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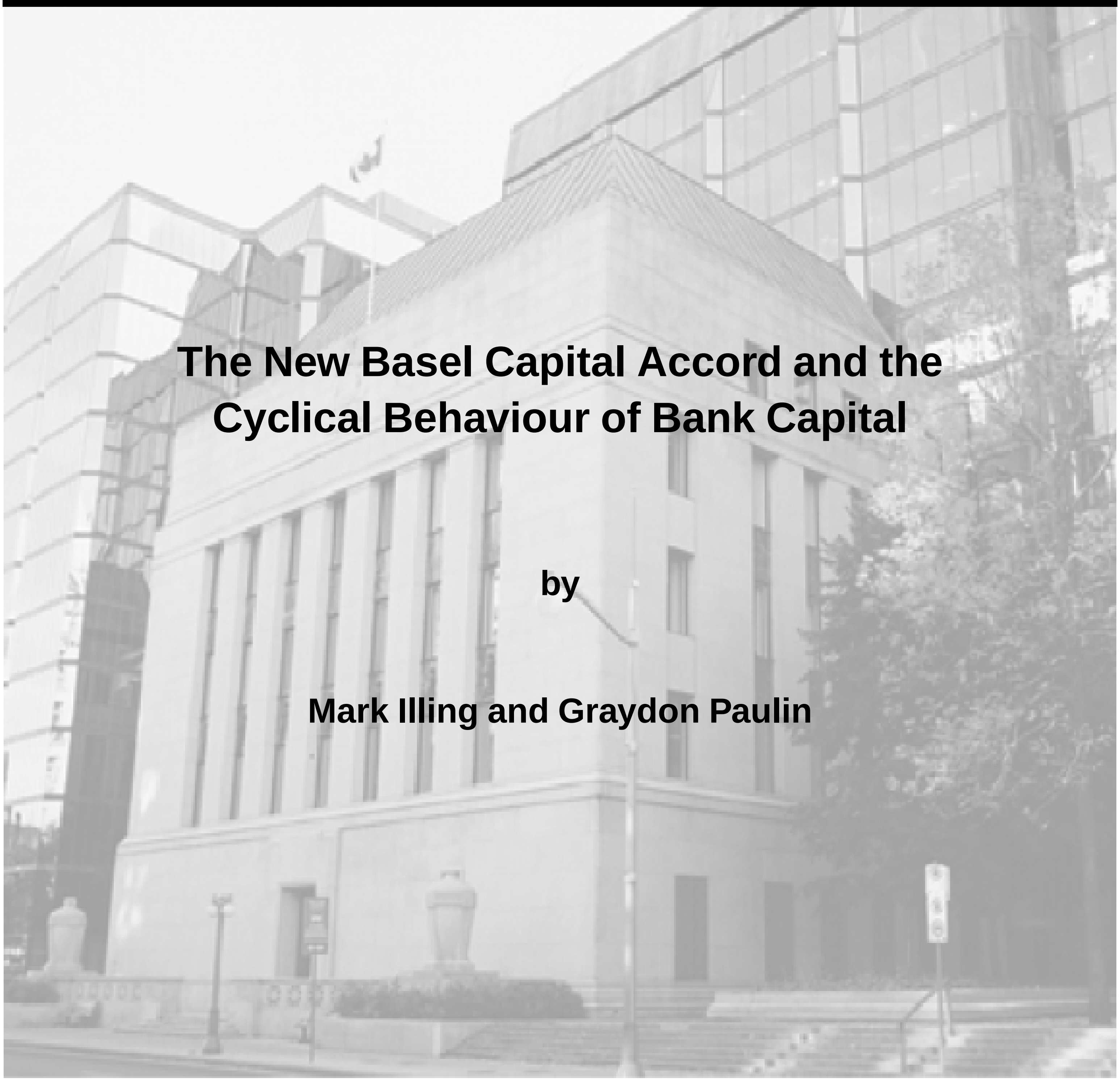

The New Basel Capital Accord and the Cyclical Behaviour of Bank Capital

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Abstract

The authors conduct a counterfactual simulation of the proposed rules under the new Basel Capital Accord (Basel II), including the revised treatment of expected and unexpected credit losses proposed by the Basel Committee in October 2003. When the authors apply the simulation to Canadian banking system data over the period 1984–2003, they find that capital requirements for banks will likely fall in absolute terms even after allowing for the new operational risk charge (bearing in mind that the induced behavioural response of banks to the changed incentives under Basel II is not captured). The impact on the volatility of required bank capital is less clear. It will depend importantly on the credit quality distribution of banks' loan portfolios and on the precise way in which they calculate expected and unexpected losses.

