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Winter 2010–2011

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Bank of Canada Review

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Cover

Roman *aes grave*

David Bergeron, Curator, Currency Museum

According to tradition, Rome was founded in 753 BC—a small settlement on the Tiber River at the foot of the Palatine Hill in central Italy. Over the next thousand years, Rome grew from a kingdom ruled by despotic Etruscan kings into the largest, richest, and most politically important city in the Western world. Under the Roman Republic, it governed most of Italy, and with the military and political exploits of Julius Caesar Roman dominance expanded. When the Roman Empire dawned in 27 BC, it covered all of Western Europe, half of Britain, and circled the Mediterranean Sea. The monetary practices of Rome before its rise to imperial prominence are as unusual as they are interesting.

The absence of coinage in Rome prior to the fourth century BC attests to its isolation from Greek influence. While Greek settlers had brought the hand-struck gold and silver coins of the Greek city-states to southern Italy and Sicily (an area known as *Magna Graecia*) in the sixth century BC, natives of central Italy, including Romans and Etruscans, adopted their own monetary system using bronze (*aes*), which was abundantly available. Lumps of raw bronze called *aes rude*, and later cast bars and ingots (*aes signatum*), were used to pay soldiers, taxes, and fines. The value of both of these was based on weight.

Around 280 BC, the *aes* was transformed into an actual currency to fund military campaigns. The first coins were initially a fiduciary currency based on the libral standard, where one *as* weighed one Roman pound (*libra*) or 12 Roman ounces (*unciae*). Because of their large size, the coins have become commonly known as *aes grave*—literally heavy bronze.

Although the Romans began to produce silver coinage for foreign trade in the late third century BC, the heavy bronze coins were used locally. The coins were cast, and a series of letters and pellets were used to identify their value, which was based on fractions of the *as*: I for *libra* (pound), s for *semis* (half-pound), four, three, and two pellets for the *quadrans* (quarter-pound), *triens* (third-pound), and *sextans* (sixth-pound), respectively, and one pellet for the *uncia*. Designs on early *aes grave* varied from deities and animals to implements and food staples. From 225 BC onwards, the coinage was standardized, and a more consistent design was adopted, with deities gracing the obverse and a ship's prow, symbolizing Rome's position as a major sea power, on the reverse. The coins pictured on the cover demonstrate the crudeness, as well as the relative size and appearance, of the *aes grave*, from the *as*, which depicts the double-faced head of Janus, measures 6.5 cm in diameter, and weighs 281 grams, down to the *uncia*, which depicts Roma and is about the size of a quarter.

Over time, with inflation and the need to increase the monetary mass, the coinage was reduced in weight, despite maintaining its currency value. By 211 BC, the *as* was reduced to a token coinage, worth 1 *uncia*—a mere fraction of its original weight. The smaller bronze coins were struck rather than cast, and the large bronze coins faded from circulation. The silver denarius (worth 10 *asses*), first minted in 217 BC, became the main coinage of the Roman Republic and then of the Roman Empire.

The Roman *aes grave* pictured on the cover are part of the National Currency Collection of the Bank of Canada.

Photography by Gord Carter, Ottawa

Contents

Articles

Competition in the Canadian Mortgage Market

Jason Allen, Financial Stability Department[*]

- *The Canadian mortgage market has changed substantially in the past 20 years: trust companies have been taken over by banks; small virtual banks have offered new mortgage products; and brokers now play an important role in matching borrowers and lenders.*
- *The changing structure and practices of the Canadian mortgage market have implications for competition authorities and for financial system regulation.*
- *Recent research suggests that the rate paid for a mortgage depends on the borrower's observable characteristics, as well as their local market. Unobserved bargaining ability also appears to play an important role.*
- *Mortgage-rate discounting affects the speed and degree of pass-through from changes in the central bank's key policy rate to mortgage rates. Research also suggests that bank mergers do not necessarily lead to mortgage-rate increases.*

At the end of 2010, the Canadian mortgage market had grown to more than $1 trillion, representing almost 40 per cent of total outstanding private sector credit. The market is dominated by Canada's six major banks, although this has not always been the case. Their most recent increase in market share coincides with changes to the Bank Act in 1992, which allowed chartered banks to enter the trust business. They did this largely through acquisition.[1] Recent research at the Bank of Canada has analyzed the Canadian mortgage market in this context. The purpose of the research is to understand how the interaction of market structure, product differentiation, and information frictions determines rates in the Canadian mortgage market. This article summarizes the main findings.

Understanding how rates are determined in the Canadian mortgage market is important for the central bank, competition authorities, and financial regulation. For example, the gap between posted rates and transaction rates should be taken into account when addressing some questions about the monetary policy transmission mechanism. Do financial institutions fully pass through changes in monetary policy rates to mortgage rates, and do they move equally fast from above and below equilibrium? Using posted rates, Allen and McVanel (2009) find that the answer to the first question is no and to the second, yes. But using transaction rates, they find that the answer to the first question is yes and to the second, no.

The changing market structure of the mortgage industry has implications for competition, but the analysis is complicated because banks are vertically and horizontally differentiated. For example, the location of branches determines the cost of shopping for mortgages (horizontal differentiation), while the quality of complementary services affects the value of

* I have benefited from discussions with and comments from Ian Christensen, Robert Clark, Toni Gravelle, Darcey McVanel, Larry Schembri, and Mark Zelmer.

1 See Freedman (1998) for a discussion of the evolution of deregulation in Canada.

signing with a particular bank (vertical differentiation). If consumers differ in their preferences for these services, then changes in market structure can have welfare effects that are more complex than those typically assumed in merger analysis.

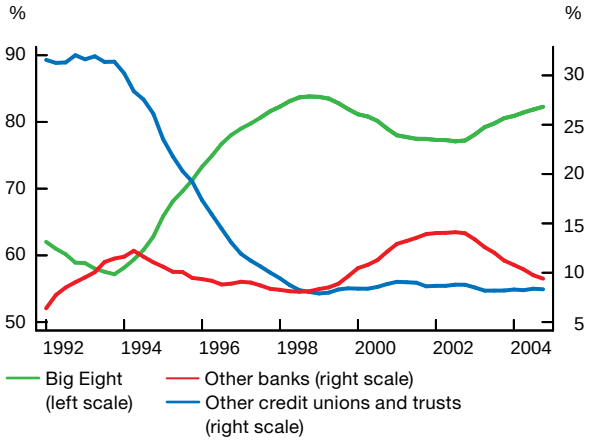
Financial regulators should also take a keen interest in understanding how lenders price mortgages, especially if mortgage-related instruments are to be included under the umbrella of "system-wide prudential regulation." For example, the effectiveness of changing the rules governing mortgage lending depends on how lenders and borrowers negotiate rates. The research summarized here shows that borrowers do not simply take the posted rate as given.

This article first provides a brief examination of the Canadian mortgage market, focusing on the evolution of the market following legislative changes to the Bank Act in 1992. This is followed by an overview of the data, which is noteworthy in its own right because it is very detailed. Key research by the Bank of Canada on the Canadian mortgage market is then reviewed.

The Canadian Mortgage Market

Canada's mortgage market is dominated by the "Big Six" Canadian banks: Bank of Montreal, Bank of Nova Scotia, Banque Nationale, Canadian Imperial Bank of Commerce, Royal Bank Financial Group, and TD Bank Financial Group. Together with a large regional co-operative network—the Desjardins Movement—and a provincially owned deposit-taking institution—Alberta's ATB Financial—this group controls 90 per cent of the assets in the banking industry. Collectively, these institutions are called the "Big Eight." **Chart 1** presents their market share of outstanding mortgages, which grew from 60 per cent to 80 per cent between 1992 and 2004 (the period for which we have detailed data and conduct the majority of our analysis) as banks entered the trust business. They all offer the same types of mortgage products, as well as other products, such as credit cards, personal loans, and wealth-management advice. In fact, most Canadians treat their primary financial institution as a "one-stop shop" (universal bank) where they purchase the majority of their financial services. This article argues that this is one reason why Canadian banks compete so fiercely in the mortgage market: a lender has many opportunities for cross-product selling once a client is locked in with a mortgage.[2] In addition to the large

Chart 1: Market share of Canada's major mortgage lenders



Sources: CMHC and Genworth Financial

lenders, small foreign banks, including virtual banks, entered the Canadian market in the 1990s, offering new products to Canadians.

The Canadian mortgage market is relatively simple and conservative, particularly when compared with its U.S. counterpart.

Mortgage products

The Canadian mortgage market is relatively simple and conservative, particularly when compared with its U.S. counterpart (Kiff 2009). Many Canadians sign five-year, fixed-rate mortgages that are rolled over with new five-year, fixed-rate contracts for the life of the mortgage—typically 25 years (the amortization period).[3] The rate is renegotiated every five years. The popularity of variable-rate mortgages has waxed and waned over time. In this case, the monthly payment is typically fixed, but the portion that is interest and not principal changes with fluctuations in interest rates. Longer-term mortgages, which are the norm in the United States, were phased out of Canada in the late 1960s after lenders experienced difficulties with volatile interest rates and maturity mismatch.

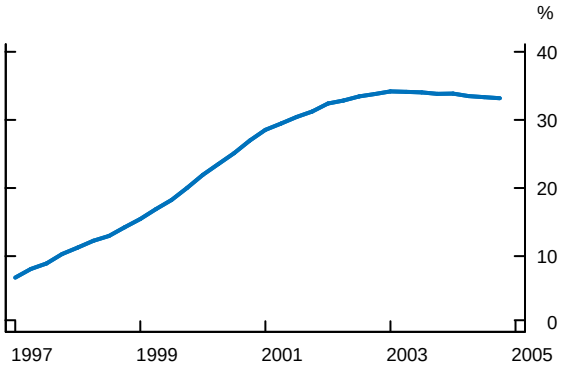
2 Consumers are said to be "locked in" if they do not switch to a seller offering a lower price. This is because there are costs to switching sellers, in terms of financial costs and effort.

3 The percentage of mortgages with longer amortization periods has increased in recent years. In the sample period covered by the analysis (1992 to 2004), however, almost every mortgage was amortized over 25 years.

Mortgage brokers

Although the 1990s saw the large Canadian banks acquire nearly all of the country's trust companies, there were a number of important developments in the mortgage industry that encouraged competition. For example, mortgage brokers became important participants in the lending process. Brokers typically earn between 1 and 1.3 per cent of the value of mortgages that they bring to a lender, which could be anything from a small deposit-taking institution to a large bank. **Chart 2** presents the share of transactions that were broker assisted over an eight-year sample period. The share increases from less than 10 per cent to over 30 per cent between 1997 and 2004.[4] This suggests that a large number of consumers sought the help of a broker when shopping for a mortgage. In addition to mortgage brokers, foreign competitors entered the Canadian banking market, although their market share remains small.

Chart 2: Broker-assisted transactions



Sources: CMHC and Genworth Financial

The Data: Mortgage Insurers

The data used in this research are provided by the Canada Mortgage and Housing Corporation (CMHC) and Genworth Financial, Canada's two mortgage insurers over the course of the sample period, which runs from 1992 to 2004 (consent for the Bank of Canada to access the data was provided by individual financial institutions). During this time, borrowers who contributed less than 25 per cent to the purchase price of a house were required to purchase mortgage insurance (today that number is 20 per cent). The majority of borrowers are insured by the CMHC, but Genworth has an important share of the market. In total, over 50 per cent of the mortgages on the balance sheets of financial institutions are insured—a proportion that has been relatively stable over time. The insurers charge the lender a premium for insurance that protects the lender in case of borrower default. Typically, a lender will pass this cost on to the borrower. To assess a loan for mortgage insurance, CMHC and Genworth Financial collect detailed information on the borrower and the property—information related to the mortgage contract and to the borrower's ability and history in managing their debts, including information on incomes and credit scores. Information related to the contract includes the interest rate negotiated between the lender and the borrower. The difference between the contract rate and the posted rate is the discount. There is also information on house prices and loan amounts and, therefore, loan-to-value (LTV) ratios. Collectively, these data help the Bank to understand how mortgages rates are determined in Canada.

