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Articles

Cover

Canada's First Coinage

David Bergeron, Curator, Currency Museum

This year, 2008, marks the 150th anniversary of the adoption of decimal coinage in Canada. Although coins were first issued in 1858 in the Province of Canada—then Canada East (Quebec) and Canada West (Ontario)—the debate on whether to base Canada's currency on a decimal system similar to that used in the United States long predated the actual event.

Decimalization of Canada's currency was being considered as early as 1841, when commercial trade was suffering because of diverging currency standards in the major centres. For example, Montréal was on the Halifax rating, which established the dollar at 5 shillings, while Toronto (York) used the York rating, pegging the dollar at 8 shillings. Values for precious-metal coins, such as the British sovereign and the French louis, fluctuated as well, making it difficult to determine their rate of exchange. For many merchants, bankers, and financiers, adopting the dollar would provide a standardized system that would also make trade easier. Nevertheless, it took several years for debate to become policy.

The Province of Canada took the first step towards standardizing its currency in 1853, through legislation that required the provincial accounts to be kept in both dollars and pounds sterling. This move reflected the Province's changing trading patterns, which were marked by increasing trade with the United States, and took place just one year before the signing of the 1854 Treaty of Reciprocity that formally linked Canada and the United States as trading partners.

Decimalization of Canada's coinage was the next logical step towards improving trade with the United States. Legislation passed in 1857 ensured that government accounts would only be kept in dollars, and introduced decimal coinage as the Province's standard currency. In 1858, the first decimal coins, consisting of 1, 5, 10, and 20-cent coins were placed into circulation. The 20-cent coin, whose value was based on the British shilling, did not last long, however, since the denomination was not used in the United States. To replace it, a 25-cent coin was introduced as part of the Dominion coinage issued in 1870. By then, the remaining provinces had adopted a system of decimal coinage, and all of Canada's coins had the same weight, dimensions, and values as their American counterparts.

The 1858 double-specimen set pictured on the cover was produced at the Royal Mint in Britain and is a spectacular representation of Canada's first decimal coins. A very limited number of such sets would have been created for presentation to the Queen, the Governor General, and other dignitaries and were meant to promote the new coinage. This rare specimen set is part of the National Currency Collection of the Bank of Canada.

Photography by Gord Carter, Ottawa.

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Canada's Experience with a Flexible Exchange Rate in the 1950s: Valuable Lessons Learned

Lawrence Schembri, International Department

- *Canada's lengthy experience with a flexible exchange rate regime has had an important impact on the development of macroeconomic theory and policy in open economies.*
- *This article focuses on the 1950–62 floating-rate period because the flexible exchange rate, combined with a high degree of capital mobility between Canada and the United States, provided an unprecedented experiment for macroeconomic policy.*
- *The Canadian experience over this period highlighted the two key benefits of a floating rate: smoother and less costly adjustment to external shocks and the opportunity to operate an independent monetary policy to achieve low and stable inflation.*
- *Canada's experience also led to the development of the Mundell-Fleming model and a better understanding of the impact of monetary and fiscal policies in open economies.*

Canada's experience with a flexible exchange rate regime in the twentieth and twenty-first centuries is remarkable not only for sheer length, but also for its impact on macroeconomic theory and policy in open economies.[1] Although Canada had a flexible exchange rate regime over the periods 1933–39 and 1950–62, and has maintained one since 1970, this article focuses on the important lessons learned from the intermediate period in the 1950s because economic historians consider it the most influential.[2] The purpose of the article is to examine the two most notable lessons from the Canadian experience. First, it highlighted the two key, and still important, benefits of a flexible exchange rate regime: namely, its ability to insulate the domestic economy from external shocks by facilitating a smoother and thus less costly macroeconomic adjustment, and the fact that it permits the operation of an independent national monetary policy.[3] Second, Canada's experience led to a better understanding of the impact of monetary and fiscal policies in an open economy with a high degree of capital mobility. Moreover, the Canadian experience demonstrated that because a flexible exchange rate is an endogenous market-determined variable, its effectiveness as a macroeconomic shock absorber depends on its being supported by a coherent monetary and fiscal policy framework

1. This article is largely based on two recent Bank of Canada research papers: Bordo, Dib, and Schembri (2007) and Bordo, Gomes, and Schembri (2008).

2. Powell (2005) provides an insightful overview of the history of the Canadian dollar.

3. In an environment of no capital controls (i.e., capital mobility) countries cannot simultaneously maintain an independent monetary policy and a fixed exchange rate. Thus, to operate an independent monetary policy, a country must adopt a flexible exchange rate.

aimed at achieving low inflation and stable output growth.[4]

Canada's floating-rate experience contributed to the postwar debate on exchange rate regimes by providing evidence to support the case for a flexible rate as a viable alternative to the Bretton Woods system of pegged exchange rates. In 1950, Canada was the first major industrialized country to leave the Bretton Woods system to adopt a floating exchange rate. The consensus is that Canada's flexible rate performed well over the next 12 years.[5] In particular, the flexible rate traded in an orderly manner and responded to shocks to underlying fundamentals largely as theory would predict; it did not fluctuate widely or erratically as a result of speculative excesses, as some had predicted. This largely beneficial experience confirmed the predictions of James Meade (1951) and Milton Friedman (1953; see also Friedman, Gordon, and Mackintosh 1948), who were early supporters of flexible exchange rates. The Canadian experience subsequently generated much interest and numerous studies.[6] This research, in turn, helped to motivate the ongoing debate on exchange rate regimes and foreshadowed the eventual collapse of the Bretton Woods system in the early 1970s, when, once again, Canada was the first of the major countries to exit.

The flexible exchange rate traded in an orderly manner and did not fluctuate widely, as some had predicted.

Canada's flexible exchange rate experience in the 1950s demonstrated the two principal benefits of a flexible exchange rate regime. First, the floating rate responded to external shocks, such as shifts in export demand or commodity-price (terms-of-trade) movements, to facilitate real exchange rate adjustment which, in turn, mitigated the impact of these shocks on domestic economic activity and on the aggregate price level. Its ability to respond to these external shocks over this period was sometimes limited, however, by monetary policy that was insufficiently countercyclical. Second, the flexible exchange rate permitted an independent monetary policy that was reasonably successful in achieving low and stable inflation. As noted in Friedman and Roosa (1967, 122), however, "floating rates are not a guarantee of sensible internal monetary policy." In the first half of the floating-rate period (1951–56), inflation and unemployment rates were relatively low. In the second half of the period (1957–62), however, monetary policy was not sufficiently countercyclical, which led to higher unemployment rates, slower growth, and episodes of monetary and fiscal policy conflicts. This chain of events played a role in the forced resignation of the Governor of the Bank of Canada, James Coyne, and eventually led to the collapse of the flexible-rate regime as Canada temporarily returned to the Bretton Woods fixed-rate system.

The same events were the inspiration for new approaches to understanding and modelling monetary and fiscal policies and their roles in macroeconomic stabilization in an open economy. In particular, Canada's flexible exchange rate and high degree of capital mobility with the United States provided an unprecedented experiment for macroeconomic policy. The ramifications of these two conditions for monetary and fiscal policy were not fully appreciated until the work of Canadian Robert Mundell and J. Marcus Fleming. Indeed, the development of the Mundell-Fleming model is widely seen as the path-breaking innovation in the development of modern open-economy macroeconomics, and for his contribution, Mundell received the Nobel Prize in 1999.

The International Monetary Fund (IMF) deplored Canada's decision to float its dollar in 1950 because its officials viewed Canada's departure as a serious threat to the newly founded Bretton Woods system. The success of Canada's float not only mollified their criticism and their calls for a quick return to the pegged-rate system, it also promoted research at the IMF on flexible exchange rates. Indeed, Fleming's research was conducted while he was an IMF official, and Mundell did some of his work on the subject while visiting the IMF in the early 1960s.

The article is divided into three sections: the historical narrative; an analysis of the behaviour of the flexible rate over the period 1950–62; and a brief discussion of the impact of the Canadian experience on economic thought.

4. See Laidler (1999) for a discussion of the need for a coherent monetary order under a flexible exchange rate regime.

5. For example, Friedman and Roosa (1967, 122) wrote "Canada went off floating exchange rates . . . because they were working so well, and their internal monetary policy was so bad." See also Yeager (1976).

6. Yeager (1976) provides an excellent critical review of this literature.

Historical Narrative

Although this narrative is organized chronologically, the two important sets of lessons from Canada's experience—on the potential benefits of a flexible exchange rate for an open economy like Canada's and the conduct of macroeconomic policies under a flexible exchange rate and a high degree of capital mobility—are identified and discussed throughout.

Prelude to floating

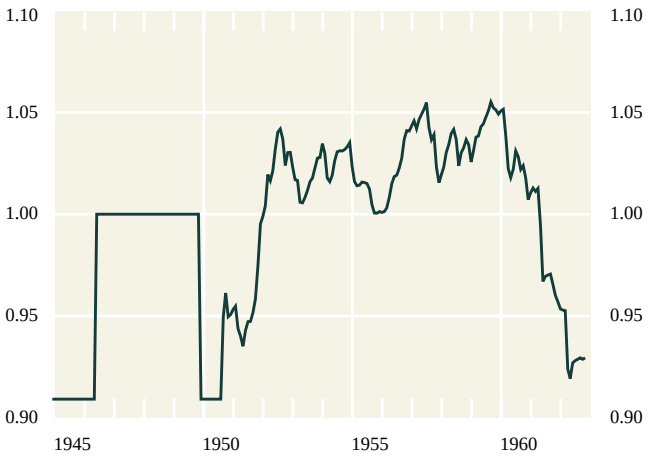
Canada played an important role in the founding of the IMF and the Bretton Woods system in July 1944. Future Bank of Canada Governor Louis Rasminsky provided critical leadership in the negotiations by serving as a mediator between the American and British teams, led by Harry Dexter White and John Maynard Keynes, respectively (Muirhead 1999). The principal goal of the Bretton Woods pegged, but adjustable, exchange rate system was to preserve the stability of the international monetary system by preventing the beggar-thy-neighbour exchange rate policies and the resulting macroeconomic instability of the interwar period.

From 1945 to 1950, Canada tried to maintain its commitment to a pegged exchange rate under the Bretton Woods system, but was forced by swings in commodity prices, investment flows, and reserve levels to adjust its pegged exchange rate in July 1946 (from US$0.909 to parity) and again in September 1949 (from parity to US$0.909) in order to preserve domestic macroeconomic stability (see Chart 1).[7] Despite the continued use of exchange controls, however, the pegged rates could not be easily maintained in either instance because sharp movements in the balance of payments and reserve levels (Chart 2) would have forced domestic prices and wages to adjust to the external imbalances via changes in the domestic money supply. Moreover, this sequence of relatively rapid up-and-down adjustments in the pegged exchange rate created the expectation that the authorities would respond with another re-pegging when economic circumstances changed. Thus, if speculators correctly anticipated a pegged-rate revaluation (or devaluation), they could earn large returns by acquiring domestic (or foreign) currency assets beforehand. Consequently, speculation could become self-fulfilling, since the expectation of an adjustment would fuel capital flows and increase the likelihood of re-pegging. Indeed, this self-fulfilling aspect of speculation against a pegged exchange rate was a critical factor in the decision to float in 1950.[8]

Chart 1

Exchange Rate

Monthly average noon rates, US$ per unit

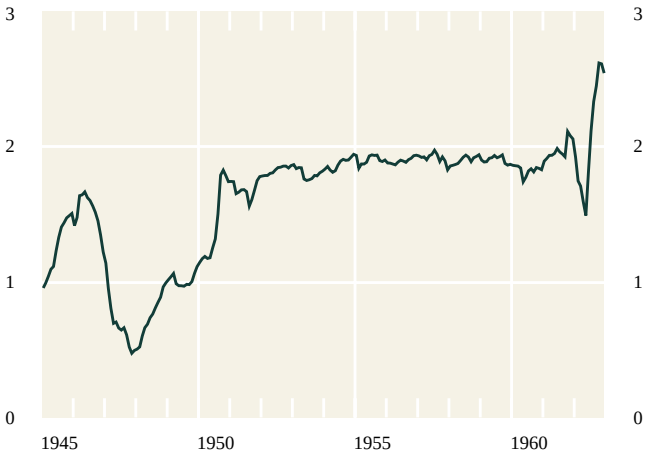


Source: Bank of Canada

Chart 2

Canadian Official Holdings of Gold and U.S. Dollars

Billions of US$



Source: Bank of Canada

1950: The decision to float

Soon after the devaluation of 1949, international economic conditions changed in favour of Canada's

7. The United Kingdom and 30 other countries also devalued their currencies relative to the U.S. dollar at the same time as Canada because of postwar difficulties in financing trade deficits.