Sensitivity analysis, including that based on a range of hypothetical distributions for banks' loan portfolios, shows the potential for a substantial increase in implied volatility. Moreover, if historical relationships are a good indicator of the future, changes in required capital and provisions for commercial and industrial, interbank, and sovereign exposures will likely be countercyclical under Basel II (i.e., capital requirements will increase during recessions). This raises questions about the new accord's potentially procyclical impact on banks' lending behaviour, and the resultant macroeconomic implications.

JEL classification: G21, G28, K23
Bank classification: Financial institutions

Résumé

Les auteurs procèdent à une simulation contrefactuelle de l'incidence des règles proposées par le Nouvel accord de Bâle sur les fonds propres (Bâle II), et notamment des modifications que le Comité de Bâle a soumises en octobre 2003 pour le traitement des pertes anticipées et inattendues. Pour la période de 1984 à 2003, les résultats obtenus à partir des données disponibles sur le système bancaire canadien indiquent que le niveau des fonds propres exigés pour les banques tendrait globalement à diminuer, même lorsqu'on intègre le nouveau coût lié à la prise en compte des risques opérationnels. Il faut savoir cependant que les changements que susciteraient les nouvelles incitations créées par Bâle II dans le comportement des banques ne sont pas modélisés ici. L'effet de ces propositions sur la volatilité des fonds propres réglementaires est moins clair. Il dépendra largement de la structure des portefeuilles de prêts (définie du point de vue de la répartition par notation) et de la méthode que les banques utilisent pour calculer leurs pertes anticipées et inattendues.

L’analyse de sensibilité, basée en particulier sur une série de structures hypothétiques de portefeuilles de prêts, montre que les dispositions de Bâle II pourraient accentuer nettement la volatilité des exigences en fonds propres. Qui plus est, si les liens dégagés par le passé permettent d’augurer de l’avenir, il faut s’attendre à ce que les changements prescrits par Bâle II, en ce qui concerne les fonds propres et les provisions exigés pour couvrir les risques associés aux créances sur les entreprises, aux opérations interbancaires et au crédit souverain, soient de nature contracyclique (ainsi, les fonds propres réglementaires augmenteront en période de récession). Ces observations amènent à s’interroger sur la possibilité que le nouvel accord accroisse la procyclicité de l’offre de crédit bancaire et sur les répercussions macroéconomiques qui en découleraient.

Classification JEL : G21, G28, K23
Classification de la Banque : Institutions financières

1. Introduction

This paper addresses the extent to which the proposed rules under the new Basel Capital Accord (Basel II) will introduce cyclicality in required bank capital. Capital requirements that are sensitive to economic conditions may increase the level of required capital during future economic slowdowns, leading banks to restrict their supply of credit and thereby exacerbating the economic cycle through the induced procyclical behaviour.

The original Basel Accord (Basel I) on common minimum capital requirements, which had the overall objective of strengthening the soundness of the international banking system, was adopted by the G-10 countries in 1988. It has since been implemented in a number of additional economies. Although causality is difficult to verify, the introduction of the accord was followed by an increase in the average G-10 risk-based capital ratio for banks, reversing a prolonged period of decline in several major industrialized countries.[1] In 1996, the accord was extended to address the treatment of market risk arising from trading activities.

The Basel Committee on Banking Supervision is currently in the process of examining substantial modifications to Basel I. After several years of discussion and quantitative testing, the committee has completed a revised capital framework, recently endorsed by G-10 central bank governors and heads of supervision. Although full implementation of the complex Basel II still remains several years away, policy-makers are faced with the task of considering its potential implications.