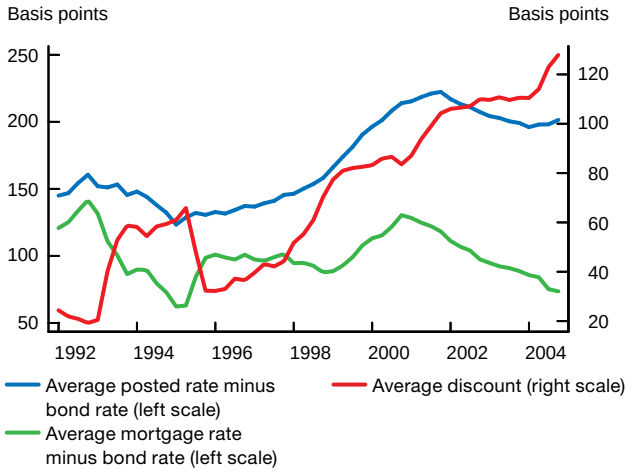
Discounting

Allen, Clark, and Houde (2011) are the first to use data at the individual level to document the use of mortgage discounting in Canada. Discounting is a situation where sellers, in this case lenders, post one rate but are willing to negotiate a different rate. The practice began in earnest in the early 1990s and is considered the norm in today's mortgage market. In its annual report on the state of the residential mortgage market, the Canadian Association of Accredited Mortgage Professionals (CAAMP) indicated that in 2009 the average consumer received a discount of 123 basis points on a five-year, fixed-rate mortgage. A natural question to ask might be why lenders post high rates if they are going to offer discounts to the majority of consumers. Allen, Clark, and Houde (2011) argue that over time lenders have improved their ability to price discriminate, that is, to offer discount rates to different sets of consumers based on their willingness to pay. Lenders can thus increase their profits through price discrimination instead of offering a blanket reduction in rates.

The increased use and magnitude of discounting hides the fact that some types of borrowers experience gains while others are worse off.

4 Survey evidence from CAAMP post-2004 shows the market share of mortgage brokers reaching as high as 40 per cent in 2008, before falling to 35 per cent in 2009.

Chart 3: Evolution of mortgage rates in Canada



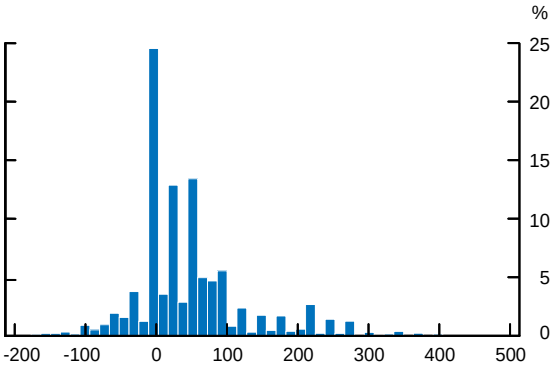
Sources: CMHC and Genworth Financial

Chart 4: Dispersion of discounts on five-year, fixed-rate mortgage

Basis points

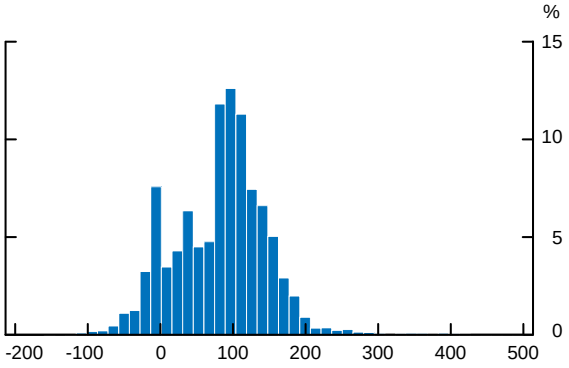
a. 1992–95

Probability (Discount ≤ 0)=35%



b. 2000–02

Probability (Discount ≤ 0)=13%



Sources: CMHC and Genworth Financial

Chart 3 illustrates the evolution of discounting from 1992 to 2004 for the five-year, fixed-rate mortgage. Over this period (and, according to survey data, beyond this period), discounting increased. However, the markup in the posted rate also rose, so that the average margin between the transaction rate and the five-year bond rate (which proxies the cost of funding) is relatively constant over time. **Chart 4** shows the dispersion in the discounts over periods 1992–95 and 2000–02. In both periods, different borrowers paid different rates, but more so in the latter period. Therefore, although the average consumer is as well off under a zero-discount environment as they are in a high-discount environment, the increased use and magnitude of discounting hides the fact that some types of borrowers experience gains while others are worse off.

Allen, Clark, and Houde (2011) examine factors that might explain differences in mortgage rates. The key variables considered are loan, borrower, and market characteristics. They also control for time trends and unobservable characteristics of the banks and neighbourhoods that do not change over time. Allen, Clark, and Houde find that over the period 1999 to 2004 consumers living in less-competitive markets (high Branch HHI) pay higher rates than consumers living in competitive markets.[5] In addition, banks with large branch networks charge higher rates than banks with smaller branch networks. This could be because more branches imply more market power. It could also imply that consumers prefer banks with an extensive branch network and are therefore willing to pay more to do business with such a bank.

The results also indicate that, *ceteris paribus*, higher-income households pay higher rates, on average, than lower-income households. High-income households are likely less inclined to spend the time shopping for and negotiating a mortgage. Since information on the age of the borrowers was not available, proxies are used: previous homeowners are classified as the oldest category, current renters as the middle category, and mortgage applicants living with their parents as the youngest category. The results show that the youngest borrowers receive the largest rate discount. This is consistent with the larger literature on price discrimination (e.g., Goldberg 1996) since banks, like most firms, try hard to attract new, younger customers because they can potentially lock them in for a long period.

5 HHI stands for Herfindahl-Hirschman Index. It is the sum of the square of the share of each bank's branches in a market. The result ranges from 0 to 1, where a low number indicates that the market is highly competitive, and a high number indicates that the market is not competitive.

With respect to LTV ratios, which are discussed in the **Box** on page 6, the authors find that borrowers who make the minimum down payment pay a rate premium over those able to put more equity into the house. Borrowers with larger equity in their houses have better bargaining positions than borrowers with minimum equity. Lenders compete for these borrowers more fiercely not only because they are less risky, but also because they are more profitable. Borrowers with more equity in the house are more likely to be in a position to take advantage of the lender's complementary services (such as wealth management or personal loans) than the most financially constrained borrowers and are thus more attractive to lenders. Lenders must therefore compete for this type of borrower by offering them larger discounts, while the most constrained borrowers pay a premium.

The authors also find that borrowers with better credit scores receive larger discounts. Banks also offer larger discounts to new clients than to existing clients. Consumers willing to switch financial institutions when shopping for their mortgage will see, on average, an additional discount of 7 basis points from the posted rate. The results also indicate that borrowers who use a mortgage broker pay less, on average, than borrowers who negotiate with lenders directly. This average discount is about an additional 19 basis points.

Finally, the authors find that a substantial amount of discounting cannot be explained by observable characteristics. The results are consistent, however, with a model of consumer heterogeneity in search and bargaining efforts/abilities, where the latter is unobserved. Borrowers who both search for and bargain more intensively with lenders can achieve larger discounts than other borrowers.

Discounting and monetary policy

Mortgage-rate discounting has implications for the transmission of monetary policy (Allen and McVanel 2009). Central banks rely on assumptions about the rate of pass-through of changes in the Bank rate to lending rates because it affects how much they should raise or lower rates when macroeconomic conditions change. These assumptions are usually based on estimates using historical data—typically the average posted mortgage rates. Allen and McVanel show that ignoring Canadian mortgage-discounting practices leads to a significant underestimation of pass-through. That is, if discounts are not factored in, Canadian lenders appear to be extremely slow to pass on changes in the Bank Rate to their customers. As noted earlier, however, discounting is an integral part of lenders' pricing strategies in Canada. Since discounting has increased over time, a downward bias potentially exists in previous measures of pass-through. Taking into account the upward trend in discounting and using data from 1991 to 2007, Allen and McVanel show that pass-through is indeed complete in the long run.

If discounts are not factored in, Canadian lenders appear to be extremely slow to pass on changes in the Bank Rate to their customers.

Once discounting is controlled for, however, the authors uncover another interesting facet of mortgage rates. They find that in the short, run five of the six largest Canadian banks adjust their rates upward more quickly when there are upward cost pressures than downward when costs fall.[6] There are a few reasons why there might be an asymmetric price response to changes in input costs. First, if banks have some market power, there is scope for banks to coordinate implicitly or explicitly. If costs rise, then banks will all want to increase their prices. If costs fall, however, there is an incentive to wait before passing on the lower costs in the form of lower rates because all the banks can earn higher profits. Second, if search is costly, banks can maintain high rates even after their costs have fallen because it takes time for mortgage shoppers to realize that rates should have fallen. The difference between posted rates and transaction rates in this market is further evidence that search costs are important.

Mergers

Most researchers that examine the effect of competition on prices take the same approach as Allen, Clark, and Houde (2011). That is, they regress prices on a measure of concentration. This approach does not directly address the effects of competition on mortgage rates, however, but measures correlation. The positive correlation between mortgage rates and branch concentration strongly suggests that rates are higher in

6 This is in line with previous research on the U.S. mortgage market (Arbatskaya and Baye 2004) or the market for deposits (Hannan and Berger 1991). More generally, Peltzman (2000) finds asymmetric price adjustments in most consumer and producer prices that he examines. Anecdotally, the Bank of Montreal's chief economist was quoted in *The Globe and Mail* (18 November 2009) as saying, "It's a safe thing to say that [mortgage] interest rates tend to move higher a lot faster than they move lower."

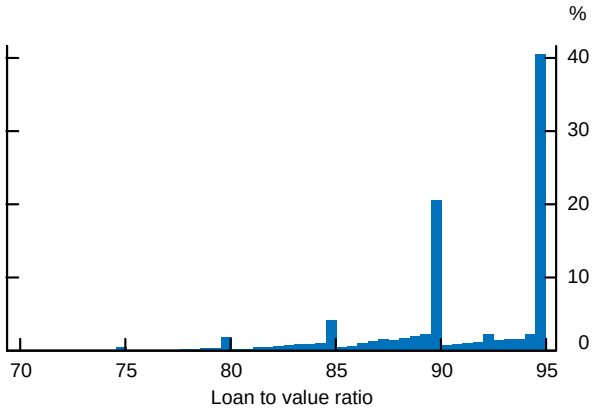
Loan-to-Value Ratios

An LTV ratio is defined as the loan amount divided by the appraised value of the house at the time of the loan. Currently, mortgages with an LTV ratio below 80 are conventional mortgages that do not require mortgage insurance. Those with LTV ratios above 80 require insurance, which is provided by CMHC or Genworth Financial. The maximum allowable LTV ratio in Canada is 95 per cent. A borrower can therefore contribute 5 per cent of their own equity to borrow 95 per cent of the purchase price from a lender for the purpose of buying a house. Since the 2007 U.S. subprime-mortgage crisis, LTV ratios have become an important source of discussion as a potential tool for system-wide risk management (e.g., CGFS 2010). Requiring borrowers to increase the amount of equity that they contribute when purchasing a house (e.g., lowering the maximum LTV ratio from 95 to 90), would likely have a dampening effect on house prices in the short-run. This is because in the short run fewer people would enter the housing market, and those who did would buy less-expensive houses.[1]

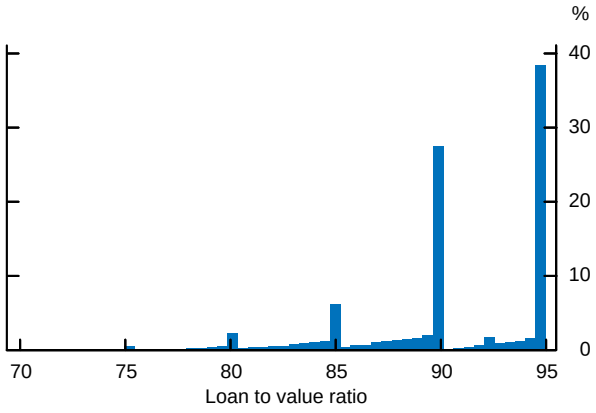
Chart A shows the LTV ratios of insured borrowers over two periods, 1992 to 1998 and 1998 to 2003, that correspond to two different insurance-premium regimes. In both cases, the majority of households are clustered at LTV ratios of 90 and 95, suggesting that most insured borrowers are highly leveraged. Changes to the maximum LTV ratio are thus likely to affect a large share of new insured mortgages. In 1998, the cost to the borrower of insuring a 95 LTV mortgage relative to a 90 LTV mortgage increased by 50 per cent. This led some borrowers to increase the equity portion of their mortgage, since the fraction of borrowers in the 95 LTV bin fell, and the fraction of borrowers in the 90 LTV bin increased. This suggests that, in addition to altering the LTV ratio, changes to mortgage-insurance premiums have the potential to influence household decisions to take on increased leverage.

Chart A: Loan to value ratio at time of issuance

a. 1992 to May 1998



b. June 1998 to 2003



Sources: CMHC and Genworth Financial

1 Note that a quality-based house price index might actually increase if consumers drive up the value of low-quality houses, even though the value of more expensive houses is falling because of the policy.

less-competitive markets, but there might be some unobservable reason for the correlation. Another approach is to look at mergers to directly measure the effects of changes in local market competition on rates. In this section, we follow this strategy by examining the impact of a merger between a bank and a trust company.