8. Self-fulfilling speculative activity against fixed exchange rate regimes was an important aspect of the exchange rate crises in Europe, Latin America, and East Asia in the 1990s. See Osakwe and Schembri (1998) for a useful survey.

exports. The terms of trade and capital inflows increased as a result of rising commodity prices and greater U.S. investment in the Canadian natural resources sector (Charts 3 and 4). The demand for these resources increased because of the economic expansion driven by the post-World War II recovery and by the expenditures related to the Korean War, which began in June 1950. This balance-of-payments surplus, which was caused by both higher exports and capital inflows, led to a significant increase in international reserves, bank reserves, and the money supply. As is evident in Chart 2, the accumulation of reserves accelerated as speculators bought Canadian-dollar assets on the expectation of another adjustment in the exchange rate peg. To offset this substantial surge in inflationary pressure, the authorities decided to float the Canadian dollar rather than try to pick another par value, only to find out, as in 1946 and 1949, that it was no longer consistent with external balance.

To offset this surge in inflationary pressure, the authorities decided to float the Canadian dollar rather than try to pick another par value, only to find out that it might no longer be consistent with external balance.

IMF reaction to Canada's decision

Canada's decision to float was significant because floating meant departing from the normal rules of the par value Bretton Woods system, under which members, once having declared a par value, could only change it if circumstances suggested a fundamental disequilibrium and only after consultation with the IMF. Thus, Canada's proposal to adopt a flexible rate in 1950 was perceived as breaking—or at least flouting—the rules by an important IMF member country and was criticized by IMF staff as demonstrating a lack of discipline. They were seriously concerned that other member countries might follow suit and jeopardize the existence of the new system, and possibly the IMF, whose founding goal was exchange rate stability.

As alternative policies to manage the inflationary pressure of the increasing capital inflows, IMF staff recommended some combination of revaluation, capital control, and sterilization of the impact of the reserve increase on the domestic money supply. As noted, Canada had little interest in revaluing, given its limited success in finding a pegged rate that could sustain external balance. Canadian officials were reluctant to impose capital controls on the inflows or to issue more debt to sterilize their impact on the domestic money supply. The IMF was more receptive, however, to the argument made by Canadian authorities that the decision to float was a temporary move, with a return to the par value system to take place once a new fundamental equilibrium had been reached.[9]

1950–51: Transition to a market-determined flexible exchange rate

After the decision to float, the Canadian dollar appreciated by 12 per cent, from US$0.909 to US$1.02, over the next 18 months. This rapid appreciation was caused by higher commodity prices driven by the U.S. expansion, which generated large and ongoing capital inflows from the United States—largely foreign direct investment (FDI)—to develop Canada's natural resources (Yeager 1976, 544) (Charts 3 and 4).

This inflation experience highlighted the need for the Bank to obtain instruments to allow it to conduct independent and countercyclical monetary policy under a flexible exchange rate.

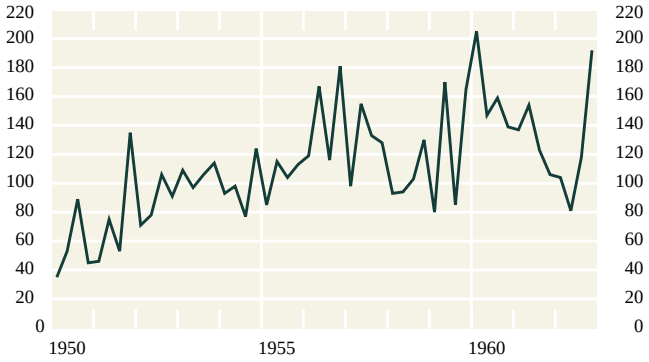
This inflationary pressure posed a serious challenge to the Bank of Canada's monetary policy. Under the Bank of Canada Act, the Bank has a broad mandate that includes protecting the external value of the currency and mitigating fluctuations in prices and economic activity. At the beginning of the floating-rate period, however, the Bank lacked the instruments, the experience, and a set of best practices to conduct effective countercyclical monetary policy under a flexible exchange rate. In particular, the Bank's conduct of monetary policy was hamstrung by the absence of an active market for short-term government securities or an interbank market for reserves. The Bank Rate was the most visible instrument of monetary policy, but

9. In a speech on 20 October 1952, the Minister of Finance, Douglas Abbott, said, "At some future time conditions may develop [in Canada] in which it would be appropriate to establish a fixed rate of exchange for the Canadian dollar." See Binhammer (1964, 639) and Yeager (1976, 544) for further details.

Chart 3

Foreign Direct Investment in Canada

Quarterly, Can$ millions

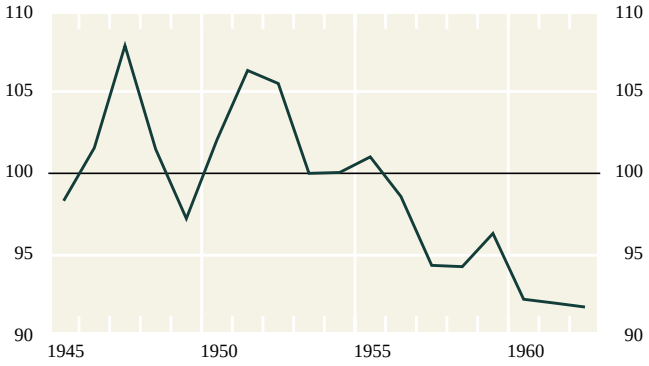


Source: Statistics Canada

Chart 4

Canadian Real Commodity Price Index

Annual (1953 = 100)

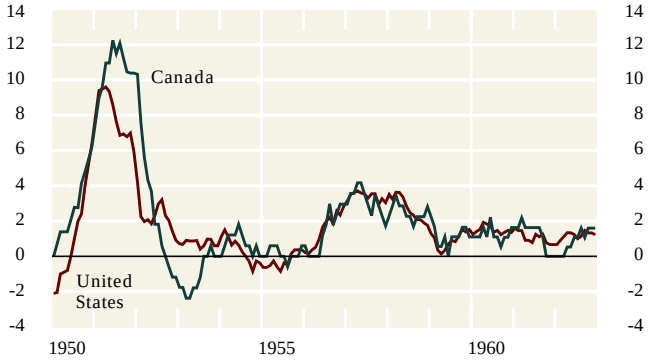


Source: Bank of Canada

Chart 5

Consumer Price Index

Monthly (1997 = 100), year-over-year growth rate



Source: Statistics Canada and U.S. Bureau of Labor Statistics

its effectiveness in influencing monetary conditions was hindered by the fact that the interest rate channel for the transmission of monetary policy was not well developed. Consequently, monetary policy was also conducted through various limited forms of open market operations involving government securities and government deposits held by the chartered banks, and by moral suasion and direct regulation to influence the volume of chartered-bank lending. To help the Bank manage the ongoing inflationary pressure, special direct restrictions on consumer and bank credit were adopted in 1950 and 1951. Despite the appreciation of the Canadian dollar, which helped to insulate the Canadian economy from U.S. inflation, the absence of a timely and effective monetary policy response made it difficult to control domestic inflation. As a result, CPI inflation was 6 per cent in 1950 and rose to over 10 per cent in 1951 (Chart 5), much of it driven by food prices.[10, 11] This experience highlighted the need for the Bank to obtain instruments to allow it to conduct independent and countercyclical monetary policy under a flexible exchange rate.

1952–56: Stability, reform, and growth

The 1952–56 period was the heyday of the 1950s floating-rate regime. The Canadian dollar traded at a premium relative to the U.S. dollar (Chart 1), and FDI-driven capital inflows continued (Chart 3). Inflation receded, and with the exception of the 1953–54 recession, growth remained relatively strong. The conduct of monetary policy became more effective as financial market transmission channels were strengthened. Nonetheless, the responsiveness of monetary policy, although improved, remained somewhat sluggish, which limited its countercyclical impact. Although exchange rate adjustment was countercyclical and stabilizing over this period, its role was constrained by the muted monetary policy response.

Since the flexible exchange rate was adjusting to manage the demand for foreign exchange, exchange controls were no longer needed and were lifted in December 1951.[12] Direct restrictions on consumer and bank credit were removed in 1952 because inflationary pressures

10. Inflation is measured year over year from December.

11. It is interesting that Mexico, which faced inflationary pressures coming from the U.S. expansion that were similar to those experienced by Canada in the early 1950s, chose to maintain a fixed exchange rate. As a result, it experienced inflation that exceeded 20 per cent, at least double that in Canada. See Murray, Schembri, and St-Amant (2003) for more details.

12. Canada was the second country after the United States to remove exchange and capital controls after WWII. Indeed, the removal in 1951 restored the situation to what it was before the war. See Powell (2005) for further details.

had subsided. This deregulation and liberalization created a favourable environment for the development of financial markets. The Bank of Canada took several important steps in 1953 to encourage the development of a broad and active market in treasury bills, which included shifting from a biweekly to a weekly auction and entering into purchase and resale agreements with dealers of government securities. This latter innovation spurred the establishment of a day-to-day loan market among the bank and investment dealers as banks became more interested in managing their reserves and the investment dealers were able to use the purchase and resale agreements to obtain cash from the Bank of Canada. Thus, the adoption of a flexible exchange rate in 1950 contributed to financial market development that strengthened the Bank's ability to conduct more effective monetary policy by establishing a clearer interest rate channel for the transmission of monetary policy.[13]

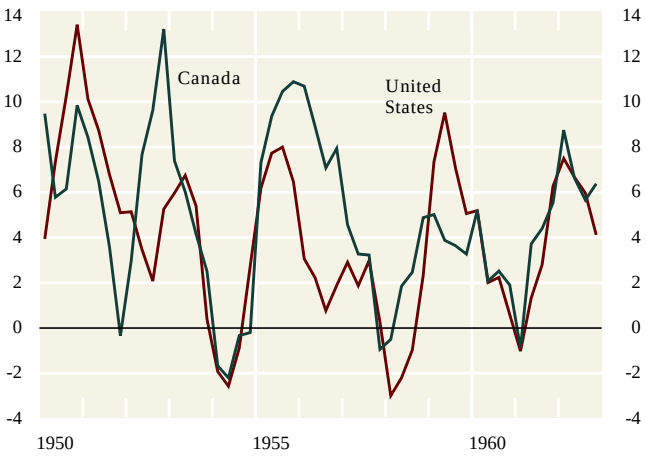
At the end of the Korean War in 1953, defence expenditures fell on both sides of the border, and the Canadian and U.S. economies went into a short but sharp recession (Chart 6). Inflation in Canada fell below zero. Since market interest rates also remained relatively low, the Bank Rate was reduced to 1.5 per cent in February 1955 because the Bank felt that this rate should be more "flexible and bear a closer (though not fixed) relation to other short-term interest rates" (Bank of Canada 1956, 7). Indeed, this change marked the beginning of more frequent use of the Bank Rate as an instrument of monetary policy.[14]

The Canadian economy grew strongly—and faster than the U.S. economy—through the rest of 1955, 1956, and into 1957 (Chart 6). Investment boomed in both countries, and in Canada was centred on the development of natural resources. The new investment required higher imports, which were financed by large inflows of foreign direct investment. As aggregate demand grew, inflation pressures began to mount and, for the first time in the floating-rate period, the inflationary pressure was domestic in origin. Although inflation was almost zero in 1955, it jumped to 3 per cent in 1956 (Chart 5).