The concerted effort to revise the accord has been prompted by a number of factors, including the experience gained under Basel I, widespread financial innovation, recognition that banks have managed their capital requirements in unexpected ways through "capital arbitrage" (discussed further below), and a desire to draw upon the considerable advances in financial risk-management practices that have been made over the past decade. The changes under consideration would extend the accord in new directions. For example, to the existing "pillar" on minimum capital requirements would be added two new pillars that emphasize supervisory review of banks' capital adequacy and improved disclosure of key information.

The central objective of the proposed changes to the first pillar on minimum capital requirements is to substantially increase the sensitivity of bank capital to the risk associated with specific classes of financial assets. These changes, and their impact over time on bank capital requirements, are the subject of this paper. Although the analysis is carried out with specific

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1. The impact of Basel I on bank capital ratios is described in detail in a paper by the Bank for International Settlements (1999).

reference to the Canadian banking system, it is believed that the broad results are relevant to banking systems wherever Basel II will be applied.

This paper consists of three main parts. The first begins with section 2, which describes the evolution of bank capital and its relationship with the macroeconomic cycle, and the impact of Basel I on capital ratios since 1988. Section 3 describes the motivation behind Basel II and the specific manner in which required bank capital will be calculated, and discusses possible sources of cyclical behaviour.

In the second main part of the paper, section 4 summarizes the existing evidence on the empirical impact of Basel II available in the literature, and section 5 summarizes the results from the quantitative impact studies undertaken by the Bank for International Settlements (BIS). Section 6 discusses the recent global cycle in corporate credit quality, which would have influenced the results of the BIS quantitative studies, but which also provides an interesting period in which to test the impact of the proposed approaches under Basel II.

The third main part of the paper empirically assesses the impact of Basel II on the level and volatility of aggregate Canadian bank capital. Section 7 provides a counterfactual analysis of how bank capital in Canada would have evolved if the requirements of Basel II had been applied over 1984–2003. We focus on the banks' wholesale exposures, since this is traditionally the most significant source of bank losses. A key constraint is that we do not have precise data on the credit distribution of Canadian bank portfolios over time (an exception being sovereign loans). We therefore apply several approaches to evaluate the credit risk of bank exposures: a "mapping" technique that translates the bond yield for a given borrower into a credit rating; the use of bond-yield spreads to derive one-year expected credit losses; and annual transition matrices that track the evolution of credit ratings over time (data for missing years are interpolated based on several constraints). Results from the latter two approaches are reported, effectively proxying a relatively volatile "point-in-time" approach and a less-volatile "through-the-cycle" approach to credit ratings. Although these approaches provide information on the evolution of credit ratings over time, we also need an initial distribution with which to start the simulations. We experiment with different hypothetical distributions, and report results for those that appear to most closely typify the Canadian situation. Section 8 interprets the results from the perspective of the implied volatility in required bank capital.

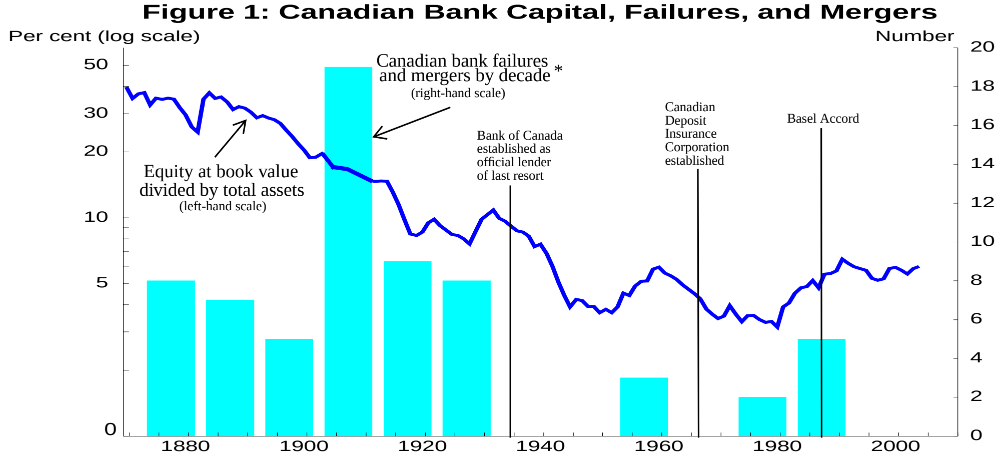
Section 9 offers some conclusions. Overall, our results are consistent with those found elsewhere. Specifically, the implied required level of bank capital under Basel II would be substantially below both actual and required current levels. Nevertheless, significant potential remains for volatility in required capital, conditional on the economic cycle. A number of factors could mitigate the actual impact of Basel II on bank capital, particularly the manner in which domestic supervisors implement the new accord.