In the 1990s, Canadian banks acquired virtually all of the existing trust companies, together with hundreds of their branches across the country.[7] Consequently, these mergers and acquisitions created a discrete change in the structure of local banking markets. In particular, when two neighbouring branches merge because of a national acquisition, competition in the local market is immediately reduced, since banks begin internalizing the impact of their actions on each other's profits. That is, branches that once competed stop doing so once the merger is announced.[8]

Since most Canadian mortgage shoppers negotiate their contracts directly with local bankers, the potential impact of a merger is determined by the number of available local bank branches. Therefore, the most direct approach is to study the impact on rates of removing lender options from the choice set of consumers.[9] The effect of this change in competition on rates is captured by comparing the rates paid by the consumers affected by the merger ("treated") with those paid by a base group as follows:

$$r_{it} = \alpha_t + \theta_0(N_i M_t) + \gamma_0 N_i + \beta X_{it} + \delta_{bank} + \epsilon_{it}, \quad (1)$$

where r_{it} is the discount; N_i is equal to 1 if household i has the merging institutions in its neighbourhood and 0 otherwise; M_t indexes the merger and is therefore equal to 1 post-merger and equal to 0 pre-merger; and θ_0 is the coefficient of interest, which captures the aggregate effect of the merger on prices.

Table 1 summarizes the key results. From column (1) it is clear that overall the merger did not have a significant impact on rates. The coefficient is small, about 1.6 basis points, and not statistically significant. In addition to estimating equation (1), column (2) presents estimates from the following regression, which allows for the effect of the merger to vary across different markets:

Table 1: Effects of mergers on mortgage rates

Variables	Equation (1)	Equation (2)	Equation (3)
Aggregate effect	0.0161 (0.0107)	0.0527† (0.0180)	
Aggregate effect X HHI		0.184† (0.0695)	
Bank-specific effects			
Merging FIs			0.0850† (0.0166)
Competing FIs			- 0.0342† (0.0108)

† Significant at 1 per cent
Note: Standard errors are in parenthesis.

$$r_{it} = \alpha_t + \theta_0(N_i M_t) + \theta_1(N_i M_t) HHI_t + \gamma_0 N_i + \beta X_{it} + \delta_{bank} + \epsilon_{it}, \quad (2)$$

where HHI_t is the Herfindahl-Hirschman measure of branch concentration.

Here we see that rates in the most competitive neighbourhoods fell after the merger, while they increased significantly in the most concentrated markets.

Rates in the most competitive neighbourhoods fell after the merger, while they increased significantly in the most concentrated markets.

The aggregate results can be explained once the merger effect is broken down into its two components: the direct effect, which is the rate impact on the set of consumers who banked with the merging institutions pre- and post-merger, and the indirect effect, which is the rate impact on the set of consumers who banked with the merging institution's competitors pre- and post- merger. The estimating equation is given by:

$$r_{it} = \alpha_t + \sum\{\theta_K(KN_i M_t) + \gamma_K(KN_i)\} + \beta X_{it} + \delta_{bank} + \epsilon_{it}, \; K = I\{(AB, AB^c)\}, \quad (3)$$

7 Examples include TD-Central Guaranty Trust (1992), Royal Bank-Royal Trust (1993), BMO-Household Trust (1995), CIBC-FirstLine Trust (1995), Scotiabank-National Trust (1997), and TD-Canada Trust (2000).

8 For an econometrician trying to identify the effects of competition on prices, these changes in competition can be viewed as exogenous to the local market conditions.

9 The impact on rates of removing one bank option can be identified because not all consumers face the same bank options. Some consumers live in markets offering many bank choices, including the two merging banks, while others live in markets containing neither of the merging banks or only one of them. The last two groups of consumers are not affected by the merger and therefore constitute the base group. The first set of consumers ("treated") is affected by the merger, since their shopping options are reduced post-merger.

where K is an indicator variable for whether or not the lender is one of the merging institutions or one of its competitors. The coefficients of interest are θ_K, since these capture the merger effects.

The results suggest an interesting asymmetry. Consumers dealing with the merging bank saw a significant increase in rates post-merger—about 8.5 basis points—while consumers dealing with the competition saw rate decreases, by approximately 3.4 basis points.

The results suggest at least two channels of influence from the merger. The asymmetric price responses could be explained by a quality increase. If the merged bank provides higher-quality service (e.g., a larger network of branches and ATM machines), then, *ceteris paribus*, it can charge higher rates and still attract customers, while its competitors must offer larger discounts. An alternative interpretation of the price results (perhaps complementarily) is that banks in neighbourhoods that experienced a merger might be attracting a different mix of consumers. For instance, by exerting a larger degree of price control, the new entity might be less likely to attract consumers willing to shop intensively for their mortgages. This would explain the result that rates are higher at the merging bank and lower at the competing banks.

The asymmetric price effect of the merger suggests that the relationship between bankers and consumers is complicated. The merging banks are able to raise rates post-merger, extracting more from borrowers than pre-merger. Given that the mortgage is the largest purchase for most households, the costs of the merger are not negligible. These borrowers value more than the price of the mortgage, however, because they have the option of paying a lower rate at a competing lender in the same neighbourhood. Competition agencies may want to consider this possibility in analyzing any future mergers.

Conclusion

This article summarizes key research on the Canadian mortgage market currently being undertaken at the Bank of Canada in conjunction with external academics. Overall, the findings are consistent with a model where consumers have different preferences and skills when shopping and bargaining for a mortgage and where lenders maximize profits based on observing these preferences and skills. The results indicate that high-income borrowers pay more for their mortgages, as do loyal consumers, consumers who search less, and those that value large branch networks. Unobserved bargaining ability also appears to play an important role in determining mortgage rates.

Results also suggest that mortgage-rate discounting affects the speed and amount of pass-through of changes in the central bank's policy rate to mortgage rates. In particular, once discounting is taken into account, the major mortgage lenders in Canada are slower to cut rates than to increase them. This asymmetry has implications for monetary policy because it means that the actions of the central bank might need to be adjusted, depending on whether it is cutting or increasing interest rates. The reasons for the asymmetric responses of mortgage lenders should also be investigated.

Finally, this research suggests that bank mergers can lead to asymmetric effects on mortgage rates. The merging parties, because of market power, can increase rates, while the competition actually decreases rates in order to attract consumers. This result is non-standard in the industrial-organization literature where both sets of lenders would typically increase prices because of market power. Given the preference of consumers for factors other than low rates (e.g., branch-network size), however, the competitors actually decrease rates, because post-merger they are relatively smaller than the merging entities in terms of their branch network.

Together, these findings are important to the central bank and to competition authorities because of their impact on our understanding of the factors affecting competition and the monetary policy transmission mechanism.

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Adverse Selection and Financial Crises

Koralai Kirabaeva, Financial Markets Department

- *Adverse selection is an impediment to the efficient functioning of a market that arises when one of the parties to a transaction has more information than the other. In financial markets, adverse selection can lead to market freezes and liquidity hoarding, reflecting buyers' beliefs that most securities offered for sale are of low quality.*
- *Uncertainty about asset values, a flight to liquidity, and an underestimation of systemic risk can amplify the effect of adverse selection in a particular market and propagate its impact to the entire financial system.*
- *Government intervention can mitigate problems of adverse selection in financial markets. The effectiveness of policy responses depends on the cause of a market freeze.*

The stability of the financial system is one of the main concerns of central banks: as the recent global financial crisis illustrates, financial system disruptions can trigger a sharp contraction in economic activity, impair the transmission of monetary policy, and undermine the efficient allocation of capital. Continuously open financial markets are one essential feature of a resilient financial system (Carney 2010a). In the recent crisis, trading in several financial markets was dramatically reduced or stopped completely,[1] and those trades that did occur were executed at significant discounts. Such disruptions in market activity played a key role in transmitting and amplifying the financial crisis. The purpose of this article is to examine the role of adverse selection—a situation in which only low-quality products are available in the market because one party to a financial contract has better information than the other—in causing such market disruptions.[2]

Information asymmetries such as adverse selection are the basis of the prevalent explanations for market freezes. If buyers cannot assess an asset's quality, its market price will reflect the expected quality based on the quality of all the assets offered for sale in the market. This asymmetric information between buyers and sellers can generate adverse selection: as the price falls, sellers of high-quality assets withdraw from the market, leaving only low-quality assets (lemons) for sale. As a result, trading in the asset may diminish or halt altogether because buyers fear that if they transact they will be left with an overpriced asset (lemon). Moreover, such assets lose their ability to serve as collateral for other transactions, which contributes to the credit crunch. Adverse selection played an important role in the financial crisis of 2007–09 and in earlier crisis episodes.

1 For example, markets for collateralized debt obligations, asset-backed commercial paper, and repurchase agreements.

2 In his Nobel-prize-winning work, Akerlof (1970) uses the market for used cars as an example of adverse selection (when only bad cars—lemons— remain in the market) generated by asymmetric information about product quality between buyers and sellers. Since then, asymmetric information has been established as the potential cause of market breakdowns in many other cases.

This article explains how adverse selection in a particular market (such as the subprime-mortgage market) can lead to market freezes and liquidity hoarding and how it can be amplified into a severe crisis affecting many financial markets. Adverse selection is usually present even under normal economic conditions, but it does not significantly affect market liquidity. When the economy is in a crisis, however, adverse selection may lead to significant losses when market trading halts. This article describes several mechanisms that can significantly increase the initial (small) effect of adverse selection and propagate it to the entire financial system. While the problem of adverse selection can be reduced by government intervention, the appropriate policy response depends on the cause of a particular market freeze.

The article begins with a description of adverse selection and the problems it can create in financial markets. This is followed by a brief overview of the role of adverse selection in the financial crises in emerging economies during the 1990s and how the resulting capital imbalances contributed to the recent crisis. The next section focuses on the evidence of adverse selection and amplification mechanisms in the financial crisis of 2007–09. Finally, possible policy responses and their effectiveness are discussed.

Adverse Selection in Financial Markets

Information imperfections, such as asymmetric information, are important frictions in financial markets. Even in normal times, borrowers in credit markets often know more than lenders about the quality of the collateral and the riskiness of their investments. If high- and low-risk borrowers are indistinguishable ex-ante, then high-risk borrowers benefit at the expense of low-risk borrowers. The resulting problem of adverse selection (when high-quality borrowers choose not to participate in the market) leads to higher interest rates and a decrease in lending.

Adverse selection and financial instability

There are several channels, such as an increase in interest rates, deterioration of financial institutions' balance sheets, and maturity mismatch that can aggravate problems caused by adverse selection and lead to financial instability.

In the presence of asymmetric information, a small increase in the interest rate can lead to a large reduction in lending. A higher interest rate increases the likelihood that high-quality borrowers will withdraw from the market, aggravating the problem of adverse selection. As a result, the average quality of the borrowers falls, which in turn raises the interest rate even further. If adverse selection is severe enough, the credit market may collapse (Mishkin 1990). Adverse selection may cause banks to impose credit rationing—putting quantitative limits on lending to some borrowers. By limiting the supply of loans, banks reduce the average default risk and therefore alleviate adverse-selection problems (Stiglitz and Weiss 1981). Another way to reduce adverse selection is to require collateral for the loan (Mishkin 1990). With collateral, even if the borrower defaults, the lender can recover losses by selling the collateral. Therefore, the asymmetric information about the borrower's default probability becomes less important.

In the presence of asymmetric information, a small increase in the interest rate can lead to a large reduction in lending.

Many financial institutions tend to finance long-term investment with short-term debt. This maturity mismatch makes them vulnerable to economic shocks. Even a small shock may lead to a financial crisis, resulting in costly asset liquidation and a large decline in asset prices. If the financial system's potential short-term obligations exceed the liquidation value of its assets, the entire financial system may collapse (Chang and Velasco 2001). For example, almost all of the emerging-market countries that experienced financial crises in the 1990s had the combination of large short-term liabilities and illiquid long-term assets. The maturity mismatch of financial institution's balance sheets was also an important factor in the financial crisis of 2007–09 (Diamond and Rajan 2009; Brunnermeier 2009).

Even if there is no maturity mismatch, shocks that cause a deterioration in the balance sheets of financial institutions make the problem of adverse selection more severe by increasing credit risk. A negative shock to balance sheets causes banks to liquidate their assets, which lowers asset prices and further deteriorates balance sheets. This, in turn, amplifies the initial shock and further aggravates adverse selection (Brunnermeier 2009; Krishnamurthy 2010). This balance-sheet effect was an important factor in reinforcing and propagating adverse selection in most financial crises, including the crisis of 2007–09 and the earlier crises in emerging economies.