Chart 6

Real Gross Domestic Product (1997 prices)

Quarterly, year-over-year growth rate



Source: Statistics Canada

In summary, over the 1952–56 period, monetary policy became more effective in controlling inflation and stabilizing economic activity; its countercyclical responsiveness, however, remained below modern standards. Although constrained by sluggish monetary policy, the exchange rate adjusted in a countercyclical fashion (see Charts 1 and 6, primarily in 1953–54 and 1956). Although the economy continued to grow from 1956 into 1957, higher interest rates and a stronger dollar (which had appreciated by almost 7 per cent over 1955 and 1956 to a premium of US$0.04 by the end of 1956) were starting to have an impact.

1957–60: Deteriorating economic performance

In 1957, after more than two years of strong growth, the economy began to experience a slowdown marked by a sharp increase in the unemployment rate (from 3 per cent to 8 per cent, Chart 7). Observers began to question the wisdom of Canadian monetary policy, especially since the Bank continued to tighten monetary conditions until August 1957, as shown in Charts 8 and 9, with the Bank Rate rising to 4.33 per cent and the Canadian dollar appreciating to a peak of US$1.06 at the same time. This further tightening seemed unwarranted, since the signs of a slowdown were apparent—the inflation rate started to decline early in 1957 and by the end of the year was at 2.2 per cent, down from 3 per cent in 1956. Criticisms of monetary policy were based on the observation that the Canadian economic downturn was more pronounced than the U.S. economic slowdown. This difference was interpreted

13. Bordo, Dib, and Schembri (2007) find that a monetary policy response function with the short-term interest rate as the policy instrument, and low inflation and output and exchange rate stability as the targets, performs reasonably well in empirically representing the Bank's conduct of monetary policy over the floating-rate period. Nonetheless, the goals of monetary policy were not as clearly articulated as they are today; without an explicit numerical inflation target, inflationary expectations were not as well anchored.

14. The Bank Rate was eventually set at 25 basis points above the 3-month treasury bill tender rate.

as indicating that the source of the adverse shock was not foreign, but domestic (i.e., tight monetary policy). In contrast, it could be argued that monetary policy over the years 1955 and 1956 had allowed growth to increase too quickly, thereby causing excess demand and higher inflation, and thus monetary policy actions in 1957 and 1958 had to be aggressive to reduce inflation. The truth likely lies somewhere in between: that is, monetary policy was insufficiently countercyclical over both the expansionary and contractionary phases of the 1954–58 business cycle.

The trough in the recession in both countries was reached in the spring of 1958, and large-scale monetary expansions helped both economies to recover quickly; interest rates in Canada fell as the Bank Rate declined from 3.92 per cent at the end of 1957 to a low of 1.91 per cent in July of 1958 (Chart 9). These monetary expansions also facilitated the conversion, or roll over into longer maturities, of government bonds, which had been issued to finance WWII defence expenditures.

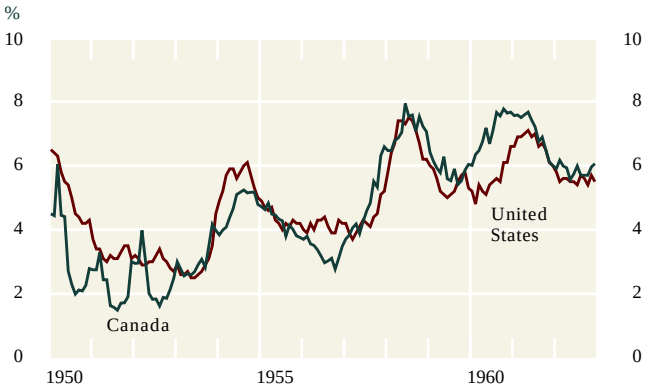
As both economies rebounded in the second half of 1958, interest rates rose sharply to levels that had prevailed at the beginning of the year (Charts 9 and 10). In Canada, the increase was larger, in part because the federal and provincial governments were running expansionary fiscal policies to combat the high unemployment. Critics of the Bank of Canada nevertheless blamed the higher rates on monetary policy that was too tight. Since neither the Bank nor its critics (e.g., Gordon 1961) had the benefit of Mundell's later work, neither side fully appreciated that, under a floating rate, expansionary fiscal policy also contributed to higher interest rates and a stronger Canadian dollar. The currency appreciated by roughly 2 per cent in 1958 and remained at a premium to the U.S. dollar into 1959.

Inflation fell from 2.5 per cent in 1958 to 2.0 per cent in 1959, and the recovery continued in Canada through to the end of 1959. As the Bank continued to push up short-term interest rates over the first eight months of 1959 (the Bank Rate increased by 257 basis points, from 3.85 per cent to 6.42 per cent over this short period), a significant spread developed between Canadian and U.S. interest rates (Charts 9 and 10), and the dollar appreciated by a further 1 per cent. The Federal Reserve also feared higher future inflation in 1959, and 1960, and it too increased its discount rate, but less dramatically than did the Bank of Canada. The impact of this tightening was felt in 1960 as both economies grew more slowly and inflation fell to 1.3 per cent in Canada. The unemployment rate in Canada increased sharply, from 6.5 per cent at the beginning of 1960 to 8.7 per

Chart 7

Unemployment Rate

Monthly

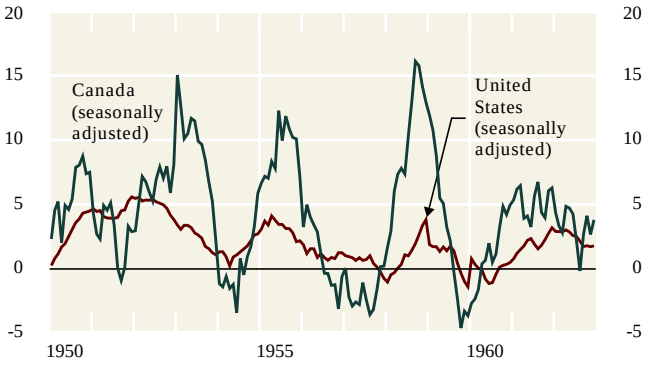


Source: Statistics Canada and U.S. Bureau of Labor Statistics

Chart 8

Money Supply (M1)

Monthly, year-over-year growth rate

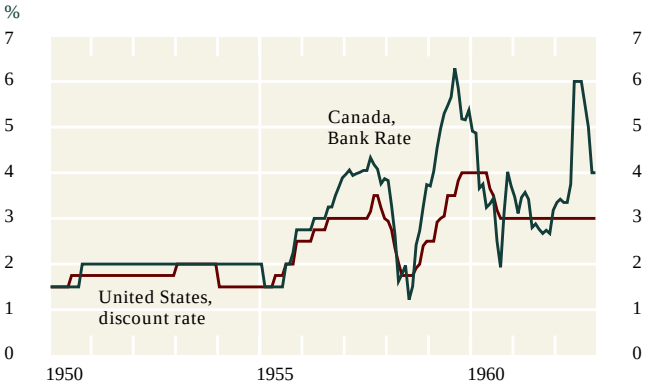


Source: Metcalf, Redish, and Shearer (1996) and the National Bureau of Economic Research

Chart 9

Interest Rates

Monthly

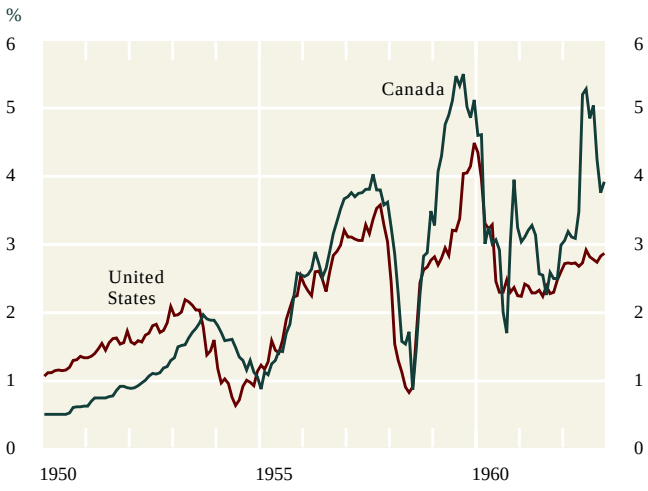


Source: Statistics Canada and the Bank for International Settlements

Chart 10

Market Yield for 3-Month Treasury Bills

Monthly



Source: Statistics Canada and the Bank for International Settlements

cent by the end of the year. In this instance, the Bank did not seem to recognize that higher interest rates attracted capital inflows and caused the Canadian dollar to appreciate, thereby further tightening domestic monetary conditions.

The impact and effectiveness of monetary and fiscal policies under a floating exchange rate and a high degree of capital mobility were not well understood.

The political pressure from the rising unemployment rate, together with other differences between Governor Coyne and the Diefenbaker government, prompted the government to introduce legislation in May 1961 to declare the position of the Governor of the Bank of Canada vacant. After the government's bill was defeated in the Senate, Governor Coyne resigned.[15]

In summary, the Bank of Canada's monetary policy over the years 1957–61 was not sufficiently countercyclical during periods of slower growth and rising unemployment, while fiscal policy during these episodes was typically expansionary. The impact and effectiveness of monetary and fiscal policies under a floating exchange rate and a high degree of capital mobility were not well understood. The combination of contractionary monetary policy and expansionary fiscal policy both worked in the direction of raising interest rates and pushing up the external value of the currency. Their effect on output was at best offsetting and, at worst, exacerbated the weak growth.

1961–62: The awkward transition to a pegged exchange rate

After the resignation of James Coyne, Louis Rasminsky was appointed Governor. Rasminsky's acceptance of the position was conditional on a clarification of the responsibility for monetary policy between the central bank and the government. Drafted by Rasminsky, the directive power, as it is known, states that should a conflict occur between the Bank and the government over the conduct of monetary policy, the government would be required to issue a specific directive to the Governor that would be published in the *Canada Gazette* (the government's official record). Under these circumstances, the Governor would likely resign.

Rasminsky's accomplishment with the directive power was overshadowed in his first year of office, however, by the government's clumsy attempts to reflate the economy by talking down the dollar, which eventually brought about an exchange rate crisis that required IMF intervention. In response to the relatively high unemployment rate, the government's 1961 budget promised a host of expansionary fiscal policy measures. The government also expressed a desire to see the dollar depreciate and, to that end, began to sell Canadian dollars in the foreign exchange market. The dollar soon declined, from a premium of approximately 1 per cent on the U.S. dollar in July 1961 to a 5 per cent discount by September. Further official downward pressure sparked a speculative attack on the dollar in April 1962, and, to stem the free fall, the government announced a devalued peg at US$0.925 cents. In June 1962, a rescue package of slightly more than US$1 billion supplied by the IMF, the United States, and the United Kingdom was required to restore stability. This announcement temporarily interrupted Canada's postwar experiment with a floating exchange rate.