2. Bank Capital and the Canadian Economy

A commonly raised concern is that Basel II capital requirements will be countercyclical: capital requirements would increase during recessions, and thus possibly induce procyclical lending behaviour on the part of banks. Therefore, it would be useful to know the extent to which capital ratios are already correlated with the Canadian business cycle. In particular, a leading relationship might suggest that variations in bank capital have amplified previous economic cycles, a phenomenon that one should be cautious about exacerbating in any new capital requirements. The objective of this section is to determine the strength, timing, and pattern of any relationships between banking system and macroeconomic variables.

Until 1980, Canadian bank capital ratios had been trending downward for over a century (Figure 1). As the banking system consolidated, the implicit subsidy of the broadening regulatory safety net became more apparent. Capital ratios declined largely without a corresponding increase in the frequency of bank failures and distressed mergers.[2] Over the 1980s and early 1990s, several Canadian banks did fail, along with 35 trust, mortgage, and loan corporations, but largely because of poor lending decisions, rather than undercapitalization.

Figure 1: Canadian Bank Capital, Failures, and Mergers



*Does not include the 40 trust, mortgage, and loan corporations that have failed since 1967
Sources: Curtis (1931), Leacy (1983), Estey (1986), CDIC, and authors' calculations

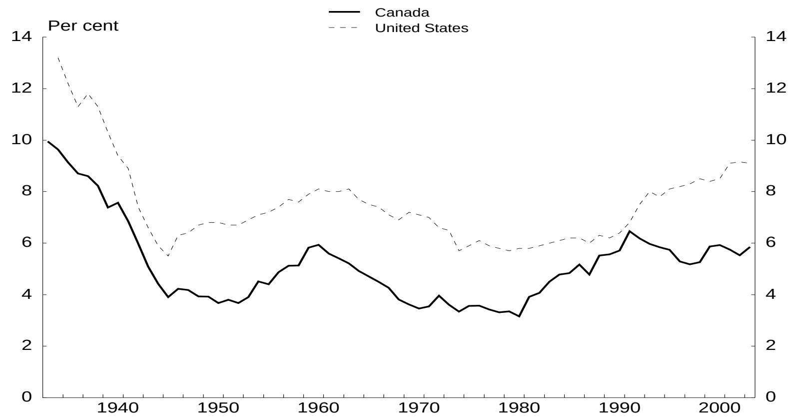
2. U.S. financial institution failures peaked in the 1980s after a similar decline in capital ratios.

The impact of financial regulation is more difficult to discern from the data. For example, extensions of the financial safety net (the creation of the Bank of Canada in 1935 and the Canadian Deposit Insurance Corporation (CDIC) in 1967) occurred well after major turning points in the trend. Similarly, capital ratios reversed their trend in 1980, well before the implementation of the (albeit long-anticipated) Basel Accord in 1988.

There has been a very strong correlation (0.89) between movements in the Canadian banking system capital ratio and that for the United States, despite the two countries' very different regulatory regimes and banking system characteristics (Figure 2). It is possible that regulatory changes in the United States indirectly affected Canadian capital ratios through competitive forces. For example, Canadian supervisors may have unofficially adjusted their judgment-based requirements to avoid large differences between the two banking systems. Alternatively, management may have sought comparable ratios to gain easier access to capital market funding. Subsequent to Basel I, the evolution of the two countries' capital ratios diverged from their historical pattern (as discussed in greater detail below). During that period, there was a significant evolution in Canada's financial supervisory regime, towards clearer goals and improved incentives to act with regards to troubled institutions, as well as a greater authority to act.