Financial crises in emerging markets

The causes of the recent financial crisis are similar to those underlying the financial crises in emerging economies in the late 1990s. Asymmetric information between domestic investors (borrowers) and foreign investors (lenders) can lead to adverse-selection problems in a country that finances its domestic investment and consumption through foreign debt or foreign equity.[3] These informational problems may exacerbate financial crises, resulting in large capital outflows and fire sales of domestic firms.[4]

Countries that have experienced financial crises in the past tend to have larger demand for aggregate holdings of safe (liquid) assets, which provide a cushion if a crisis does occur (Kirabaeva 2010). On the other hand, countries with little experience of financial crises tend to have smaller aggregate holdings of safe liquid assets relative to illiquid, risky, long-term investments. In these countries, when a financial crisis occurs, it is more severe and is more likely to be accompanied by market freezes. As a result, while capital flows into emerging-market countries are often volatile,[5] capital flows into the United States are more stable, driven by a search for safe instruments (Caballero and Krishnamurthy 2009).

Caballero and Krishnamurthy argue that one of the key contributors to the recent financial crisis was a *safe-assets imbalance*.[6] A global excess demand from foreign investors and central banks, as well as from domestic financial institutions, for safe U.S. debt instruments led to low real interest rates. The shortage of such assets provided the U.S. financial system with the incentive to produce new highly rated (safe) instruments, primarily by securitizing existing long-term, risky assets.[7] These securitized assets became a source of systemic fragility. Indeed, Acharya and Schnabl (2010) find empirical evidence that the geography of the recent crisis was determined by global banking flows, particularly by a country's exposure to the market for asset-backed securities.

The Financial Crisis of 2007–09

Adverse selection in the subprime-mortgage market led to market freezes and liquidity hoarding in the recent financial crisis. Increasing uncertainty about asset values, a flight to liquidity,[8] and an underestimation of systemic risk amplified the effect of adverse selection and propagated it to the entire financial system.

Adverse selection in securities markets and systemic risk

While banks have traditionally been the main providers of credit in the economy, the role of the "shadow" banking system in managing and diversifying risks has increased in recent years. The shadow banking system includes market-based financial institutions, such as investment banks, money-market mutual funds, and mortgage brokers. These institutions are the main players in securitization, which grew substantially in the past decade (Adrian and Shin 2009).

Securitization brought new information asymmetries to financial markets because the complexity of the instruments and their lack of transparency made it difficult for investors to evaluate securitized assets.[9] Structured products, such as collateralized debt obligations (CDOs), were created from diversified portfolios of mortgages and other types of assets, such as corporate bonds, credit cards, and auto loans. The pooled portfolios were sliced into different tranches that were prioritized based on how they would absorb losses from the underlying portfolio. The top tranches were constructed to receive a AAA rating. These tranches were the first to be paid out of the underlying cash flows and were widely considered to be safe, with a minimal risk of default. The most junior equity tranches (which became known as "toxic waste") were the last to be paid (Gorton 2008a).

Large holdings of securitized products increased the exposure of many financial institutions to systemic risk (i.e., the risk of market-wide instability such as market freezes) because of their skewed payoffs: they produced high returns in normal times but incurred substantial losses during the crisis. They were also

3 In Mexico in 1995, Russia in 1998, Brazil in 1999, and Argentina in 2001, the debt was owed mainly by governments; in Indonesia, Korea, and Thailand in 1997, it was owed primarily by private banks and firms. In all of these cases, the countries' vulnerabilities were exacerbated by currency mismatches: since assets are typically denominated in the domestic currency while debt is denominated in a foreign currency, an unanticipated depreciation or devaluation increases the value of debt. As a result, financial crises in emerging economies are usually accompanied by a currency crisis.

4 Acharya, Shin, and Yorulmazer (2007) and Kirabaeva (2009) show how adverse selection can explain the fire sale of direct investments during liquidity crises.

5 Capital flows that have equity-like features (e.g., foreign direct investment) are regarded as more stable and less prone to reversals, while debt flows, consisting of bank loans and bonds, are more volatile. Speculative and volatile capital flows are considered to be a source of *global imbalances* (massive and persistent current account deficits) and *sudden stops* (sudden reversals in net capital inflows).

6 Caballero and Krishnamurthy and Schembri, Santor, and Epstein (2009) argue that global current account imbalances caused the safe-assets imbalances, since emerging markets had limited ability to produce safe assets. However, during the crisis, the United States did not experience the feared sudden reversal in net capital inflows.

7 Securitization is the multi-stage process of turning cash flows from a pool of non-tradable (illiquid) assets into tradable debt instruments (Paligorova 2009).

8 A flight to liquidity occurs when investors sell what they perceive to be less-liquid or higher-risk investments and purchase more-liquid assets, such as U.S. Treasuries.

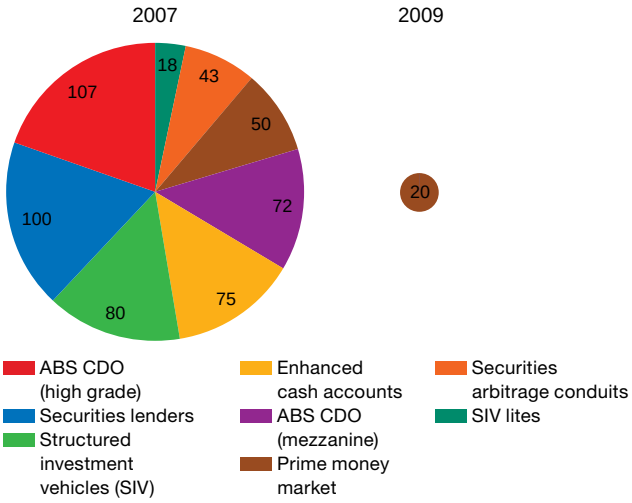
9 Gorton (2008a) and Ashcraft and Schuermann (2008) provide a detailed description of the stages of securitization and how asymmetric information problems were created in the process.

considered liquid: financial institutions believed that if they needed cash, they could sell these securities at a fair market price, because they were perceived to be safe and likely to yield a steady stream of payments. In 2007, defaults on subprime mortgages increased, and a large fraction of CDOs were downgraded.[10] The impact of declining house prices on the securities depended on the composition of assets and mortgages that backed them. The complexity of structured financial products and the heterogeneity of the underlying asset pool gave their issuers an informational advantage in evaluating them.[11] Because of this asymmetric information, buyers did not know whether securities were being sold because of their low quality or because of the seller's sudden need for liquidity.[12]

Securitization brought new information asymmetries to financial markets because the complexity of the instruments and their lack of transparency made it difficult for investors to evaluate securitized assets.

The resulting adverse selection led to market freezes, reflecting buyers' belief that most securities in the market were of low quality. For example, during the crisis, the demand for asset-backed securities (ABS) in the United States collapsed from over US$500 billion in 2007 to US$20 billion in 2009 **(Chart 1)**. The difficulty of evaluating these assets also resulted in a reduction in their ability to serve as collateral. Credit markets experienced considerable pressure: spreads widened significantly, and haircuts on collateral increased.[13] In particular, the haircut on ABS, which was 3 per cent to 5 per cent in August 2007, increased to 40 per cent to 50 per cent in August 2008 (Gorton and Metrick 2009). In Canada, the amount of asset-backed commercial paper outstanding fell from about $120 billion to about $30 billion.[14]

Chart 1: Demand for asset-backed securities
US$ billions



Source: Pozsar et al. (2010)

Market trading based on asymmetric information reduces the idiosyncratic risks of financial institutions, but it exacerbates systemic risk by increasing the likelihood of market freezes (Kirabaeva 2010). When the economy is in a normal state with strong fundamentals, asymmetric information does not significantly affect asset values. If the market is liquid, informed investors can gain from trading on private information at the expense of liquidity traders. But increased risk sharing often leads to increased risk taking by financial institutions, which may result in significant losses during a crisis when market trading halts. When the economy is subject to a negative shock, such as a decline in house prices, the value of these securities may become more sensitive to asymmetric information, and the resulting problems of adverse selection can cause market illiquidity. This supports the argument that the problem in the recent crisis was not only the lack of transparency in securitization, but also the sensitivity of the created securities to economic shocks (Holmström 2009; Stiglitz 2008).

Amplification mechanisms

How were the problems of adverse selection that originated in the subprime-mortgage market amplified and propagated to other financial markets? The market for subprime mortgages was relatively small, comprising only about 25 per cent of the outstanding amount in the US$6 trillion mortgage-backed securities (MBS) market and about 30 per cent of total non-agency MBS issuance in the years before the crisis (Gorton 2008b). Direct losses from household defaults

10 For example, 27 of the 30 tranches of asset-backed CDOs underwritten by Merrill Lynch in 2007 were downgraded from a rating of AAA to "junk" (Coval, Jurek, and Stafford 2009).

11 This problem was particularly pronounced for junior equity tranches, which were hard to value, since they were usually held by the issuing bank and were traded infrequently (Brunnermeier 2009).

12 Drucker and Mayer (2008) find that underwriters of prime mortgage-backed securities appeared to exploit access to better information when trading in the secondary market. Elul (2009) also finds evidence of adverse selection in the prime mortgage market.

13 A haircut is the percentage by which an asset's market value is reduced for the purpose of calculating the amount of overcollateralization of the repurchase agreement (Gorton and Metrick 2009).

14 The reduction includes a $33 billion restructuring into long-term assets by the Montreal Accord (Hendry, Lavoie, and Wilkins 2010).

on subprime mortgages are estimated to be about US$500 billion, but the subprime crisis triggered losses in the U.S. stock market that reached US$8 trillion in October 2008 (Brunnermeier 2009).[15]

In explaining the disproportionate effect of the subprime-mortgage crisis on the financial system, one can identify a number of amplification mechanisms that can significantly increase the initial impact of adverse selection: an increase in uncertainty about asset values, a flight to liquidity, and a misassessment of systemic risk.[16] Increasing uncertainty about asset values contributes to the decline in demand for these assets, while a flight to liquidity and an underestimation of systemic risk cause a shortage of liquid assets in the market.

Uncertainty about asset values

Rising defaults on subprime mortgages and a lack of historical evidence caused an increase in market uncertainty about the impact of economic shocks on the value of financial securities. Because of the complexity and opaqueness of securitization, the size and location of expected losses were not fully known (Gorton 2008a). As the safest AAA subprime tranches experienced losses, investors started to question the valuation of all securitized products. This caused a dramatic increase in uncertainty and investor panic in all financial markets, not only in the subprime market (Caballero 2010).

Unlike an increase in risk exposure, Knightian uncertainty[17] may cause investors to make decisions based on the worst possible outcome. In this case, the beliefs of market participants about the extent of adverse selection become crucial: if they believe that there may be too many low-quality assets in the market, then trading breaks down (Kirabaeva 2010).

The increase in uncertainty also made it harder to obtain accurate information about counterparty risk. As noted by Stiglitz (2008), "No bank knew what its own balance sheet looked like, let alone that of a bank to which it might lend." If market participants are uncertain about the exposure of other participants to legacy assets, they disengage from trade, which leads to asset fire sales and possibly market collapse. Moreover, when financial institutions are lenders and borrowers (or buyers and sellers) at the same time, gridlock can occur if they fail to cancel out offsetting positions because of perceived counterparty risk (Brunnermeier 2009).

If market participants are uncertain about the exposure of other participants to legacy assets, they disengage from trade, which leads to asset fire sales and possibly market collapse.

Flight to liquidity

The flight to liquidity that accompanies an initial economic shock can also amplify adverse selection into a severe financial crisis. The concept of liquidity can be divided into two categories: funding liquidity, the ease with which investors can obtain funding, and market liquidity, the ease with which an asset is traded (Brunnermeier and Pedersen 2009).

The higher preference for liquid assets during a crisis can be viewed as precautionary liquidity hoarding because of a tightening in funding liquidity. A higher preference for liquidity may alleviate the problem of adverse selection, since assets are more likely to be sold because the seller needs to raise liquidity rather than because of an asset's low quality. Nevertheless, a higher demand for liquid assets also implies a lower demand for illiquid assets. If the demand for illiquid assets is sufficiently low, then the asset's price will be determined by the liquidity available in the market rather than by the expected return on the asset (Allen and Gale 2004). Hence, an increase in liquidity preference can lead to fire-sale pricing and possibly to a market freeze.

Banks were exposed to market-liquidity risk through the maturity mismatch of their balance sheets: they financed long-term asset holdings with shorter-maturity debt. Because of the losses on their assets, some banks became undercapitalized; however, their attempts to recapitalize pushed the market price down further.[18] Such deleveraging can further aggravate adverse selection by lowering the average quality of

15 According to an estimate by Bloomberg, cumulative reported losses across financial institutions from the second quarter of 2007 to the second quarter of 2009 were about $1 trillion. These losses are expected to reach US$2.8 trillion from 2007–10.