15. Powell (forthcoming) provides an insightful analysis of the events surrounding the resignation of Governor Coyne.

The Floating Canadian Dollar: Its Stable Behaviour and Stabilizing Role

This section focuses on two issues: the remarkable stability of the Canadian dollar over the 1950–62 floating-rate period, and the related issue of whether this relatively stable exchange rate actually helped to insulate the Canadian economy from external shocks. Over the full 12-year period, the dollar fluctuated in a narrow range of 13 cents (US), from a low of US$0.93 in early 1951 to a peak of US$1.06 in August 1957. Over the core period, 1952–60, the range was much smaller, only 6 cents (US), from US$1.00 in early 1952 to US$1.06 in August 1957. Moreover, high-frequency fluctuations were very mild and orderly. Over the whole period, the average day-to-day change was 0.08 per cent, and only 5 per cent of the daily changes over the floating-rate period exceeded one quarter of a per cent (Poole 1967).

Several explanations have been put forward to rationalize the dollar's stability. Many attributed it to stabilizing speculation by agents who believed that movements in the rate were temporary (Poole 1967; Marsh 1969; Yeager 1976). This evidence was perceived as being consistent with the original assertion by Friedman (1953) that speculation under a floating exchange rate would necessarily be stabilizing in order to be profitable. Others attributed it to the coincidence of Canadian and U.S. cyclical positions and monetary policies (Hawkins 1968, 31) (Charts 6, 8, and 9).

It has also been argued that official intervention operations served to stabilize the value of the Canadian dollar, but the literature has concluded that official intervention did not play a significant role in stabilizing the nominal exchange rate. Although intervention was frequent over the 1952–60 period, the scale of intervention was limited and simply offset short-run fluctuations to maintain an orderly foreign exchange market (Plumptre 1970, 4).[16]

Several observers, including Plumptre (1970, 6), argue that the relative stability of the floating Canadian dollar was due, in part, to the absence of large shocks during this period.[17] Bordo, Dib, and Schembri (2007) find evidence consistent with this argument. They use their estimated model of the Canadian economy to extract structural shocks for the postwar decades and find that the volatilities of the shocks during the 1950s were generally lower than those experienced during the other flexible-rate decades (the 1970s, 1980s, and 1990s).

The Canadian dollar was relatively stable over this period, not only because shocks were comparatively small and to some degree common to both the Canadian and U.S. economies, as shown by the close correlation of their business cycles, but also because capital was relatively immobile globally (capital flows between Canada and the United States were the glaring exceptions). In addition, it is important to recognize that Canada was the only major industrialized country floating its currency at that time—all other major countries had rates pegged to the U.S. dollar.

In addition to giving the domestic authorities control over monetary policy, the other main benefit of a floating rate is its ability to shelter the domestic economy from external shocks. As noted earlier, the Canadian floating rate was very stable, especially when compared to the experience of the industrialized countries since the collapse of the Bretton Woods system in the early 1970s, and this was despite two sizable recessions. This stability has led some observers (Wonnacott 1965; McLeod 1965) to conclude that Canada's experience in the 1950s did not provide overwhelming evidence on the postulated insulation properties of a floating rate.

Unfortunately, the qualitative bivariate comparison conducted by these authors is incomplete and does not provide an adequate counterfactual analysis. In particular, it is likely that exchange rate adjustment to movements in U.S. export demand was hindered by weakly countercyclical monetary policy. Mundell (1964), McLeod (1965), and Dunn (1971) argue that Canadian monetary policy was less countercyclical than U.S. monetary policy in the two coincident recessions of 1953–54 and 1957–58 (Charts 6, 8, and 9). Consequently, the Canadian dollar tended to appreciate when the U.S. authorities eased monetary policy earlier and more aggressively than did their Canadian counterparts, and therefore, the exchange rate appeared not to provide much insulation for the Canadian economy when U.S. demand declined.

The impact of this higher interest rate differential was felt by the Canadian dollar. Because there was a significant degree of capital mobility between Canada and the United States, there is much evidence that the Canadian dollar was very sensitive to the short-term

16. Net monthly changes in official reserves were less than 20 million dollars in the majority of months when intervention occurred (Wonnacott 1965; Yeager 1976; Canada 1964; Binhammer 1964).

17. Plumptre (1970) also notes that when the Canadian dollar floated in the 1930s, its movements were relatively stable as well.

interest rate differential in the 1950s.[18] Thus, the tighter Canadian monetary policy in the second half of the floating-rate period held the Canadian dollar above parity with the U.S. dollar, thereby reducing the domestic and world demand for Canadian-produced traded goods and slowing economic activity.

Bordo, Dib, and Schembri (2007) conducted two counterfactual experiments with a well-specified model of the Canadian economy to examine the economic impact of its monetary and exchange rate policies in the 1950s. The first involves eliminating the apparent shift in monetary policy that took place over the second half of the sample by maintaining the estimated monetary policy response function that prevailed over 1950–56, throughout the floating-rate period. The second experiment consists of assuming that the fixed exchange rate parity of 1950 is not abandoned in favour of a flexible exchange rate.

The results of the first counterfactual experiment suggest that, had monetary policy not changed during the second half of the floating-rate period, the Canadian economy would have performed better. The policy actually followed was not only more volatile, but also produced higher interest rates. Consequently, output was less stable, and growth was likely slower because higher interest rates also generated a more appreciated exchange rate. This misunderstanding of the impact of monetary policy under a floating rate contributed to the demise of this regime.

These counterfactual experiments indicate that output and inflation were more stable under a flexible exchange rate than they would have been under a fixed one.

Under the second counterfactual experiment of a fixed nominal exchange rate, the volatilities of all the variables (except the exchange rate) increase dramatically. The results suggest that the flexible exchange rate regime was successful in stabilizing the Canadian economy, even during the post-1957 period when monetary policy was more volatile.

18. See, for example, Caves et al. (1971).

As noted earlier, the Canadian floating rate was unexpectedly stable in the 1950s, which begs the question as to how much of a role it played if it varied so little. Although there are several possible explanations for this stability, an important one is that monetary policy was not conducted to take full advantage of the flexible rate's ability to facilitate macroeconomic adjustment. Nonetheless, these counterfactual experiments indicate that output and inflation were more stable under a flexible exchange rate than they would have been under a fixed one.

Impact on Economic Thought

Although Canada's decision to adopt a flexible exchange rate was initially opposed by the IMF, the successes and difficulties encountered by the Canadian authorities in managing monetary and fiscal policy under this regime drew the interest of researchers at the IMF and elsewhere. Canada's experience had a significant impact on the development of the Mundell–Fleming model, and in particular, on Mundell's contribution. This model became the workhorse of the IMF for three decades and was a fundamental building block of the new field of open-economy macroeconomics.

The Canadian flexible exchange rate experience inspired the research of Robert Mundell. Mundell spent a year (1961–62) in the Research and Statistics Department at the IMF, and his work complemented and influenced that of two IMF researchers, J. Marcus Fleming and Rudolf Rhomberg.

In two recent retrospectives, Mundell discusses the influence of the Canadian experience on the development of his part of the Mundell-Fleming model:

> It was around this time [1956–57] that I shifted research topics from writing about and further refining the pure classical model to thinking about the way to write down the general equilibrium equations for an open economy taking into account monetary variables, exchange rates, and capital movements. The fact that Canada had a flexible exchange rate and capital flows between Canada and the United States were significant background influences but there was absolutely no model in the literature that was capable of dealing with the subject. (Mundell 2002, 4)

In describing the implications of the version of the model in his 1960 article for the *Quarterly Journal of Economics*, he states:

> One implication of the model was that a domestic boom would raise interest rates, attract capital inflows, appreciate the real exchange rate, and worsen the balance of trade, . . . a conclusion that would hold under either fixed or flexible exchange rates. This was very relevant to an understanding of the economy of Canada, which was the only major country with a flexible exchange rate in the 1950s. (Mundell 2001, 221)

Rudiger Dornbusch (2000, 200) and Andrew Rose (2000, 217), in their articles describing Mundell's Nobel achievements, emphasize that Canada's experience inspired his work. Mundell wrote several key papers in the early 1960s (in particular, Mundell 1961 and 1963) that dealt directly with the Canadian experience with floating and capital mobility. Mundell (1963), the most well known, carefully compares the use of monetary and fiscal policy under fixed and flexible exchange rates and capital mobility. His demonstration that, under floating rates, an increase in government expenditure puts upward pressure on the interest and exchange rates and limits the impact of the fiscal expansion on output accurately captures the Canadian experience of the late 1950s and early 1960s. A contractionary monetary policy also puts upward pressure on the interest rate and the exchange rate and causes output to fall. Once again, this analysis is a good representation of the Canadian experience in the late 1950s. In particular, Mundell (1964) argues that Governor Coyne's policy of tight money in response to his concerns about expected inflation and large capital inflows from the United States backfired. The rise in interest rates attracted additional capital inflows, appreciated the Canadian dollar, and depressed both domestic investment and the demand for exports. Moreover, the government's fiscal expansion in response to the deteriorating economic conditions had little effect because it served to raise interest rates and the exchange rate further.

J. Marcus Fleming was in the Research and Statistics Department at the IMF from 1954 to 1976. His contribution to the development of the Mundell-Fleming model was similar to (though less prolific than) that of Mundell, and he is viewed as an equal contributor (Boughton 2003). In his 1962 paper, Fleming obtains results similar to Mundell's using a fixed-price IS-LM model with the addition of endogenous current and capital accounts. Like Mundell, he shows that fiscal policy is more effective than monetary policy under a fixed rate, while the opposite prevails under a floating rate.

Rudolf Rhomberg joined the IMF Research and Statistics Department in 1959 after completing his PhD thesis at Yale on the Canadian experience with floating rates. In his first paper, Rhomberg (1960) models the short-run balance-of-payments adjustment process in an open economy and uses it to examine the determinants of the remarkable stability of the Canadian floating exchange rate regime. He finds that speculative movements were, on the whole, equilibrating and the main cause of exchange rate stability. He noted, however, that the floating rate did not automatically insulate Canada from external shocks because it had not been fully incorporated into Canadian monetary policy. Nonetheless, the floating rate was more effective in combating inflation than it was against recessionary pressures. Rhomberg's work also refuted earlier propositions that the flexible exchange rate would be unstable unless strict capital controls were in place. He pointed out that the earlier theory was incorrect because it put too much weight on large short-term capital movements driven by significant changes in expectations and concluded that the Canadian experience had shown that a flexible exchange rate is not inherently fragile.

The Canadian experience helped to demonstrate that flexible exchange rates were a viable alternative to the Bretton Woods system.

In his second influential paper, Rhomberg (1964) estimates a small macroeconometric model of the Canadian economy and obtains results that support the Mundell-Fleming finding that monetary policy is most effective under flexible rates, while fiscal policy is most effective under fixed rates. He also finds that, under floating rates, the domestic real economy is well insulated from foreign output shocks.

The research of Mundell, Fleming, and Rhomberg was inspired by the Canadian experience with a flexible exchange rate and the challenges Canada faced in conducting monetary and fiscal policy in this environment. Although their work was perhaps the most influential, many other economists and policy-makers learned

useful lessons from the Canadian experience. In particular, it helped to demonstrate that flexible exchange rates were a viable alternative to the Bretton Woods system, and the relative success of the subsequent system of generalized floating has confirmed this prediction. Moreover, central banks in many countries now benefit from the monetary policy independence that flexible exchange rates provide by adopting a policy that targets a measure of national inflation. In so doing, they have been able to achieve large gains in overall macroeconomic stability, partly through the achievement of low and stable inflation, but also by incorporating the exchange rate channel in their monetary policy process and by allowing the exchange rate to play a stabilizing role.

