the end of 1980, privately-held, Canadian dollar denominated, Government of Canada direct and guaranteed debt was approximately sixty billion dollars. If we include the monetary base as well as privately-held provincial and local government Canadian dollar debt, the figure would be closer to one hundred billion dollars. In contrast, Canada's official reserves minus gold stood at just over three billion U.S. dollars. (Choosing another year in the sample would not qualitatively change this comparison.) A country can, of course, increase its intervention resources by drawing on swap lines with other central banks, by issuing foreign-currency denominated debt, or by using forward market operations. Also, a small intervention may have large general equilibrium effects, especially if it is unanticipated.[22] Nevertheless, the fact that sterilized intervention operations are typically so small relative to total stocks might make one reluctant to believe that they have any significant macroeconomic impact through a portfolio balance channel.

6. Conclusions

The portfolio balance model predicts that the uncovered interest rate differential on assets denominated in currency A, relative to assets denominated in currency B, should be an increasing function of their relative supply. The existence of a portfolio balance effect is a necessary condition for sterilized intervention to be an *independent* tool of monetary policy. The voluminous exchange market 'efficiency' literature does provide some weak evidence that there exists a time-varying exchange rate risk premium. But it has proven very difficult to demonstrate that this time-varying risk premium responds as predicted to changes in the relative supplies of outside assets denominated in different currencies.

In this study, we have attempted to use high-frequency weekly data to detect a portfolio balance effect in the Canadian dollar/U.S. dollar exchange rate risk premium. Unfortunately, the data have resisted all our efforts to obtain equations for the uncovered interest rate differential in which portfolio balance variables appear with statistically significant coefficients of the right sign. The results are therefore no more encouraging than those obtained in studies based on lower-frequency data.

[22] From March 1973 to December 1980, the mean absolute value of weekly changes in Canada's international reserves (adjusted for valuation effects and SDR allocations) was ninety-eight million U.S. dollars, about half the size of mean absolute changes in privately-held Canadian government debt. So it is possible that a significant percentage of unanticipated changes in the latter series was due to exchange market intervention (rather than domestic debt operations.)

Because empirical implementation of portfolio balance models requires vast theoretical simplifications, the negative results presented here and elsewhere in the literature cannot be regarded as decisive. Of course, if the portfolio balance model were literally impossible to implement empirically, then it would be rather difficult to provide policy makers with any firm quantitative basis on which to conduct sterilized intervention operations.

Appendix: Data description

The sample period, March 1973 through December 1980, was chosen to correspond to the availability of weekly Canadian Exchange Fund data (obtained from the Bank of Canada). All raw data is seasonally unadjusted.

One-week ex-post uncovered interest differentials, $r - r^* - \Delta s$: Spot exchange rates and 7-day time deposit interest rates are London closing bid rates from the *Financial Times*. Where 7-day rates are not quoted, 30-day rates are used as a proxy. Note that the delivery lag on standard Euro–U.S. dollar time deposit contracts is two days, whereas the lag for Euro–Canadian dollar time deposits and U.S./Canadian spot exchange contracts is one day. Therefore, Thursday Euro–U.S. dollar interest rate quotes are aligned with Friday quotes for other rates. (The text results are qualitatively unchanged when all quotes are drawn from Fridays.)

One-month forward exchange rates are Friday and Tuesday opening bids from Data Resources Inc. These are aligned with spot rates (DRI) one month hence; see Riehl and Rodriguez (1977) for the exact procedure.

Weekly data on net private holdings of Canadian dollar denominated assets are from the *Bank of Canada Review*. Interest-bearing assets include Government of Canada direct and guaranteed Canadian dollar denominated securities, net of central government and Bank of Canada holdings (series B2482 minus B2421; for 1980, B2400 and B2508 are used in place of the discontinued B2482). Non-interest-bearing assets include notes in circulation plus chartered bank deposits at the Bank of Canada (B51 plus B55).

Weekly data on net private holdings of U.S. dollar denominated assets are from the Federal Reserve Board. Interest-bearing asset series are constructed from FRB data on all Treasury bill, bond and note issues and retirements: Federal Reserve System and foreign official purchases are netted out. Non-interest bearing assets are the seasonally-unadjusted monetary base minus government checking accounts. U.S. dollar assets are converted to Canadian dollars using Wednesday London closing spot exchange rates. (Qualitatively equivalent results obtain when Friday rates are used.)

In constructing a weekly exchange market intervention series from Canadian Exchange Fund data, SDR allocations and bookkeeping valuation effects (due mainly to changes in the SDR/dollar rate) were netted out.

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