16 Kirabaeva (2010) develops a theoretical model that illustrates how even a small amount of adverse selection in the asset market can lead to market freezes if it is accompanied by an increase in liquidity preferences, an underestimation of systemic risk, and uncertainty about the asset's value.

17 Knightian uncertainty refers to events with unknown probabilities. It is named after Frank Knight (1885–1972), who distinguished *risk* (events with objectively or subjectively known probabilities) and *uncertainty* (events where probabilities are unknown).

18 Brunnermeier and Pedersen (2009) explain this phenomenon, using a "loss spiral" and a "margin spiral." A "loss spiral" arises when a decline in the value of the assets of a leveraged financial institution erodes its capital and therefore limits its ability to borrow. The "margin spiral" reinforces the loss spiral: the financial institution has to sell even more assets to reduce its leverage ratio.

the assets in the market. As margins and haircuts increase, lenders become more selective in their choice of collateral, which further contributes to the credit crunch.[19]

Market beliefs about systemic risk

During the recent crisis, market participants underestimated systemic risk, which exacerbated the impact of adverse selection in financial markets. They underestimated the extent to which these risks were correlated and overestimated the benefits of diversification. The structured securities rated AAA (even if correctly rated) were riskier than similarly rated standalone bonds, since the correlation between these securities and a systemic event was much higher (Coval, Jurek, and Stafford 2009). Overly optimistic ratings from credit-rating agencies further contributed to the underestimation of systemic risk (Gorton 2008a).[20]

During the recent crisis, market participants underestimated systemic risk, which exacerbated the impact of adverse selection in financial markets.

Kirabaeva (2010) shows that adverse selection is likely to increase the severity of a crisis if systemic risk is underestimated. If crises are (or are believed to be) rare events, then financial institutions may not hold enough safe liquid assets to cushion the impact of a systemic shock when it occurs. Thus, an underestimation of systemic risk contributes to liquidity shortages, which can cause market freezes in the same way as a flight to liquidity.

19 Even financial institutions that were not exposed to maturity mismatch (such as life insurance companies and pension funds) were affected by declining asset prices. For example, changes in accounting standards have led to growing use of fair value accounting. As a result, the decline in asset prices reduced the value of assets on financial institutions' balance sheets and, hence, increased concerns about their capitalization and their ability to meet regulatory standards.

20 One reason that the default risks of the underlying securities were underestimated is that the statistical models used were based on historically low rates of mortgage default and delinquency. Another factor was the potential conflict of interest: investment banks (arrangers) paid the rating agencies to rate the securities that they created. Banks were able to choose the most favourable rating, since the rating agencies were consulted at the design stage about the requirements for a desired rating level.

Policy Implications

Market inefficiency

Financial markets are efficient if market prices already reflect all known information.[21] If there are information imperfections, however, a market equilibrium is not efficient, which implies that government policy could improve market efficiency.

In particular, the investment allocation is not efficient when financial markets are subject to two frictions: asymmetric information about exposure to systemic risk, and liquidity risk because of maturity mismatch (Kirabaeva 2010). In a market equilibrium, financial institutions overinvest in risky, illiquid assets (relative to efficient allocation), which potentially increases the severity of a crisis. Since asymmetric information reduces idiosyncratic risks, financial institutions invest more in risky assets. They do not take into account the effect of their investment choices on market liquidity, however, thereby creating systemic externalities. Because of adverse selection, more assets are offered for sale, particularly, more low-quality assets. Absorbing this asset trading requires more market liquidity. The systemic externalities provide a rationale for government intervention to alleviate a crisis and ex-ante regulation targeted to prevent market freezes.

The systemic externalities provide a rationale for government intervention to alleviate a crisis and ex-ante regulation targeted to prevent market freezes.

Policy responses during a crisis

The effectiveness of policy responses during crises depends on the cause of the market distortions. Kirabaeva (2010) demonstrates that if market freezes are caused by a shortage of liquid assets because of a flight to liquidity and an underestimation of systemic risk, then the provision of liquidity through open market operations can restore asset trading. However, if the breakdown of trade is the result of a large fraction of low-quality assets in the market or uncertainty about it, then liquidity provision is not efficient and leads to further liquidity hoarding.[22] In this case, it is

21 Bauer (2004) describes different concepts of market efficiency and its importance for policy-makers.

22 Bernanke (2008) notes that traditional liquidity provision was inadequate for addressing the strains in short-term funding markets. For example, despite massive liquidity injections by the Federal Reserve, many over-the-counter markets continued to experience liquidity problems.

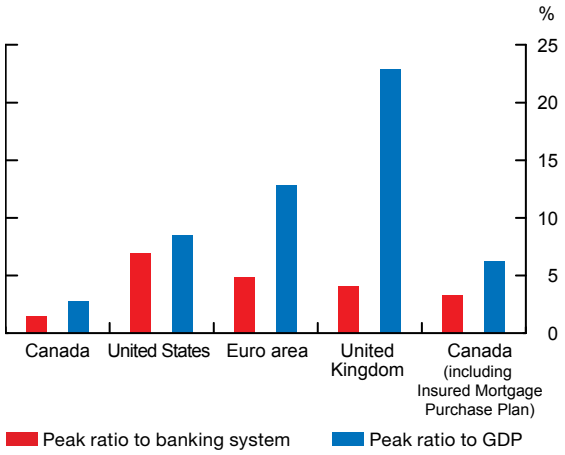
more effective to purchase legacy assets. Removing such assets from the market reduces adverse selection and uncertainty.

Troubled assets can also be removed by the direct injection of liquidity into financial institutions[23] and the creation of a "bad bank" (a closed-end fund to hold the toxic assets).[24] Governments can also introduce loan guarantees that reduce counterparty risks.[25] Even a government announcement about intended asset purchases at a later date can cause markets to function again (Chiu and Koeppl 2010).

During the recent crisis, central banks in advanced economies intervened on an unprecedented scale. Central banks typically provide liquidity in times of crisis through open market operations. As interest rates started to approach the zero bound, however, some central banks used unconventional measures, such as providing banks with liquidity on extraordinary terms and at longer maturities and intervening in selected credit markets to support liquidity in secondary markets (Hannoun 2010). **Chart 2** illustrates the total liquidity extended in advanced economies relative to GDP. As a result, central banks' balance sheets expanded significantly **(Chart 3)**. For example, the Federal Reserve's balance sheet exceeded 15 per cent of GDP in 2009, compared with 6 per cent of GDP in 2007 and 2008 (IMF International Financial Statistics). The Bank of Canada intervened to provide liquidity to financial institutions. It used traditional liquidity tools, such as the overnight rate, and developed new liquidity tools that included term purchase and resale agreements and a term loan facility (Zorn, Wilkins, and Engert 2009).

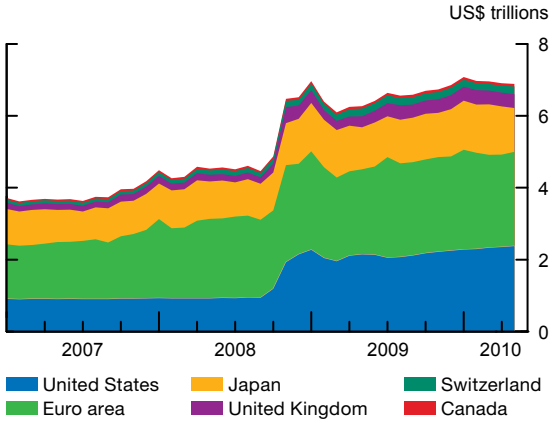
Government intervention during crises may create a moral hazard problem: if market participants anticipate such interventions, then their optimal holdings of risky assets are larger. Government bailouts (debt guarantees) can be inevitable during crises, and as a result, they lead to the inefficient allocation of capital towards risky investments.[26] The pre-emptive policy response is an ex-ante requirement for larger holdings of safe assets (e.g., capital requirements), which offsets systemic externalities and reduces the probability of market breakdowns during crises (Kirabaeva 2010). Raising the quantity and quality of the capital base, as well as improving balance sheet liquidity, are important regulatory requirements for strengthening the resiliency of financial institutions. The Bank of Canada also supports the idea of "contingent capital,"[27] which can reduce moral hazard and increase the efficiency of capital allocation (Carney 2010b).

Chart 2: Total extension of public sector liquidity



Notes: Liquidity extension refers to central banks' liquidity-provision operations, as well as foreign currency swaps with other central banks.
Source: Bank of Canada

Chart 3: Central bank balance sheets



Source: Hannoun (2010)

23 This is consistent with arguments about the effectiveness of the Troubled Asset Relief Program (TARP). TARP was originally established to buy "troubled assets" from financial institutions in order to restore their financial solvency. Ultimately, the funds (US$700 billion) were used for direct capital injections into financial institutions and for other purposes.

24 Holders of problematic ("toxic") assets sell them to the bank, which finances their purchase by issuing shares that entitle the owners to the cash flows generated by these securities. This helps banks improve their balance sheets and therefore their ability to raise private capital, since the toxic assets will no longer be a concern for lenders. One problem with this proposal is that bad assets cannot be removed from good banks without someone (i.e., the government) taking over the liabilities.

25 For example, Philippon and Skreta (2010) show that government guarantees of new debt issuance are preferable to injections of equity and asset buybacks.

26 Selody and Wilkins (2010) describe the principles established to mitigate the moral hazard that might have been associated with the Bank of Canada's extraordinary liquidity interventions.

27 Contingent capital allows a financial institution to convert debt instruments into equity when it needs to raise capital.

Concluding Remarks

The recent financial crisis has highlighted the importance of adverse selection as a contributing factor to financial market instability. Asymmetric information and adverse selection may prevent financial markets from functioning efficiently during a crisis. The possibility of such market disruptions provides a rationale for government intervention to alleviate financial crises and for ex-ante regulation to ensure the continuous functioning of financial markets.

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Payment Networks: A Review of Recent Research

James Chapman, Lana Embree, and Tom Roberts, Financial Stability Department; Nellie Zhang, Funds Management and Banking

- *Network analysis offers a new approach to understanding the complex relationships among participants in Canada's Large Value Transfer System (LVTS), the main system used for clearing and settling transactions between financial institutions.*
- *Network analysis can help payments-system supervisors to better understand the importance of individual participants in the system and the connections between them.*
- *Research using network analysis that takes account of the intensity of transactions between groups of LVTS participants suggests that there are two communities of participants in the LVTS: one consisting of the five major banks and another consisting of some smaller, more regionally focused participants that interact closely with one another.*

A stable and efficient financial system is a critical component of a well-functioning economy. It intermediates the flow of funds between savers and borrowers, and it helps to allocate risk to those best able to manage it. In assessing the risks and vulnerabilities of the financial system as a whole, it is important to understand the relationships among financial institutions, markets, and infrastructure (e.g., trading links, risk exposures, and payment relationships).

One of the central pieces of infrastructure in a well-developed financial system is its large-value or wholesale payments system used to process payments between financial institutions. Financial Institutions (FIs) transfer significant dollar amounts through these systems, as they process payments among themselves on behalf of their clients. Canada's wholesale payments system—the Large Value Transfer System (LVTS)—is a systemically important payments system. The rules and risk controls of this system insure that as payments pass the system's risk controls throughout the day, they are final and irrevocable.[1] The LVTS is a key infrastructure in the financial system because LVTS payments are used to complete important business transactions and to settle Canadian-dollar obligations arising from securities and foreign exchange transactions. Every business day, the LVTS successfully completes thousands of transactions worth billions of dollars. In 2008, the wholesale payments systems of the G-10 countries processed a total value of payments that was 62.2 times their GDP, on average; for Canada, this ratio was 28.7 times (BIS 2009).[2] Given the central role

1 Arjani and McVanel (2006) provide an overview of the structure of the LVTS and its relationship to the Canadian financial system.

2 A possible explanation for Canada's lower ratio of payments to GDP is that some large participants in the LVTS settle a significant amount of payments between clients across their own books, rather than with another participant through the LVTS.

of wholesale systems and the large volume of transactions settled through them, financial-stability policy making and oversight of systemically important infrastructure, in particular, can benefit from understanding the relationships that exist between participants in these systems.

A wholesale payments system, such as the LVTS, can be thought of as a complex network in which the relationships between its member FIs can be modelled using the tools of network analysis. Network analysis is an interdisciplinary field that has developed in the past decade (Vega-Redondo 2007). It examines the bilateral relationships in a given system of participants and then considers the overall effect that a given pattern of bilateral relationships can have on the system as a whole. The application of network analysis is relatively new to financial economics.

In this article, we review work done at the Bank of Canada and at other central banks that applies network analysis to data on payments systems.[3] These techniques give us a new approach to analyzing the systemic risks inherent in payments systems. Known as payment networks, this branch of network analysis focuses on payments systems and draws on techniques from monetary economics.