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Price Discovery Across Geographic Locations in the Foreign Exchange Market

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- *A new class of exchange rate models focuses on the institutions and trading behaviour of market participants in the foreign exchange market in an environment where private information is dispersed.*
- *The average information content of trades is measured in two relatively liquid foreign exchange markets: the US-dollar/Australian-dollar market and the US-dollar/Canadian-dollar market.*
- *Evidence presented in this article suggests that, in addition to dealers operating in the world's largest foreign exchange commercial centres, dealers domiciled in a country whose currency is being traded have superior information about the fundamental or long-run value of the exchange rate.*

In the foreign exchange market—the world's largest financial market—access to information about the future direction of the exchange rate can be extremely valuable. With average daily turnover that surpassed US$3 trillion in April 2007 (BIS 2007), it is important that foreign exchange (FX) markets are efficient and liquid if participants are to make sound international trade, investment, and consumption decisions.[1]

Unlike equity markets, where some investors may have more precise information on the business operations and conditions of a company, information about the exchange rate is assumed to be public and simultaneously available to all interested participants. This assumption of market efficiency, which is common in the academic literature, reflects the belief that relevant information about the exchange rate is related to macroeconomic variables such as foreign and domestic nominal interest rates, inflation rates, and output levels. It also reflects the belief that, globally, FX dealers have access to similar, real-time news feeds that broadcast new information about these variables immediately after it is released.

Since earlier models of exchange rate determination based on macroeconomic fundamentals had little success in explaining exchange rate movements, some recent models have departed from the assumption of

* The research reported in this article is summarized from a working paper written by the author (D'Souza 2007).

1. Market liquidity refers to the ability of market participants to quickly execute large trades without causing a significant movement in prices, while informational efficiency in financial markets is a measure of the speed with which all public and private information is reflected in prices. See Bauer (2004) for a detailed discussion of market efficiency.

efficient markets.[2] In particular, these newer models focus on market microstructure, i.e., the trading behaviour of market participants and the institutions of the FX market in an environment where private information is dispersed. Several studies, including Evans and Lyons (2002) and Payne (2003), provide empirical support for the hypothesis that FX order flow, a measure of buying or selling pressure in the market and a key variable in the microstructure literature, can explain up to two-thirds of the variation in exchange rate returns.

Customer orders are a key element of these models and are assumed to be the catalyst for all subsequent interdealer trading. Evans and Lyons (2007), for example, suggest that individual customer trades in FX markets contain bits of information about the underlying fundamentals that drive movements in the exchange rate. Their theory is based on the assumption that these pieces of information, taken together as part of aggregated order flow, are able to convey information to dealers about the state of the macroeconomy. The information is conveyed as dealers engage in price discovery, the process in which relevant information is reflected in prices (or exchange rates).

Order flow is a valuable source of information that can be used to attract additional customers.

An FX dealer trading with a customer is in a position to learn about, or acquire, private information. Although some individual orders may not be very informative, when trading is frequent or the quantity traded is significant, a dealer can adjust his or her perception of the customer's overall observed order flow. Dealers will also try to deduce the customer order flow of other dealers through interdealer trades. This aggregate measure of order flow is a valuable source of information that can be used to attract additional customers who also want to obtain better forecasts of future exchange rate movements. It also conveys information about the fundamental value of the exchange rate (Evans and Lyons 2007).

This article examines the impact of a trader's geographic location on price discovery.[3] Recent empirical evidence confirms that certain market participants in the foreign exchange market are better informed than others about the future direction of the exchange rate. The trades of financial institutions, for example, are more informative than those of non-financial firms.[4] It has been suggested as well that major international financial centres such as New York, London, and Tokyo, which operate during the core business hours in North America, Europe, and Asia, respectively, may have a natural advantage in the intermediation of trades (Gaa et al. 2001).[5] Simply by operating during the hours when potential customers are conducting their business operations, dealers may be able to increase their involvement in customer deals. Furthermore, many international financial institutions devote significant amounts of capital to their trading desks in these locations.[6]

This article takes a market microstructure approach to account for the flow of information in the FX market.[7] It focuses on the US-dollar / Australian-dollar and the US-dollar / Canadian-dollar FX markets—the fourth and sixth largest currency markets (CAD and AUD will hereafter be used to represent these exchange rates and their respective FX markets.)[8] Results from studies focusing on the largest FX markets, such as the markets for the US dollar / euro or the US dollar / Japanese yen, may not accurately represent the majority of FX markets operating in the global marketplace.[9]

2. Meese and Rogoff (1983), for example, show that the macroeconomic variables that are the basis of the asset-model approach do not move exchange rates as predicted. Bailliu and King, in their review (2005) of the literature in this area, suggest that models based on macroeconomic fundamentals have had little success at explaining or forecasting exchange rate movements because of the simplifying assumptions that they use.

3. Covrig and Melvin (2002) find that interdealer quotes from Japanese traders lead quotes in the rest of the US-dollar / Japanese-yen market, while Sapp (2002) finds that banks in several European and U.S. locations exhibited price leadership in the former US-dollar / German-mark market.

4. See Bjønnes, Rime, and Solheim (2005); Fan and Lyons (2003); Froot and Ramadorai (2002); and Osler, Mende, and Menkhoff (2006).

5. Hong Kong and Singapore also have a significant market share of global FX trading, especially during Asian trading hours (BIS 2007).

6. The ability to offer competitive quotes to customers is also an important factor in determining a dealer's share of customer-dealer trades. The formation of a dealer's quotes will be related to how effectively dealers manage their inventories and any undesired positions. D'Souza and Lai (2006) illustrate how market-making activities are influenced by the risk-bearing capacity of a dealer, which is itself determined by the amount of risk capital allocated to this activity by each financial institution.

7. Theoretical research suggests that the strategic behaviour of informed and uninformed market participants affects price dynamics. See Grossman and Stiglitz (1980); Kyle (1985); and Glosten and Milgrom (1985).

8. The U.S. dollar is always the base currency used for conversions.

9. The CAD and AUD markets examined in this article represent 4 per cent and 6 per cent of total FX currency volumes, respectively. The largest FX markets, the US-dollar / euro, US-dollar / Japanese yen, and US-dollar / British pound sterling, account for 27 per cent, 13 per cent, and 12 per cent, respectively, of total trading in all currency markets (BIS 2007).

Given the relatively small and open nature of the Australian and Canadian economies, firms, investors, and even consumers may spend significant resources on managing foreign exchange risk (Bank of Canada 2008). These relatively liquid markets are analyzed so that the results can be compared over a sample period with similar external market conditions.

The research reported here also provides insight into a related concern. The growing importance of global financial trading centres and the ensuing competition for order flow is raising questions about the long-run viability of "national" financial markets. In light of this, can dealers domiciled in smaller national markets provide value to their customers via information about future movements in exchange rates similar to that supplied by those in the larger global marketplaces?[10]

The article begins with a brief overview of the institutions of the FX market, followed by a description of the methodology used for the study. The empirical analysis that follows examines the relationship between trades initiated in different locations and exchange rate returns to determine the information content of trades. Evidence on the significance of geographic location and hours of operation is presented in the summary of the results. The article concludes with a summary of the findings.

The Structure of FX Markets

In the spot FX market, trades take place between customers and dealers, or between dealers in the interdealer segment of the market. Customers are the financial and non-financial firms that are the end users of foreign exchange currencies used for settling imports or exports, investing overseas, hedging business transactions, or speculating. It is important to note that customers do not necessarily reside in the dealer's geographic location.

Interdealer trading accounts for between 40 per cent and 60 per cent of total trading in the FX market, since dealers manage their inventories by trading with each other.[11] In this segment of the market, trades are executed either directly or via an interdealer broker (IDB) to ensure anonymity. IDBs match the best orders among dealers and disseminate dealer quotes to the market without revealing the identity of the dealer.[12]

Unlike equity exchanges, trades in the FX market occur continuously around the clock.

Unlike equity exchanges, which have fixed opening and closing hours, trades in the FX market occur continuously around the clock. Since customers may be located across different time zones, trading must be organized in a decentralized fashion. Important differences are thus thought to exist in the dynamics of trading and liquidity provision across time and markets. This study is unique in that it simultaneously accounts for both the location from which a trade is initiated and the regional business hours in each location.[13]

Methodology

Completed transactions are analyzed, rather than the indicative quotes used elsewhere in the literature.[14] The data set includes all market orders executed with a single IDB in the CAD and AUD markets over the 2-year period from 1 October 2000 to 30 September 2002. This is unique because, in addition to the transacted exchange rate and the volume associated with each trade, the data set discloses the geographic location of the initiator of the trade (i.e., the country where the market order was entered into the IDB's electronic trading platform). This information is necessary to establish whether dealers in one location have an informational advantage over those in another location.

Trades from over 30 countries were initiated on the IDB in both the Canadian and Australian currency markets. For most countries, fewer than a handful of trades are executed per day, on average. The following analysis focuses only on trades initiated in Australia, Canada, Japan, the United Kingdom, and the United States. Australia, Canada, and the United States are included in the analysis, since their own

10. While the existence of an established domestic trading centre offers some clear employment and spin-off benefits, access to global capital markets, and possibly to cheaper capital, are also beneficial.

11. The share of interdealer broker (IDB) trading fell from 59 per cent in 2001 to 53 per cent in 2004 and 43 per cent in 2007 (BIS 2007).

12. Brokers are pure matchmakers and do not take positions. Electronic brokers have taken market share from both voice brokers and direct trading. According to Rime (2003), electronic brokers are now the main trading channel in the interbank market.

13. D'Souza (2007) illustrates why it is necessary to break up the 24-hour day into five separate, non-overlapping regional time zones.

14. The proprietary trade data were obtained from a large IDB in the FX market.

currency forms part of at least one of the currency pairs examined. Japan and the United Kingdom are included because both Tokyo and London, like New York, have historically been considered large FX commercial centres.[15]

To calculate order flow, trades must be categorized as either buyer initiated or seller initiated. Trades are signed according to the following rule: If a transaction occurs above the prevailing mid-quote, it is regarded as buyer initiated; otherwise, it is signed as a seller-initiated trade.[16] Trades are signed as +1 if Canadian or Australian dollars are sold by the trade initiator, and as –1 if Canadian or Australian dollars are purchased. Order flow in each location is then determined by summing up the signed trades in each 5-minute interval. Midpoints of bid / ask quotes, which are observed at the end of each 5-minute interval, are used to generate a series of exchange rate returns. The analysis is completed in Greenwich Mean Time (GMT).[17]

Trading in the FX market occurs throughout the day. Chart 1 illustrates the intraday pattern of hourly trades across the 24-hour clock.[18] Note that, for the CAD market, trade activity peaks after the opening of business hours in North America (around 15:00 GMT). As business hours wind down in North America, trading falls. In the AUD market, at least two peaks in trades are associated with morning trading in London and New York. A third, smaller peak occurs during Asian hours.

Since some financial centres are open while others are closed, it is necessary to analyze exchange rates and trades separately across a variety of time periods over the 24-hour day. Based on an examination of trading volumes initiated around the world, we adopt the breakdown of regions proposed by Cai, Howorka, and Wongswan (2006) for the US-dollar / euro and US-dollar / Japanese yen markets. Periods in which the business hours of one region overlap those of another are separated from periods in which only a single region has regular business hours. Table 1 lists the five regional time zones (Asia, Asia-Europe, Europe, Europe-North America, and North America), as well as the specific hours for each zone outside of, and during, daylight savings time (DST).