Modelling Payments Systems as Networks

Given its oversight responsibilities for designated payment, clearing, and settlement systems under the Payment, Clearing and Settlement Act (PCSA), the Bank of Canada has a strong interest in better understanding the behaviour of the LVTS and ensuring that it is well risk-proofed. A network approach provides a framework for understanding the complex interrelationships between participants in a payments system in a way that complements conventional economic modelling.

The payment-network approach to modelling is typically implemented as follows: a payments system is simplified into a set of nodes, where each node represents a participant in the system (e.g., a bank). The nodes form a network by being linked to each other according to key financial relationships. For example, the network approach could be used to model payments, securities trades, loans, or credit limits. The links that are modelled will depend on both the data available and the questions being addressed. Two possible areas of interest involve understanding how financial shocks or problems can spread from one institution to others (financial contagion) and measuring the systemic importance of different participants.

By identifying and studying the links between participating institutions, researchers can better understand whether the interconnected nature of payments-system participants increases or reduces the resiliency of the system to shocks.

Financial contagion can be better understood by examining how participants are connected as a network, because the links studied in network analysis can present avenues through which financial shocks could spread to other institutions. However, when applying network analysis, consideration must be given to the nature of the links being studied. For example, although some links can provide channels through which financial disruptions could spread among LVTS participants, other links can promote resiliency by dispersing risk among participants. By identifying and studying the links between participating institutions, researchers can better understand whether the interconnected nature of payments-system participants increases or reduces the resiliency of the system to shocks. This framework allows the overseer of the system to appropriately monitor or mitigate any potential risks.

Network analysis allows us to examine how participants are linked to one another. A network may be quite simple, where each institution transacts with only a few others and knows the risk exposures of its counterparties. It could, however, be quite complex, where the number and size of each institution's counterparties varies greatly. The complexity of the network itself can contribute to increased uncertainty (Haldane 2009; Caballero and Simsek 2010). For example, complexity can be a factor in market disruption because participants are uncertain regarding their counterparties' exposures to a troubled institution. A better understanding of the network of relationships (links) can help to reduce uncertainty in stress scenarios.

3 A related body of research takes a network approach to analyze the balance-sheet exposures of banks. See for example (Gauthier, Lehar, and Souissi 2010) or (Gauthier, He, and Souissi 2010).

Network analysis can also provide an alternative approach to assessing the systemic importance of particular participants in a payments system by identifying participants that might have a large impact on a system if they default or have some type of liquidity problem. This approach is useful, given that the effects on the payments system of operational, credit, or liquidity events at one participant would be a function of both the participant's size and its interconnectedness. Interconnectedness depends on the breadth and intensity of a participant's financial relations with other members of the payments system. A participant could be considered highly connected, and therefore important to the system, if it transacts with many participants or if its transactions represent large values (possibly with few participants). Network analysis can help to provide a more complete picture—beyond simple measures of value and volume of transactions—of a participant's role and importance in a system.

In summary, the network approach to payments systems provides a new conceptual framework to assess their vulnerabilities and risks. Research in this area, as well as the resulting tools, can complement existing approaches of conventional economic modelling or statistics.

Recent Research

Research into payments-system networks can be divided into two broad categories. The first category, network topology, seeks to describe the key features of a typical payment network. The second category, network characteristics, seeks to use these features, along with economic theory, to help uncover previously unknown and potentially important insights about the payment network.

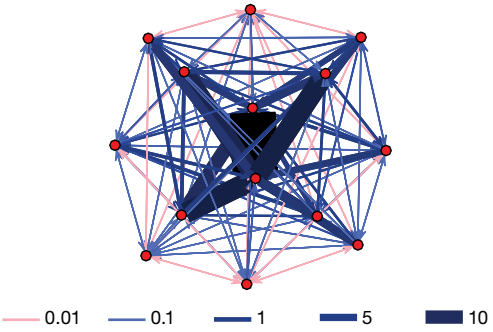
Network topology of the LVTS

The way in which a payment network is measured and understood is through its topology, which is the pattern (or layout) of the links between nodes. The topology of the network characterizes the structure and functions of complex networks and can assist in understanding how the structure of a network influences its stability, resiliency, and efficiency in the face of a disruption.

The seminal study of payment-network topologies is by Soramäki et al. (2007). In their paper, the authors describe the payment network composed of nodes that represent members of the Fedwire Funds Service, the wholesale system at the centre of the U.S. financial system, operated by the Federal Reserve, and links that represent the existence of a payment between two members. They show that this network displays the classical features of a complex network; that is, the number of links that originate with a given node follows a power-law distribution, where the network has a few nodes with many links and a large number of nodes with few links.[4] This hub-and-spoke-like structure of the network implies that the Fedwire system is resilient to a random outage but may be vulnerable to a shock that affects a strongly connected node.

Embree and Roberts (2009) provide a characterization of Canada's LVTS using a network-topology approach similar to that of Soramäki et al. They find that the LVTS is, in general, a highly connected network, with a small number of large participants at the centre. The finding that a small group of participants form the hub of a payments system is common to the network analyses of wholesale systems in many other countries. This structure can be seen in **Chart 1**, where nodes represent the 14 LVTS members, and links represent average daily payment flows during 2008. A discernibly small number of these banks are more strongly connected than other participants.

Chart 1: Average daily gross payment flows in the LVTS, 2008
Can$ billions



Source: Bank of Canada

Examination of how this tendency towards centralization in a hub evolves within an average day reveals that it is typically higher at the beginning and the end of the day than during the rest of the day. This suggests that during these two periods, certain participants may play a more significant role in the payment network than at other times of day.

4 A power-law distribution is a probability distribution that exhibits scale invariance: for a given ratio of two values in the distribution, the relative frequency of encountering the two values does not change. For example, with a power-law exponent of 2, a node of degree 6 is four times less frequent than a node of degree 3; a node of degree 10 is four times less frequent than a node of degree 5. Many man-made and natural phenomena exhibit this property (e.g., the ranking of cities by population).

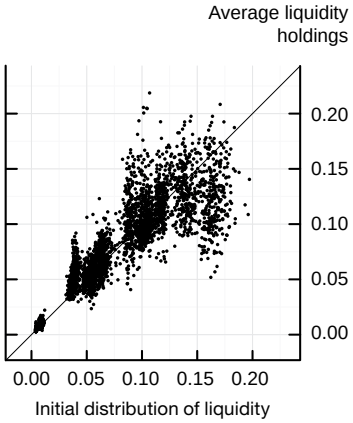
Characteristics revealed by the network structure of the LVTS

In addition to the work that characterizes the network topology of payments systems, a second fruitful avenue of research involves exploring the structure of the payment network to uncover characteristics that would not be apparent from simply focusing on the behaviour of an individual member of the payments system. Such characteristics may include identifying key participants for circulating liquidity in the system, as well as participants that are important for subgroups of system participants. This type of study depends on intimate knowledge of the institutional features of the payments system. Because of these information requirements and the recent development of this field, there are only a handful of published studies that fit into this category. These include two empirical Bank of Canada studies that use certain readily observable transaction linkages among the direct participants in the LVTS to uncover important payment behaviours and relationships that are hard to see by examining the behaviour of each participating FI in isolation.

In the first study, Bech, Chapman, and Garratt (2010) examine the implicit network structure defined by the bilateral credit limits (BCLs) among participants. They then develop a method of determining which participant is likely to hold the most liquidity at any point in time during the payment cycle.[5] The authors characterize this participant as being "central" to the system. A central participant plays an important role in ensuring that liquidity flows through the system and therefore that payment activity continues to function smoothly. This has important policy implications, since a well-functioning payments system requires that liquidity flow between participants in a timely manner to ensure prompt execution of payments across the system's participants, as well as their customers.

Chart 2 shows the relation between the initial and the average distribution of liquidity for all participants on all dates. Each point on the chart represents the initial and average share of an individual's liquidity on a given day in the sample. Points above the 45-degree line represent participants that held more liquidity throughout the day than at the beginning of the day; points below the 45-degree line are participants that held less liquidity during the day than at the beginning of the day. Since the majority of points do not lie on the 45-degree line, we can see that the distribution of liquidity throughout the day does not match the initial allocation. This is an important point, since a participant outage during the day can lead to difficulties for the system if that participant holds a large amount of system liquidity (McPhail and Senger 2002).

Chart 2: Initial versus average liquidity holdings



Source: Bank of Canada

Bech, Chapman, and Garratt go on to investigate the intraday dynamics of liquidity in the LVTS. Using empirical methods based on Markov chain theory, they estimate the unobservable payment speeds of LVTS participants by calculating an expected average distribution of liquidity (known as a "stationary distribution"). Their estimated payment speeds are obtained as follows. Given the model, Markov chain theory implies that for a given a set of payment speeds there is a unique stationary distribution. The authors then estimate the payment speeds by matching the stationary distribution to the observed average distribution of liquidity in the model.

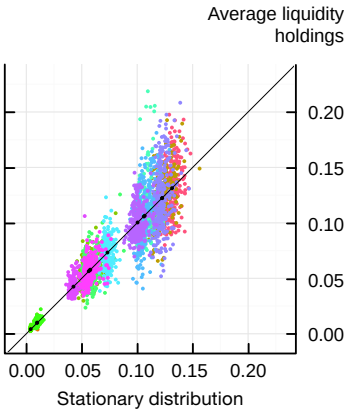
Their results show that there is a large degree of heterogeneity in payment speeds. In the most extreme case, one participant can be six times quicker in processing outgoing payments than another.

As illustrated by **Chart 3**, when the speed of payment processing is taken into account, the stationary distribution of liquidity holdings in the LVTS shows a closer match with the participants' average liquidity holdings. **Chart 3** is similar to **Chart 2**, with the exception that the horizontal axis now contains the expected stationary distribution instead of the historical initial distribution, and the liquidity holdings of individual participants (both average and stationary) are segregated by colour to show that there is a clear ranking of the amount of average liquidity held among participants.[6]

5 A measure of liquidity in the LVTS is defined in the **Box** on page 16.

6 Each colour represents all the daily observations of average and stationary liquidity for a given bank in the LVTS.

Chart 3: Stationary versus average liquidity holdings



Source: Bank of Canada

In the second Bank of Canada study, Chapman and Zhang (2010) use the network aspects of LVTS transactions data to examine various degrees of interconnectedness among the system's direct participants.[7] The researchers examine whether LVTS participants send payments to all other LVTS participants equally, or whether they form clusters of transaction relationships and then send relatively more payments to members of the same cluster. Knowledge of this partition can help to identify groups or clusters of closely connected participants. Identifying these clusters or partitions is important to understanding the impact of a participant outage on the entire system.

Identifying these clusters or partitions is important to understanding the impact of a participant outage on the entire system.

Chapman and Zhang use the model derived by Čopič, Jackson, and Kirman (2009) to estimate the most probable partitions of participants. This model uses the concept of "community" and assumes that participants that are members of the same community transact with each other relatively more intensely than with participants outside the community.

To measure this relative intensity, the model requires a measure of transaction intensity among LVTS participants, as well as a pair-wise maximum level of intensity (or capacity). These maximums are constructed for every combination of participants to serve as a benchmark for comparison with the actual observed payment flow. Chapman and Zhang use two measures of transaction intensity: (i) a "liquidity" measure that compares the average daily total value of payments sent from one participant to another against an estimate of the cyclical maximum liquidity available to the payment sender,[8] and (ii) an "averages" measure that compares a payment sender's outflow of bilateral transactions with its multilateral average.[9] This last measure effectively takes into account the fact that LVTS participants differ by orders of magnitude in the amount of payments they make.

Using these two measures, the authors find that the most likely partition of the LVTS network includes two larger communities that seem to be based on both transactions amount and geographic location. One community consists of the five major Canadian banks; the other is a smaller community of financial institutions that are more regionally focused and based in Montréal. These two communities are not easily discernible if one looks only at simpler metrics, such as bilateral payment flows. Uncovering such a network structure can have useful policy implications. For example, identifying clusters can contribute to a better understanding of the potential impact of problems experienced by a key member of a community, even if they are not one of the largest participants in the system.

Benefits and Limitations

Work on network centrality and clustering could be useful in helping to assess a participant's systemic importance in payments systems and in the financial system more generally. The simulated system-wide effect of removing a bank or combination of banks further illustrates this potential network aspect of a disruption. Even though the exact consequences of any particular bank failure are unknown in advance, the presence of significant network linkages between banks could exacerbate the problem. In these cases, a relative ranking of banks' centrality in the payments system could help prioritize the policy responses of financial regulators in the event of any future financial crisis.

Empirical research on the structure of financial systems suffers from a scarcity of data. Whereas

7 Direct participants are the financial institutions that are members of the LVTS.

8 It is estimated as the sum of the maximum amount of daily gross payment receipts and the maximum bilateral credit limit granted to the payment sender.