Increased levels of FX trading activity in each geographic location across time zones reflect the beginning of regular business activity in that location. Daily trading indexes are presented in Table 2. Most trades initiated in Australia and Japan occur during Asian hours, while most trades initiated in Canada and the United States take place during North American hours. Interestingly, a large proportion of U.K.-initiated trades occur during the overlapping Asia-Europe and Europe-North America time zones. Trading in the CAD market is dominated by trades initiated in Canada, the United States, and the United Kingdom. These trades make up 75 per cent of all trades in the CAD market. U.S. and U.K. trades also account for the majority of

Chart 1

Hourly Trading Activity Index for the CAD and AUD Markets, Greenwich Mean Time

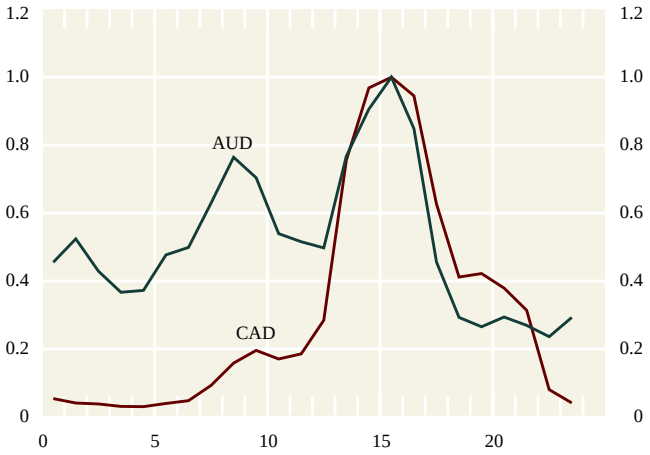

Table 1

Regional Business Hours, Greenwich Mean Time

Trading region (duration)	No daylight savings	Daylight savings
Asia (9.5 hours)	22:00-07:30	21:00-06:30
Asia-Europe (1.5 hours)	07:30-09:00	06:30-08:00
Europe (3.5 hours)	09:00-12:30	08:00-11:30
Europe-North America (4.5 hours)	12:30-17:00	11:30-16:00
North America (5 hours)	17:00-22:00	16:00-21:00

15. Data indicating the city centre from which trades are initiated were not available.

16. Intraday quote data for CAD and AUD exchange rates were obtained from Olsen and Associates <http://www.oanda.com> and were collected from various real-time data feeds. If a transaction occurs precisely at the mid-quote, it is signed using the previously transacted exchange rate, which is determined by using the following tick test: The trade is buyer initiated if the sign of the last non-zero exchange rate change is positive.

17. National holidays and weekends are excluded from the analysis. Weekends begin on Fridays at 22:00 GMT and end on Sundays at 22:00 GMT.

18. Chart 1 accounts for changes to and from daylight savings time (DST).

Table 2

Index of Average Daily Trading Initiated Across Locations

U.S. trading in North America = 100

Regional time zone	Location of trade initiation				
	Australia	Canada	Japan	United Kingdom	United States
CAD					
Asia	21.7	1.2	15.6	2.6	7.6
Asia-Europe	2.5	0.0	3.2	20.2	2.4
Europe	2.2	8.3	0.9	58.6	8.2
Europe-North America	0.2	219.1	0.7	61.9	158.7
North America	2.0	118.7	1.3	3.1	100.0
AUD					
Asia	261.5	0.1	36.0	8.9	8.3
Asia-Europe	25.5	0.0	5.0	72.7	1.1
Europe	27.7	1.1	2.4	156.4	5.8
Europe-North America	41.0	16.1	0.5	177.9	156.7
North America	49.3	9.0	4.8	9.9	100.0

trades initiated in the AUD market after Asian hours. Surprisingly, Japanese-domiciled trading desks tend to be a small player in each of these markets.[19]

Empirical Analysis

The methodology allows for an examination of the relationship between trades initiated in multiple locations and exchange rate returns. Multivariate regression analysis (see Box) is used to determine the informational content of trades.[20] The impact of order flow, characterized by the location in which a trade is initiated, cannot be determined from a single regression. All variables are endogenous, and causality between the different order flows and exchange rates may occur in multiple directions. For example, while an unexpected purchase of foreign currency by a trader may lead to a change in the exchange rate, the causality may also work in the other direction: An unexpected increase in the exchange rate could influence purchases of a foreign currency by other market participants. Alternatively, trades initiated in the United Kingdom may serve as a catalyst for trades initiated in the United States or Canada. The methodology is robust to modelling assumptions and is also able to characterize the dynamics of trades and exchange rate returns.

Theoretically, exchange rates can be assumed to consist of two elements: an informationally efficient price and an element reflecting frictions in the trading process. While new fundamental information will lead to a permanent revision in the market's valuation of the exchange rate, effects arising from trading-friction illiquidity will be short lived and transitory. Empirically, the long-run response of the exchange rate to a trade will depend on whether or not that trade was initiated by an informed trader with private fundamentals-based information.

Two summary measures of trade informativeness developed by Hasbrouck (1991a, b) are calculated from the estimates of a reduced-form vector autoregression (VAR): the long-run accumulated impulse response of exchange rate returns to shocks in each order-flow variable, and the proportion of the permanent variation in the exchange rate explained by each order-flow variable. The latter is derived from a variance decomposition of exchange rate returns.

Results

The summary measures of trade informativeness are presented in Tables 3 and 4. In each table, the information content of trades in the CAD market is presented in the first panel, while those for the AUD market are presented in the second panel.[21] Impulse-response functions are presented in terms of percentages (e.g., 0.10 represents a 0.10 per cent long-run change in the exchange rate). To make the exposition clearer, summary-measure estimates are not reported if they are not statistically significant at the 5 per cent level.[22]

Trades initiated in Canada, the United Kingdom, and the United States have the largest impact on the CAD exchange rate. The size of the impact is largest during normal business hours in each country. A buyer-initiated trade innovation placed by a Canadian-domiciled trader has a long-run impact of at least 0.066 per cent

19. With the recent popularity of carry trades, trading volumes in the Australian-dollar/Japanese yen market have increased substantially. Despite this, Japan accounts for a relatively small proportion of these trades (BIS 2007). A currency carry trade is usually defined as a leveraged cross-currency position designed to take advantage of interest rate differentials and low levels of volatility.

20. This methodology is also used by D'Souza, Lo, and Sapp (2007) to examine European and Canadian government bond markets.

21. Since the ordering of each VAR may affect the results, all possible rankings of the order-flow variables are considered. The lowest impact of the long-run cumulative exchange rate resulting from each trade innovation is reported across all regional time zones. Twenty 5-minute periods (or, 100 minutes) is found to be sufficiently long.

22. A parametric bootstrap procedure (1,000 replications) is used to calculate standard errors for both impulse-response functions and variance decompositions.

Empirical Methodology

A vector autoregression (VAR) is estimated to determine the sources of exchange rate variation. A VAR is a linear specification in which each variable is regressed against lags of all variables.[1] Let z_t denote the vector of variables,

$$z_t = [x_{it}, \ldots x_{mt}, r_t],$$

where x_{it} is the order flow calculated from trades initiated in the i'th location, and r_t is the percentage exchange rate return over the 5-minute interval. There are m locations in total. The VAR specification can be written as

$$z_t = A_1 z_{t-1} + A_2 z_{t-2} \ldots + A_p z_{t-p} + v_t, \qquad (1)$$

where p is the maximum lag length, and v_t is a column vector of serially uncorrelated disturbances with variance-covariance matrix Σ.[2] Coefficient estimates and the associated variance-covariance matrices can be obtained from least-squares estimation. The model captures the dynamic relationships between all variables. It also allows for lagged endogenous effects.

Impulse-response functions represent the expected future values of the system conditional on an initial disturbance, v_t, and can be computed recursively from equation (1):

$$E[z_t + z_{t+1} + \ldots z_{t+\infty} | v_t].$$

The long-run impact of a trade innovation on the cumulative exchange rate return measures the fundamental information in a variable and the first summary measure of trade informativeness examined in this article:

$$E[r_t + r_{t+1} + \ldots r_{t+\infty} | v_t].^3$$

If the innovation in the permanent component of an asset price is denoted as w_t, its variance, σ_w^2, will be a measure of the variation in the permanent component of exchange rate returns:

$$\sigma_w^2 = var(E[r_t + r_{t+1} + \ldots r_{t+\infty} | v_t]). \qquad (2)$$

Since the covariance matrix will not be diagonal, the right-hand side of equation (2) will involve terms reflecting the contemporaneous interaction of the disturbances. The variance of the permanent component of the exchange rate can be written as

$$\sigma_w^2 = \sigma_{x1}^2 + \ldots \sigma_{xm}^2 + \sigma_r^2,$$

where σ_{xi}^2 corresponds to the incremental contribution of the i'th order-flow variable. Relative contributions of each trade and exchange rate return variable to explaining the total variance in the permanent component of exchange rate returns are calculated by dividing both sides of the above equation by σ_w^2:

$$1 = \sigma_{x1}^2 / \sigma_w^2 + \ldots \sigma_{xm}^2 / \sigma_w^2 + \sigma_r^2 / \sigma_w^2.$$

Each term on the right-hand side represents the second measure of trade informativeness analyzed in this article.[4]

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1. See Hamilton (1994) for a complete discussion.

2. Intraday hourly exogenous dummies are also added to each equation of the VAR model to account for intraday seasonality. The Schwartz information criterion is used to determine the lag length across the system of equations.

3. Innovations in v_t are orthogonalized using a Choleski decomposition of the variance-covariance matrix.

4. The ordering of variables may affect the values of each summary statistic. In particular, placing a variable earlier in the ordering may increase its information share.

Table 3

Cumulative Response to Order-Flow Innovations in Each Location

Per cent returns, by location of trade initiation

Regional time zone	Location of trade initiation				
	Australia	Canada	Japan	United Kingdom	United States
CAD					
Asia	0.044	–	0.036	–	0.017
Asia-Europe	0.028	–	0.032	0.068	–
Europe	–	0.040	–	0.075	0.036
Europe-North America	–	0.059	–	0.011	0.051
North America	–	0.066	–	–	0.041
AUD					
Asia	0.118	–	0.030	0.015	0.036
Asia-Europe	0.066	–	0.026	0.091	0.016
Europe	0.048	–	0.010	0.105	0.017
Europe-North America	0.034	–	–	0.073	0.065
North America	0.067	0.047	–	0.041	0.096

Table 4

Variance Decomposition of Cumulative Returns in Each Regional Time Zone

Per cent of variation explained by order flow, by location of trade initiation

Regional time zone	Location of trade initiation				
	Australia	Canada	Japan	United Kingdom	United States
CAD					
Asia	10.0	–	6.7	–	1.4
Asia-Europe	7.1	–	9.8	42.8	–
Europe	–	13.2	–	45.8	10.8
Europe-North America	–	33.8	–	12.0	26.9
North America	–	48.5	–	–	20.1
AUD					
Asia	45.9	–	3.2	0.8	4.3
Asia-Europe	22.2	–	3.6	40.2	3.2
Europe	12.7	–	0.6	54.7	1.4
Europe-North America	7.3	–	–	31.4	25.3
North America	11.3	5.7	–	4.3	23.5

on the CAD exchange rate during North American hours. In contrast, U.S. trades during these same hours have a 0.041 per cent impact on the CAD exchange rate. Surprisingly, U.K. trades during European hours have a slightly larger long-run effect (0.075 per cent) than Canadian trades. During Asian hours, Australian and Japanese trades have a smaller influence. Interestingly, the U.K. trade effect is much larger before the start of the North American day, when Canadian and U.S. traders begin to make markets.

The variance-decomposition results mirror the qualitative results of the impulse-response functions. This is reassuring, since the two measures attempt to capture similar aspects of price discovery. During Asian hours, Australian and Japanese trades explain about 10 per cent and 7 per cent, respectively, of the permanent variation in the CAD exchange rate. Within Asian-European and European regional time zones, U.K. trades explain more than 40 per cent of the variation in the CAD exchange rate. This result is consistent with the perception of London as a major FX commercial centre. Once North America opens up for trading, Canadian and U.S. trades account for more than 60 per cent of the variation in the exchange rate. Interestingly, Canadian trades are unambiguously more informative than U.S. trades during North American hours.

Trades initiated in Canada, the United Kingdom, and the United States have the largest impact on the CAD exchange rate.

Similarly, Australian trades have a significantly larger impact on the AUD exchange rate than U.S. and U.K. trades during each country's respective business hours. An Australian trade during Asian hours has a permanent impact of 0.118 per cent on the AUD exchange rate. In contrast, U.K. trades during European hours have a 0.105 per cent long-run effect, while U.S. trades during North American hours have a 0.096 per cent effect. Results also illustrate that U.K. trades explain more than 50 per cent of the permanent variation in the exchange rate during European hours, while U.S. trades explain about 25 per cent of the variation during both European-North American and North American hours. Note that while Japanese and U.K. trades have similar effects on the AUD market during Asian hours, Japanese-initiated trades have a significantly smaller effect during the Asian-European overlapping period.

Across the CAD and AUD markets, results suggest that a local, or home-country, bias exists. Australian and Canadian trades explain about 50 per cent of the variation in the permanent component of exchange rate returns during core business hours. This result confirms the premise that dealers operating both at the same time and in the same geographic region as fun-

damentally driven customers have a natural informational advantage.

There are strong time-of-day effects associated with the informational content of trades. In particular, the long-run impact of a trade depends on which financial centres are operating at a specific moment in time. It is also noteworthy that trade informativeness is usually smaller at the opening and closing of a region's regular business hours. For example, in both markets, U.K.-initiated trades are less informative during the overlapping hours before and after core European business hours. Anecdotal evidence suggests that FX traders must "close out" their positions at the end of their business day. These end-of-day closing trades should therefore be less informative in terms of exchange rate fundamentals.

Conclusions

Since FX traders located across the globe have access to similar news sources, and since relevant information regarding the determination of the exchange rate is thought to be public, it is sometimes claimed that trades initiated in one location should not be more informative than trades initiated in another. Evidence presented here suggests that this hypothesis should be rejected. Overall, results point to a participant's location and hours of operation as two of the factors driving informed interdealer trading.

This article finds evidence to support the view that local traders in FX markets are better informed about the future direction of the exchange rate. Furthermore, dealers operating from within the largest FX commercial centres, such as the United Kingdom (London) and the United States (New York), though not Japan (Tokyo), are also asymmetrically informed, at least during their regular business hours in the CAD and AUD markets. Trades initiated during non-business hours, or from alternative locations, may be related less to fundamentals and more to temporary demands for liquidity.

A participant's location and hours of operation are two of the factors driving informed interdealer trading.

Barker (2007) discusses recent changes in the structure of the FX market, including adjustments to technology, greater participation by buy-side players in providing liquidity, and an overall reduction in transactions costs. As well, clients who understand the value of the information content of their trades are increasingly preventing dealers from exploiting their order flow. In light of the current transformation of the FX market, some caution must be exercised when drawing policy implications from the results presented above, which analyzed data covering an earlier period (2000–02). It is reasonable to assume that changes in openness, transparency, and liquidity have recently affected trading dynamics in this unregulated market. Consider the example of hedge funds, which have grown both in numbers and in the amount of capital under management. This capital can be rapidly deployed through the current trading structures of the FX market. Nevertheless, given the importance of speed in the execution of trades, there may be additional incentives for new participants to locate among the largest global financial centres.

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Developing a Framework to Assess Financial Stability: Conference Highlights and Lessons

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The Bank of Canada hosted its sixteenth annual economic conference in Ottawa on 7 and 8 November 2007. Papers and discussions presented by an international group of economists focused on such topics as stress testing financial systems, models for assessing risks to financial stability, and the effects of linkages among payment, clearing, and settlement systems.

Developing a framework to assess financial stability is an important subject for central banks, both because of their involvement in various aspects of the work on financial system stability and because the framework currently in place is still rather rudimentary. On the monetary policy side, clear policy strategies have been identified and are supported by well-developed macroeconomic models; central banks are still defining their approach to questions of financial stability, however, and are at an early stage in the development of useful models. The objective of the conference was to stimulate progress in further developing the financial-stability framework.

In this article, we report on conference highlights and propose directions for future research on financial-stability issues. We begin by reporting on the experiences of central banks with stress-testing exercises performed in the context of the International Monetary Fund's (IMF) Financial Sector Assessment Program (FSAP), which is designed to help countries identify vulnerabilities in their financial system and to determine necessary reforms. Recent FSAP work on stress testing provides a good illustration of the progress that has been made in financial-stability analysis and clearly points to various areas where progress is needed. This is followed by a discussion of each of the three frameworks proposed by conference participants as having good potential to generate such progress: the contingent-claims-analysis (CCA) framework, the semi-structural framework, and structural financial-stability models. We then report on discussions about the implications for financial stability of linkages among payment, clearing, and settlement systems.[1] We conclude with some suggestions for future research priorities.

Experiences with FSAP Macro Stress Testing

In 2006, Canada invited the IMF to examine the country's financial system under its FSAP. An important component of FSAP was a stress-testing exercise to assess the ability of Canada's financial system to resist various adverse shocks and to respond to a scenario representing a disorderly resolution of global imbalances. As a key participant in the stress-testing exercise, the Bank of Canada organized a panel session at the conference on central banks' experiences with FSAP

1. The full text of selected conference papers and some of the discussants' presentations are available on the Bank's website at <http://www.bankofcanada.ca/en/conference_papers/econ_conf07/papers.html>. A partial list of the conference papers and presentations is provided at the end of this article.

stress testing, with the objective of sharing experiences and identifying strengths and areas for improvement. In a session open to all conference participants, central bankers from Australia, France, Denmark, and Canada made short presentations that were intended to stimulate discussion among participants.

Stress testing will be an important component of the framework, since it can be used to assess the financial system's robustness to negative shocks and scenarios.

The four countries have shared similar FSAP experiences, which included using single-factor shocks and macroeconomic scenarios to assess the stability of financial systems. While single-factor shocks have focused on liquidity and market risks, macroeconomic scenarios have focused on credit risk. The choice of shocks and scenarios to be simulated emerged from discussions between the IMF and the various national authorities. Among the single-factor shocks were sudden interest rate changes and abrupt illiquidity in certain markets. As for the macroeconomic scenarios, central banks have often taken the lead in designing the details of scenarios that have been agreed upon with the IMF. For instance, the Bank of Canada used its version of the Global Economy Model (BoC-GEM) to design a coherent scenario of a disorderly resolution of global current account imbalances (Coletti et al. 2007).[2] This macro scenario was supplemented with single equations linking sectoral default probabilities with macroeconomic variables (Misina and Tessier 2007).[3] In some cases, developing the macroeconomic scenario(s) has been a joint effort by various authorities. In Australia, for example, developing the macroeconomic scenarios (sharp decline in house prices, difficulties experienced by banks in obtaining foreign funding) was a joint effort by the Treasury, the prudential regulator, and the central bank (Aylmer 2007).

Bottom-up and top-down approaches have been used to simulate the impact of shocks and scenarios on financial institutions. In a bottom-up approach, simulations are performed by financial institutions with their own internal models. In a top-down approach, the IMF and / or the national authorities use their models and the information they have about financial institutions' exposures to measure the impact of shocks and scenarios. In most cases, top-down and bottom-up approaches have produced similar results. An exception was Denmark where, because of differences in assumptions concerning loss-given default, top-down results showed more severe outcomes for financial institutions (IMF 2007; Lund 2007).

There was general agreement at the conference that there are significant net benefits from participating in FSAP stress testing. It can promote co-operation among the various government authorities involved and improve communication between these authorities and financial institutions. It can also reveal useful information about the exposure of financial institutions to various types of risk and stimulate the development of stress-testing tools.

Of particular interest will be stress-testing methods that can be used to assess potential contagion risks and feedback effects between the financial system and the real economy.

The FSAP stress-testing exercises discussed at the conference show that much progress has been made in developing macro stress-testing tools. Only a few years ago, macro stress testing could not have been performed in most countries; now, useful tools are available to assess credit risk in banks' loan portfolios. Nevertheless, current tools have important limitations. In particular, existing bottom-up and top-down approaches do not allow for an integrated analysis of the types of risk affecting financial institutions (market, credit, liquidity, etc.). In practice, these risks are likely to be correlated, which could accentuate the impact of severe negative shocks. As well, existing tools do not factor in contagion effects between various components of the financial system and feedback effects between this system and the real economy. Since the models used by financial institutions are not likely to include feedback and

2. The approach to monitoring and analyzing international risks that is presented in Maier, Paulin, and Santor (2007) shares common characteristics with the approach used for Canada's FSAP stress testing: risk identification, development of a macroeconomic scenario with a structural model, and analysis of the potential implications of the scenario.

3. An alternative approach to modelling default probabilities was presented at the conference by Jiménez and Mencía (2007).

contagion effects, factoring in these effects could be a significant contribution of top-down approaches. Finally, the links between the macro models used to design the scenarios and the tools used to assess their impact on financial institutions tend to be ad hoc.[4]

The Contingent-Claims-Analysis Framework

A contingent claim is a financial asset whose future payoff depends on the value of another asset. The best-known contingent claim is an option—the right to buy or sell a specified asset at a pre-specified exercise price, by a certain expiration date. When applied to the analysis and measurement of credit risk at the firm level, the CCA is commonly called the Merton model. Gray, Merton, and Bodie (2002) proposed an extension of the CCA to generate a risk-adjusted balance sheet at the national level where the sectors of the economy are viewed as interconnected portfolios of assets, liabilities, and guarantees.[5]

Gray, Merton, and Bodie (2007) presented applications of such a framework to Chile and proposed different ways of doing stress testing through the estimation of reduced-form equations or factor models linking the risk indicators identified by the CCA to macro variables. The last section of their paper discusses ways of integrating indicators of financial risk (such as those generated by the CCA) with monetary policy models. The discussant, Jack Selody, was of the view that the CCA approach is promising, in particular because it allows for a clear quantification of default risks and can be a good monitoring tool. He noted important limitations of this approach, however, including that it does not explicitly model the behaviour of economic agents and is not able to factor in the role of policy instruments. Pierre Duguay commented that, while instructive, the sectoral aggregation proposed by Gray, Merton, and Bodie could not be used to identify important sources of financial stress, such as loss of confidence in counterparties.

Souissi (2007) uses the CCA to evaluate the risks in the Canadian mortgage portfolio. He calculates the probability of default for different loan-to-value (LTV) ratios and combines them with the distribution of Canadian mortgages by LTV to obtain an estimation of the overall rate of default in the mortgage portfolio. Souissi also analyzes the impact of changes in housing prices on the decision to default. The model could be used to assess the impact of changes in the LTV distribution on the level of risk in the mortgage portfolio.

Tools based on the contingent-claims analysis are worth developing further because they provide a useful framework to monitor and quantify default risks.

Allenspach and Monnin (2007) use the CCA to shed light on two questions: What is the impact of international integration on banks' exposure to shocks between 1993 and 2006? And what is its impact on systemic risk in the international banking sector? To answer the first question, they analyze the evolution of the correlations between banks' asset-to-debt (AD) ratios using a new method to estimate the joint dynamics of the AD ratios of all banks. To answer the second question, they analyze the evolution of an index of systemic risk proposed by Lehar (2005). Lehar's index measures the probability of observing a systemic crisis (defined as a given number of simultaneous bank defaults) at a given time. Both the AD ratio and Lehar's index are based on the market value of banks' assets assigned by the Merton model. As well, the authors try to determine whether there is a link between banks' common exposures and systemic risk. Their findings are that: (i) common exposures have decreased in the first part of the sample and increased in later parts; (ii) there is no significant trend in their measure of systemic risk; and (iii) common exposures as measured by correlations between banks are not a reliable measure of systemic risk. Discussant Ramdane Djoudad emphasized the difficulty of translating linear correlations into non-linear measures of systemic risks.