9 Under the "averages" measure, the observed interaction among pairs of participants is defined to be the number of days on which one participant's payment flow to the other exceeds the average payment flow to all system members.

Defining Liquidity in the LVTS

Bech, Chapman, and Garratt (2010) focus on the Tranche 2 payment stream in the LVTS.[1] They study Tranche 2 for two reasons. First, the majority of payments are executed in this Tranche of the LVTS.[2] Second, in Tranche 2, the amount and size of payments between any two pairs of participants are restricted by mutually agreed upon Bilateral Credit Limits (BCLs), as well as a multilateral Net Debit Cap for all Tranche 2 payments, known as T2NDC. A participant's T2NDC is a function of the BCLs granted to that participant.[3] These BCLs are backed by collateral posted by the system participants.

The usual definition of liquidity is the ability to make a trade or payment promptly. The authors therefore define the liquidity available to a participant in the system at any moment as the net payments that have been made to the participant, as well as their initial T2NDC. The latter can be thought of as liquidity since it is the maximum amount of payments that a participant can make unilaterally. Since the summation of all net payments in the system must equal zero at any moment, the sum of the T2NDCs may be thought of as the total amount of available liquidity in the system.

The authors calculate the initial share of this total available liquidity to which each participant has access at the start of a payment cycle as the ratio of each participant's T2NDC to the sum of T2NDCs. The authors then propose a measure for the observed average amount of liquidity that one participant holds during a payment cycle. This is defined as the total of two quantities: the time-weighted sum of the liquidity balance in Tranche 2, and the participant's T2NDC on that day. The first part of the quantity is the average net payments to an individual participant during the day, and the second is the initial amount of liquidity held by the individual participant. The distribution of such average liquidity holdings across all participants represents the average allocation of liquidity between participants in the LVTS.

1 The LVTS is composed of two payment streams: Tranche 1 and Tranche 2. The two streams differ primarily in terms of collateralization. Tranche 1 payments are fully collateralized by the sender and settle in real time on a gross basis like an RTGS system in many other countries, while Tranche 2 payments are partially collateralized by the sender and are also backed by a survivors-pay collateral pool and are settled at the end of the day on a net basis.

2 Tranche 1 payments are primarily payments between participants and the Bank of Canada. These are for transactions such as foreign exchange settlement.

3 This is a necessarily brief explanation of the institutional details of the LVTS system. Arjani and McVanel (2006) provide further information.

information regarding an institution's bilateral on- and off- balance-sheet exposures is not usually readily available, payments systems offer an opportunity to observe actual financial activity. But even with this payment information, such as LVTS data, a direct connection to a participant's underlying financial activity might be difficult to detect because of lack of information about payment rationale, or the amount of time between a payment request and the corresponding payment settlement. Nonetheless, innovative econometric techniques can complement network analysis by helping to interpret the economic significance of observed payments data.

Payments data typically reveal little about the financial linkages that involve indirect participants, and this is arguably an obstacle to our understanding of the financial system, as well as a challenge to determining the systemic importance of individual banks.[10] There have been some recent attempts to capture these indirect linkages. For example, Becher, Millard, and Soramäki (2008) use the 2003 CHAPS Traffic Survey by the Bank of England, which consists of a sample of CHAPS payments for five days in February 2003, including those of indirect participants.[11] The Banking Act 2009 in the United Kingdom has since legislated that the Bank of England can require the operators of interbank payments systems to provide it with information, including data on indirect clearers, as it deems necessary (Bank of England 2009). For its part, the Bank of Canada does not regularly collect data from Canadian payments systems apart from the LVTS. Further surveys or data access on financial

10 Indirect participants are smaller banks and deposit-taking institutions that are not direct members of the payments system and that, instead, rely on direct participants to execute payments on their behalf.

11 The Clearing House Automated Payments System (CHAPS) is the United Kingdom's wholesale system.

exposures or payments in Canada would be beneficial for understanding the structure of the Canadian financial system.

Conclusion

Network analysis is a relatively new method of analyzing financial systems. This approach allows researchers to study the operation of the payments system as a whole, rather than at the participant level. For example, recent work on the LVTS has uncovered a couple of communities within the payments system and has provided new ways to evaluate the systemic importance of participants. This type of information significantly enhances the ability of financial-stability policy-makers and payments-system overseers to analyze issues that might affect the payments system as a whole. While not the focus of this article, network analysis can also be used in the context of the financial system more broadly, to understand liquidity and contagion (Cifuentes, Ferrucci, and Shin 2005; Gauthier, He, and Souissi 2010; Gauthier, Lehar, and Souissi 2010).

The main limitation to this work is the lack of available data from which to make high-quality inferences about network structures. One consequence of the ongoing reforms to the international financial system is an increasing interest in and collection of the types of data needed for the effective modelling of payments systems and financial networks.

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Conference Summary: Financial Globalization and Financial Instability

Scott Hendry, Financial Markets Department[*]

- *The Bank of Canada's annual conference, held in October 2010, brought together leading researchers from universities and central banks around the world to discuss the issue of* Financial Globalization and Financial Instability. *The conference covered such topics as the effects of financial globalization on risk, liquidity, and asset prices, the causes of crises and their effects, and appropriate regulatory responses.*

The trend over the past few decades has been towards greater financial globalization. In other words, the ties between the economies of different countries have grown stronger over time as markets for goods and services, as well as those for financial assets, have been liberalized to greater trade. Cross-border financial flows have increased tremendously, bringing with them benefits in terms of growth from new investment and export opportunities, as well as potential costs in terms of increased uncertainty, financial market volatility, and possibly even a greater probability and size of crises. The characteristics and size of the overall net benefits from this process are still the subject of much debate.

The conference was divided into six sessions plus a keynote address and a panel discussion. The remainder of this article briefly summarizes these papers and discussions.

Session 1: Financial Globalization and Risk

There has been strong trend growth in cross-border financial flows among industrial economies and between industrial and emerging-market economies. At the same time, economists have been debating the benefits and costs of such financial globalization. Some economists believe that unfettered capital flows pose a serious impediment to global financial stability. Others argue that increased openness to capital flows has proven essential for economic growth and for the development of financial markets in emerging-market economies, while significantly enhancing stability among industrialized countries. The two papers in this session further advance this debate.

Charles A. Trzcinka and Andrey D. Ukhov (Indiana University) examine both the costs and benefits associated with financial globalization and risk sharing.

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They develop a new modelling approach that allows heterogeneous agents to endogenously choose whether to participate in financial markets. The paper studies the welfare effects of opening markets to foreigners, using a framework that models the opposing economic forces that affect decision making in an economy as it is opened to foreign investment. As is the case with other research on asset pricing in a multicountry model, it demonstrates that financial globalization generally reduces a country's cost of capital. In contrast to previous models, however, motives to trade and participate are endogenous, and the authors are able to compute the change in welfare of the domestic agents. The model shows that the decision to open markets affects risk-sharing arrangements in the economy and asset prices, as well as the welfare of agents. The removal of barriers changes the distribution across different types of investors, causing prices and the cost of capital to change. It may also make it more expensive for some domestic agents to participate in the risk-sharing offered by risky domestic assets and will lead to a decrease in their welfare. Contrary to previous models, their model shows that opening markets is not Pareto optimal: the welfare of certain domestic agents, particularly demanders of risky assets, may be lower after the opening of markets.

The findings have political-economy interpretations and policy implications. Investment barriers may enhance a country's welfare, and the decision to maintain such barriers may be an endogenous, rational economic decision and not the result of agency costs or political failure. The argument for liberalization may be refined by identifying the set of agents who find risk sharing attractive after markets are opened. The timing of liberalization is not random, and it depends on endowments, prices, and risk exposure. The model also provides a rational explanation for the historical evidence of liberalization and the reversals of liberalization found by previous studies.

Gianni De Nicolò (International Monetary Fund) and **Luciana Juvenal** (Federal Reserve Bank of St. Louis) use data for a large number of advanced and emerging-market economies from 1985 to 2009 to investigate the real effects of financial integration on economic growth. First, the authors document the dynamics of financial integration. Strong evidence is given of a declining trend in the cross-country dispersion of equity premiums, which indicates increased integration in international financial markets. This result is driven primarily by increases in the financial integration of emerging economies. Second, the authors investigate the relation between financial integration and economic growth. New measures are constructed for the level of financial integration and "risk-adjusted" growth opportunities. The measure of financial integration is given by the difference between a country's equity premium and that of the group average at each date. The measure of "risk-adjusted" growth opportunities is a Sharpe ratio-type measure[1] of the market price-to-earnings (PE) ratio relative to the global PE ratio. The paper tests whether financial integration predicts "risk-adjusted" growth opportunities, as well as the converse, both at the global and regional levels with monthly data. Increases in financial integration are found to robustly and significantly predict better growth opportunities, while "risk-adjusted" growth opportunities do not necessarily predict advances in financial integration.

The authors also examine the predictive impact of financial integration on actual growth and on a proxy of growth volatility, using annual data. They find that advances in financial integration predict higher growth, lower growth volatility, and lower probabilities of systemic real risk for equity markets. Three indirect channels through which financial integration may foster economic growth are explored. Financial integration is found to foster domestic financial development and the liquidity of equity markets. Finally, they find that better-quality institutions and corporate governance are associated with higher levels of financial integration. Each of these effects promotes economic growth over the long term.

Session 2: Liquidity

Liquidity in financial markets is important for the stability and efficiency of the financial system. Sudden and extreme shifts in market liquidity may create a channel through which contagion can grow and propagate systemic risk throughout the economy. The two papers in this section analyze the contributing role of liquidity shocks to financial fragility.

Maya Eden (MIT) studies how financial integration between emerging and developed economies affects the global distribution of output volatility. She presents a model that explains why shocks to external funding are an important source of crises in emerging markets but are typically irrelevant in developed countries. The paper proposes a novel link, based on the interaction between financial distortions and the process of

1 The Sharpe ratio compares a portfolio's return to a risk-free return, and then scales the result by the variance of the portfolio's return. The higher the Sharpe ratio, the better is the portfolio's return, given the amount of risk taken.

financial integration, to explain the interdependencies between the vulnerability of emerging economies to shocks to external funding and the moderation of liquidity-driven fluctuations in output in the developed world prior to the recent crisis. The model also generates volatility patterns that are consistent with the amplification of the subprime-mortgage crisis. In particular, it suggests that financial integration between developed and emerging economies may have led to endogenous structural changes in the financial system that set the stage for the crisis. These structural changes include the loosening of lending standards, increased securitization, and increased reliance on securitized products in banks' balance sheets.

Koralai Kirabaeva (Bank of Canada) studies the interaction between adverse selection, liquidity risk, and beliefs about systemic risk in determining market liquidity, asset prices, and welfare. The paper characterizes the portfolio choices of financial institutions between safe and risky assets when systemic risk is anticipated, and examines how investors' beliefs may contribute to market freezes. In the presence of information and liquidity frictions, financial institutions do not fully internalize the impacts of their actions on market liquidity and overinvest in risky, illiquid assets, which creates systemic externalities. The paper illustrates how even a small amount of adverse selection in the asset market can lead to fire-sale pricing and, possibly, to a market breakdown if it is accompanied by a flight to liquidity, an underestimation of systemic risk, or uncertainty about asset values. The paper further explores the effectiveness of possible policy responses, such as liquidity provision and purchases of low-quality assets, as well as an ex-ante requirement of larger liquidity holdings.

Session 3: Securitization and Capital Flows

Volatile capital inflows played an important role in aggravating the recent financial crises. The two papers in this section examine how such capital inflows affected housing markets and yields on U.S. Treasury bonds.

Filipa Sá (University of Cambridge), **Pascal Towbin** (Banque de France), and **Tomasz Wieladek** (Bank of England) examine the effects of capital inflows, monetary policy, and financial innovation on housing market activity. The study is motivated by recent discussions on how these factors affect housing markets.

One argument highlighted in the paper is that expansionary monetary policy has kept interest rates low, which has fuelled the demand for housing. Others attribute the growth in the housing market to global imbalances—countries with excessive savings and underdeveloped capital markets invest in countries with developed capital markets and thus depress the price of credit in the latter. It is also believed that interest rate changes have a much stronger impact on housing activity in countries with high consumer leverage and active securitized markets.

Using data for 18 OECD countries from 1984 to 2007, the study offers several results. Capital inflows and monetary policy shocks have a significant positive effect on real credit to the private sector, real house prices, and residential investment. These housing variables are more sensitive to shocks in countries with a developed mortgage market. The authors reason that in these countries, households can pledge a larger fraction of their house's value as collateral and increase their leverage, which makes them more sensitive to changes in the value of that collateral. Another finding is that the response of housing activity to capital inflows is larger and lasts longer in countries with developed mortgage markets.

The results provide input to the debate on global imbalances as a contributing factor to the crisis. Capital inflows to countries with developed mortgage markets expose their housing sector to capital-inflow shocks.

Carol Bertaut, **Laurie Pounder DeMarco**, **Steve Kamin**, and **Ralph Tryon** (Board of Governors of the Federal Reserve System) study the role played by inflows of international capital to the United States in the financial crisis. The authors document that foreign flows into corporate debt—including asset-backed securities (ABS)—were as large as those into U.S. Treasury bills and U.S. Agency securities. Inflows from Emerging Asia and the Middle East were primarily in the form of U.S. Treasuries and Agencies, while inflows from Europe were in the form of corporate debt and ABS. The non-European countries financed their investments through current account surpluses, while the European countries expanded their external liabilities.

The paper argues that global investors in U.S. Treasuries pushed down yields on safe assets to such an extent that the appetite for riskier assets in general, and for subprime mortgages in particular, was greatly increased. On the other hand, foreign investors' demand for risky assets contributed to the decline in the interest rates on ABS relative to those on safe

assets. Furthermore, it led to an increase in the supply of ABS, thereby directly increasing the flow of resources to subprime and other risky borrowers.

Using a calibrated portfolio-balance model, the authors show that inflows from non-European countries suppressed the yields on U.S. Treasury bills. Foreign purchases of ABS, mainly by European investors, pushed down the yield spreads on the mortgages underlying these securities.

Session 4: Regulatory Responses

Historical evidence proves that financial systems are prone to periods of instability. The global financial crisis that began in mid-2007 has highlighted the ongoing debate about designing new and more effective financial regulation and supervision. The two papers in this session examine optimal regulatory policies in order to prevent future crises.

Javier Bianchi (University of Maryland) and **Enrique G. Mendoza** (University of Maryland and NBER) examine overborrowing[2] and financial crises in an equilibrium model with collateral constraints. The authors focus on the comparison of the allocations and welfare attained by private agents facing collateral constraints in a decentralized competitive equilibrium with those attained by a social planner subject to the same constraints. The private agents take the price of their collateral assets as given. As a result, a "credit externality" arises because they do not internalize the effects of their individual borrowing plans on the market price of collateral and on the wage costs relevant for working capital. On the other hand, the constrained social planner internalizes these effects and takes into account how current borrowing choices affect future asset prices and wages.

Although the credit externality results in only a small overborrowing compared with the constrained-efficient allocations of the social planner, it produces financial crises that are significantly more severe and more frequent than in the constrained-efficient equilibrium, and produces higher variability in the business cycle in the long run. The credit externality also produces excess returns on assets, Sharpe ratios, and market prices of risk that are much larger than in the constrained-efficient equilibrium. The authors suggest the introduction of an optimal schedule of state-contingent taxes on debt and dividends. In other words, the policy implication of their model is a tax on debt and dividends that should be higher in bad times, i.e., when the economy is building up leverage and becoming vulnerable to a financial crisis, but before a crisis actually occurs, and lower in good times. This is to induce private agents to value the accumulation of savings more than they do in the competitive equilibrium without taxes.

The second paper in this session by **Alan D. Morrison** (University of Oxford and CEPR) and **Lucy White** (Harvard Business School and CEPR) sheds light on the optimal regulation of the financial system by a *common* regulator in order to reduce the risk of interbank contagion. The authors demonstrate that the reputation of the common regulator can be a cause of financial contagion, and, therefore, it may be socially desirable that regulators engage in ex post "reputation management." Such management can be achieved through private or public policies, depending on the regulator's initial reputation.

In their model, the failure of one bank can undermine the public's confidence in the competence of the banking regulator and, hence, in other banks chartered by the same regulator. Thus, depositors may withdraw funds from the other banks, even when the returns on the assets in which those banks invest are uncorrelated and there is no interbank lending. Under these panic circumstances, it can be optimal for the regulator to exercise forbearance privately towards a failing bank in order to conserve its own reputation and hope that the bank—and, hence, other vulnerable banks—survives. In contrast, public bailouts are ineffective in preventing panics because they do not conserve the regulator's reputation ex post. Therefore, when forbearance is public, it may need to be supplemented by additional and costly measures, such as increased deposit insurance. Whether transparency or privacy is optimal ex ante depends on the regulator's initial reputation and the likely size of shocks to its reputation. Regulatory transparency improves confidence ex ante but impedes the regulator's ability to stem panics ex post. Hence, privacy and discretion may be socially preferable for regulators with strong reputations; however, transparency is essential if the regulator's reputation is initially very poor.

2 Overborrowing is defined as the difference between the amount of credit that an agent obtains acting individually in an environment with a given set of credit frictions, and the amount obtained by a social planner who faces the same frictions but internalizes the general-equilibrium effects of its borrowing decisions.

Session 5: Crises and Expected Returns

The global 2007–09 crisis has provided a clear illustration for the existence of "economic disasters" and the impact of such rare events on the returns obtained by international investors. Along these lines, Barro (2006) finds that, despite being low-probability events, such economic disasters can have a large impact on expected returns and can even explain asset-pricing puzzles, such as the equity premium. The papers in this session address whether the risks of global economic disaster can also explain international asset-pricing puzzles, such as uncovered interest rate parity.

François Gourio (Boston University), **Michael Siemer** (Boston University), and **Adrien Verdelhan** (MIT) develop a rich two-country model of the real business cycle with a small, yet time-varying, risk of a global economic disaster (i.e., a large drop in global consumption) and where countries differ in their exposure to this global risk. The authors find that changes in the probability of a worldwide disaster lead not only to variations in risk premiums, but also induce variability in macroeconomic quantities. In particular, as the probability of a disaster increases, investment becomes less attractive, and thus investment and output fall. On the other hand, demand for precautionary savings increases, leading to a drop in the interest rates on risk-free assets, while yield spreads on risky assets increase. For this reason, capital is pulled out of the riskier country, which experiences the largest recession, as investors seek safety. The model also rationalizes the risk premium on carry trade because, in their setup, the currency with high interest rates depreciates when global risk increases.

Alexandre Jeanneret (HEC Montréal) develops and calibrates to U.S. data a two-country general-equilibrium model with international trade, where the default decisions of firms and governments are endogenous. In his model, a negative economic shock in the foreign country deteriorates the fiscal position of the foreign government and increases the risk of a sovereign default abroad and of a contraction in economic growth in the domestic country. Thus, an increase in sovereign risk reduces the expected value of future export revenues for U.S. firms through a depreciation of the terms of trade and triggers an incentive for portfolio rebalancing towards the risk-free bond, thus depressing equity prices in both countries. The risk of a contraction in economic growth abroad amplifies, through these two channels, the initial fall in the equity values of U.S. firms and thus the rise in volatility of equity returns in the United States.

Session 6: Global Imbalances and Asset-Price Dynamics

Global imbalances have been cited as a possible cause of the recent financial crisis, since it is believed that they may have contributed to the decrease in interest rates that, in turn, increased the risk-taking behaviour of market participants. However, empirical evidence of a significant impact on the prices of domestic assets from foreign purchases of net assets is still inconclusive. On the other hand, it is also possible that changes in asset prices may have led to capital movements; in fact, at the aggregate level, a country's net foreign asset position necessarily embeds expectations about future asset prices. The papers in this session attempt to shed some light on the causal relationship between asset prices and international capital flows.

Jesus Sierra (Bank of Canada) studies the impact of international capital flows on interest rates through risk premiums. Interest rates contain two components: expectations of future short-term rates and expected excess returns (risk premiums). Given that the central bank does not set its policy rate in response to foreign purchases of long-term bonds, any impact of capital flows on interest rates must take place through risk premiums. If we assume rational expectations, this suggests that the impact of capital flows on asset prices could be measured by calculating the correlation between future realized excess returns and current flows. Inflows of funds by foreign official institutions have a negative and non-linear impact on risk premiums and thus appear similar to relative supply shocks, while private net purchases, with a positive and linear effect, absorb excess supply and are thus compensated in equilibrium for this service. The results do not support the view that international capital flows were among the main drivers of the decrease in long-term U.S. rates from 1994 to 2007.

In the second paper in this session, **Martin D. D. Evans** and **Alberto Fuertes** (Georgetown University) examine the channels through which the net external asset position of the United States deteriorated over the past 35 years. They find that most of the quarter-by-quarter changes in the U.S. external position between 1973 and 2008 are due to news (shocks) about future returns and trade flows, with news about future returns dominating news about future trade flows. Over long horizons, however, the changes reflect prior expectations about how the United States would meet its international financial obligations. Their results suggest that only through *both* favourable

changes in return differentials and future trade surpluses will the United States be able to return to an external balance and that this process could take over 13 years and involve a significant real depreciation of the dollar.

John Kuszczak Memorial Lecture

Eswar Prasad (Cornell University and Brookings Institution) delivered the conference's keynote speech. He discussed how globalization created channels for the cross-country spillover of shocks, and examined the implications and future prospects of global imbalances. The speech covered lessons and challenges for monetary policy in an integrated world economy with open capital accounts. In particular, he discussed the scope of a central bank's objectives, including whether and how asset prices might be incorporated into the monetary policy framework, and what the optimal degree of central bank independence is. Some potential research topics arising from these issues were also outlined. For example, he called for further exploration of the connections between price stability and financial stability, and for the development of more robust monetary policy frameworks that address challenges faced by emerging markets in the post-crisis world.

Panel Discussion: Whither Financial Globalization?

The conference concluded with a discussion of the future prospects for financial globalization by a panel consisting of **Timothy Lane** (Bank of Canada), **Stanley Zin** (New York University), and **Martin Evans** (Georgetown University).

Timothy Lane led off the discussion with a brief review of some of the costs and benefits of financial globalization and of recent financial crises that have hit the global economy. In advanced economies, financial globalization was not seen as a real problem until recently, and the probability of a crisis was thought to be remote. There was a much larger concern that financial globalization could cause problems in emerging-market economies by making macroeconomic management much more difficult. In the wake of the Asian crisis, there was only weak evidence that liberalization was good for growth. The most recent global financial crisis largely reflected a combination of macroeconomic imbalances, a search for yield, and pervasive weaknesses in the financial systems of many countries. In the wake of the crisis, some are arguing that global capital flows should be limited, but international efforts are instead focused on making the global financial system more robust. Financial reform is under way on capital regulation, infrastructure, resolution policies, and system-wide prudential policies. These efforts need to promote information sharing in the regulation of globalized financial institutions and to monitor the risks possible from regulatory arbitrage. There is a risk that regulation could become a source of financial protectionism going forward, but international efforts are under way to counter this risk and allow globalization to promote growth.

Stanley Zin expressed the belief that the trend towards financial globalization will continue strongly into the future and will not be derailed by any regulatory changes because the underlying forces promoting it are simply too strong. One of the most important driving factors that he cited was demographic imbalances (e.g., an aging population and global population distribution). Financial assets are designed to move capital across time, space, and generations, all of which will support financial flows going forward. Zin then went on to discuss some ideas on how we should structure global financial markets. He argued there is a strong need for international coordination of regulatory initiatives and that there should be a preference for rules versus discretion in the design of policy. Rules are more appropriate for keeping regulators from being co-opted by business and for maintaining a stable environment. Solid regulation should be built and then maintained so that, going forward, decisions can be made with more certainty with respect to the financial environment.

Martin Evans also expressed the opinion that financial globalization will continue unabated because of strong underlying drivers, such as demographic trends, continuing advancements in telecommunications, and the difficulty in coordinating international regulatory efforts (which creates large opportunities for regulatory arbitrage). He went on to discuss some of the gaps in our knowledge that need to be addressed by researchers. For example, he called for extensive work on the links between the fields of finance and macroeconomics. Our macroeconomic models need to incorporate more detail on how financial markets function, the roles of market-makers and heterogeneous agents, and the nature of information problems. This combination of macroeconomic and financial factors is required for the design of optimal regulatory policy.

Literature Cited and List of Conference Papers

The conference papers cited in this article are also available on the Bank's website at <http://www.bankofcanada.ca/en/conference_papers/economic_conference2010/papers.html>.

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Speeches and Statements by the Governor

Bank of Canada Banking and Financial Statistics (monthly)*

Weekly Financial Statistics (published each Friday)*

Renewal of the Inflation-Control Target: Background Information

Annual Report

A History of the Canadian Dollar
James Powell (available at Can$8 plus GST and PST, where applicable) (2005)

By All Accounts: Outside Perspectives on the Bank of Canada**
A portrait of the Bank from the perspective of outside observers, showing how Canadians have perceived the performance of their central bank over the decades through the eyes of those who monitor its work on the public's behalf. (2010)

Beads to Bytes: Canada's National Currency Collection**
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To celebrate the Bank's 70th anniversary, this book depicts the history of the Bank from 1935. (2005)

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James F. Dingle (June 2003)

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