In summary, the CCA approach appears particularly useful for measuring and monitoring default risk, at least as perceived by the market. It is likely, however, to be of limited use in the study of stress scenarios.

The Semi-Structural Framework

The potential for contagion between financial institutions may have increased with the size and complexity

4. de Bandt (2007) presented work to better link developments in the corporate debt market to implied stress-testing scenarios and their impact on French banks.

5. For an application to the Canadian business sector, see Kozak, Aaron, and Gauthier (2006).

of their interconnections. One goal of the semi-structural framework is to integrate some of the potential contagion channels that exist between financial institutions. A first channel comes from direct balance-sheet interlinkages between financial institutions, i.e., distress at one bank may cause distress at another because of mutual exposures. A second channel for contagion is the impact of fire sales of the assets of a distressed institution on both its own marked-to-market balance sheet and on those of other institutions holding the same class of assets.

Cifuentes, Ferrucci, and Shin (2005) discuss the case where a bank that fails to meet its regulatory capital ratio may feel the need to sell some of its liquid assets in order to reduce the size of its balance sheet. If this is not sufficient, illiquid assets may have to be sold. Because of their illiquidity, their price goes down in a non-linear way with the amount sold.[6] This could affect the balance sheet of other institutions so that they would also fail to meet their minimum capital requirement and, in turn, would need to take measures to reduce the size of their balance sheets.

Pier Allessandri (Bank of England) presented work that explicitly integrates these two channels into a quantitative framework for gauging systemic risk. He also suggested ways to quantify the impact on banks' balance sheets of macro credit risk, interest income risk, and market risk.[7]

Frisell et al. (2007) adopt a method proposed by Elsinger, Lehar, and Summer (2006) to analyze the stability of the Swedish banking system, relying mostly on market data. Their approach captures both correlated exposures of banks and mutual credit exposures that can cause domino-effect insolvencies. The main contribution of the paper by Frisell et al. is on the data side. The four largest banks, representing 80 per cent of total bank assets in Sweden, have reported their 15 largest counterparty exposures since 1999. Data include both on- and off-balance-sheet items, such as credit commitments, guarantees, derivatives, etc. Exposures between banks are found to be very asymmetric and to vary considerably over time. Frisell et al. find that although the use of entropy maximization to estimate bilateral exposures on the basis of aggregate exposures may be the best possible approach when bilateral exposures are not disclosed, it may underestimate the largest exposures and contagion risks.

Céline Gauthier expressed reservations about the approach used by Frisell et al. First, some double counting may occur, since publicly known interbank exposures should already be integrated in market prices. This would lead to some overestimation of risk. Second, stress testing based on Monte Carlo simulations of the multivariate distribution of asset correlations does not allow for explicit linkages between the real economy and the banking system, whereas a balance-sheet approach, such as the one followed by Allessandri, does.

The semi-structural framework offers some promising developments for the analysis of various types of contagion effects.

The semi-structural framework seems to have good potential for addressing some of the present weaknesses of the models and approaches used to analyze financial-stability risk. In particular, it offers some promising developments for the analysis of various types of contagion effects. Nevertheless, its main limitations are that it is not always based on well-specified microfoundations, and it may not account for feedback effects between the real economy and the financial sector. An objective of structural financial-stability models is to address these limitations.

Structural Modelling

Dimitrios Tsomocos presented results based on a calibrated version of the Goodhart, Sunirand, and Tsomocos (2006) model. This is a microfounded general-equilibrium model with endogenous default and heterogeneous agents, which treats banks' defaults as an equilibrium phenomenon. Policy instruments are factored in, notably through capital-adequacy requirements.

Aspachs et al. (2007) suggest ways to assess the stability of the overall banking system using a two-factor model that includes banks' default rates and profitability. At this stage, both indicators are based on market data: The probability of default is estimated from CCA-based distance-to-default data calculated by the IMF,

6. In its current applications, an ad hoc non-linear inverse demand curve is assumed for the illiquid assets.

7. The paper is currently not available.

and profitability is represented by equity values. The authors use a reduced-form vector-autoregression approach to evaluate the impact of the two financial-fragility "factors" on output. In his discussion of the paper, Césaire Meh stressed that the model included a large number of free parameters and that the exclusive focus on banking intermediation was at variance with increasingly market-based financial systems. He expressed concern that the empirical reduced-form applications of the model might have only weak links with the theoretical model. He also indicated that capital ratios could be determined endogenously by banks and were not entirely determined by regulators. During the final panel discussion, Charles Goodhart and Pierre Duguay agreed that the focus on banks was fully warranted, given their role in providing the means of payment.

The existence of coordination failures and the "special" role for money in the business cycle and in macroeconomics were highlighted by David Laidler as arguments in favour of a role for the central bank as lender of last resort (LLR) and, therefore, for the development of models with a non-trivial monetary / financial sector. In his John Kuszczak Memorial Lecture, Laidler reviewed economic history back to the early nineteenth century. A general theme was that, historically, the business cycle was actually considered a credit cycle. Nowadays, the success of central banks in maintaining price stability should pave the way for them to take a more active role in the area of financial stability. Indeed, both the monetarist tradition, which stresses the possible discrepancy between the supply of and demand for money, and the Wicksellian tradition, which highlights discrepancies between savings and investment (a form of coordination failure), indicate that stabilizing the inflation rate is not sufficient to stabilize the real economy and eliminate the risk of financial instability.

Several contributors picked up on the observation made by both David Laidler and Charles Goodhart that, in the absence of default risk (i.e., if borrowers would repay their debt with certainty), there would not be any need for money. This calls for augmenting the dynamic-stochastic general-equilibrium model currently used with success in the analysis of price stability by incorporating the risk of default. The analysis of financial stability would require investigating additional transmission channels (such as the financial accelerator), constructing richer models than representative-agent models, and considering the difference in behaviour between "tranquil" and "crisis" periods. The need to capture the amplifying effect triggered by fluctuations in financial prices was also a joint conclusion of the three final panellists.

Payment, Clearing, and Settlement Systems

Conference participants also investigated a third theme: how systemic risk may arise from the transmission of shocks in payment, clearing, and settlement systems. Different papers addressed these issues through the lens of liquidity management, which appeared to have been crucial during the subprime crisis and is characterized, among other things, by a reduced willingness of financial institutions to transact with other participants. Liquidity is a broad concept, however. Payment and settlement systems are usually not the primary sources of liquidity shock, even if they might transmit shocks across banks or market participants, particularly in cases where, by delaying payments, participants create system gridlock. From that point of view, payments-system experts observed no unusual behaviour in the subprime crisis, although caution is still warranted.

Given their significant role in linking the components of the financial system, it is important that further progress be made in the research on payment, clearing, and settlement systems.

Several perspectives on these systems were reflected at the conference. First, Larry Radecki presented the provisional conclusions of the "Report of the Working Group on System Interdependencies,"[8] one of which is that, given the complexity of current payment and security settlement systems, participants often have little information on the other participants and on the degree of interdependencies among them (CPSS 2007). Its most surprising result is that large global banks do not pose a high degree of risk, since most of them operate through correspondents in foreign countries and have limited direct linkages with payment and security systems. Discussant Charles Freedman commended the report for providing a useful taxonomy,

8. The paper is currently not available.

including a three-by-three matrix distinguishing these interdependencies along two dimensions: the form of interdependence (system, institution, and environment) and the type of relationship (clearing and settlement, risk management, and operational relationships). He pointed out, however, that the report focused on benign conditions, but said little about crisis periods.

Second, Bech, Chapman, and Garratt (2007) addressed the issue of the liquidity in payment systems, with reference to the Canadian Large Value Transfer System. The two main innovations of the paper are that it formally models the network of relations among banks in the payment system, and it estimates the main parameters of this model. Liquidity is determined by bilateral credit limits and by self-generated credit created by the bank's ability to delay payments. Using the special mathematical properties of the payment network (i.e., the structure of flows among banks), the authors manage to estimate the stationary structure of the network, as well as the degree of delay in processing the payment orders.

Commentator Thorsten Koeppl congratulated the authors for the originality of their approach and the focus on the delay parameter, which is indeed crucial. This stands in contrast to traditional methods, where the resilience of the network is generally assessed through its response to simulated shocks. Indeed, the ability of banks to slow outgoing flows has often been acknowledged as creating gridlock in payment systems and, hence, systemic risk. Nevertheless, beyond its mathematical complexity, the model is only descriptive and does not explain the behaviour behind the delay parameters. Banks may delay in response to either shocks or heterogeneous characteristics, which may depend on size or competition. From a policy perspective, this limits the conclusions that can be drawn from the model.

The issue of liquidity was also the central question investigated by Schanz (2007), although with particular emphasis on foreign exchange (FX) transactions. Schanz considered how the coordination of liquidity management within financial institutions affects the transmission of liquidity shocks, using a model that compares local banks to a global bank with subsidiaries. He addressed the very topical issue of possible market failure in the domestic interbank market (resulting from adverse selection), which might prevent liquidity-rich banks from lending to liquidity-strapped banks. His main conclusion is that, for financial institutions, going global implies an increased risk of technical defaults, because banks with high solvency risk would not be able to refinance themselves, either domestically or via FX transactions, in response to liquidity outflows. This is partly offset, however, by a lower transmission of losses within and across systems. In her comments, Alexandra Lai notably stressed the need to take into account market structure, which can affect how funding decisions are made during a crisis, and the need to look at various types of shocks (in particular, global liquidity shocks).

Conclusion

This sixteenth annual Bank of Canada economic conference provided an opportunity for researchers to exchange information on the various strands of research that are contributing to the development of a framework to assess financial stability.

There is no doubt that stress testing will be an important component of the framework, since it can be used to assess the financial system's robustness to negative shocks and scenarios. Significant progress has been made in the development of stress-testing methods, including some that have been used in FSAP exercises. Various areas for further improvement remain, however. Of particular interest will be methods that could be used to assess potential contagion risks and feedback effects between the financial system and the real economy. As well, the various types of risk need to be better integrated into the analysis. Some of the conference papers, in particular those using a semi-structural, network-based approach, demonstrate the significant progress being made in both the analysis of contagion channels and in integrating the analysis of different types of risk.

Structural general-equilibrium models could also be used to perform macro stress testing. The general-equilibrium model presented at the conference by Goodhart, Sunirand, and Tsomocos (2006) incorporates many of the desirable features of a stress-testing model. The model is very complex, however, and seems difficult to calibrate or estimate with actual data. As well, there may be considerable distance between the more theoretical general models and the versions to be used with actual data. More work is needed in evaluating and developing this type of model.

The contingent-claims analysis suffers from some limitations. In particular, it does not explicitly model the behaviour of economic agents and is of limited usefulness in performing stress-testing, or counterfactual, exercises. Nevertheless, it provides a useful framework to monitor and quantify default risks. For

this reason, we believe it is worth developing further, although it should not be a main focus of our research efforts.

Finally, given their significant role in linking the components of the financial system, it is important that further progress be made in the research on payment, clearing, and settlement systems. The functioning of these systems is conditioned by the behaviour of economic agents, indicating that these behaviours need to be modelled explicitly. As well, given that there can be feedback effects between these systems and the rest of the financial system, we believe that these effects should be factored into future research.

While significant progress has been made in recent years towards the development of a framework to assess financial stability, much remains to be done, and this field of research should remain an exciting one.

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