The persistent difference in levels between the Canadian and American bank capital ratios can be partially explained by significant differences in accounting regimes, including the treatment of equity and booking of provisions, and partially by the relatively larger median size and asset diversity, and therefore generally lower risk, of Canadian banks. Indeed, the average Canadian bank is about 170 times bigger than the average U.S. commercial bank by asset value (and about 104 times bigger in terms of capital). Capital ratios for just the 30 largest U.S. commercial banks, which are more comparable in scale and scope of activity to Canadian banks, are somewhat lower than the overall U.S. average, but not by enough to explain the entire difference in capital ratios. As stated earlier, however, trends in the two countries' capital ratios have been very similar.

Figure 2: Reported Bank Capital Ratios Over History*



*Total capital at book value. Prior to the 1990s, capital ratios would have likely been lower had modern-day "fair value" accounting principles been used, in particular when recognizing loan losses.
Sources: Bank of Canada (2004), FDIC (2004)

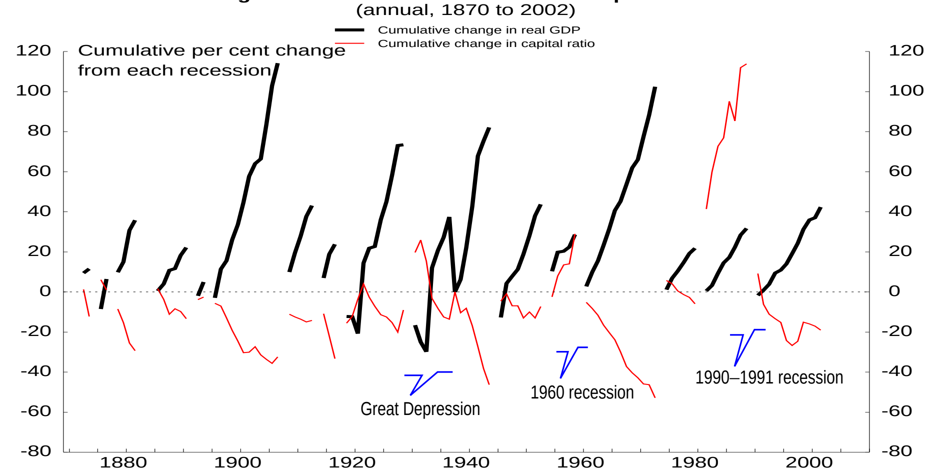
Since capital is relatively stable compared with assets, and assets are procyclical, the capital ratio has tended to decline during economic expansions (Figures 3 and 4). The only exceptions to this pattern in the modern period were the second half of the 1950s and the 1980s, which coincided with shifts in banking supervision in the United States but not in Canada.[3,4]

Output growth and changes in the capital ratio are negatively correlated (–0.26), and a casual inspection of the historical data for Canada suggests that a large increase in the capital ratio has been followed by a contraction of real output during certain episodes (Figure 3). Early occurrences were the recession of 1883 and the Great Depression (when banks continued to accumulate capital for several years following a decline in the value of their assets). Of greater relevance, the 1960 and 1990–91 recessions were preceded by extended periods of rising capital

3. According to the Federal Deposit Insurance Corporation (FDIC) (2003a) in the United States, "In 1952, different capital-to-risk assets ratios were proposed in separate studies by a committee of the New York State Bankers Association, the Illinois Bankers Association, and the Federal Reserve Bank of New York. The Board of Governors of the Federal Reserve developed a 'Form for Analyzing Bank Capital' in 1956."
4. According to FDIC (2003a) in the United States, "The convergence of macroeconomic weakness, more bank failures and diminishing bank capital triggered a regulatory response in 1981 when, for the first time, the federal banking agencies introduced explicit numerical regulatory capital requirements. The standards adopted employed a leverage ratio of primary capital (which consisted mainly of equity and loan loss reserves) to average total assets. . . . The Federal Reserve Board and the Office of the Comptroller of the Currency announced a minimum primary capital adequacy ratio of 6 percent for community banks and 5 percent for larger regional institutions. The FDIC established a threshold capital-to-assets ratio of 6 percent and a minimum ratio of 5 percent. Over the next decade, regulators worked to converge upon a uniform measure."

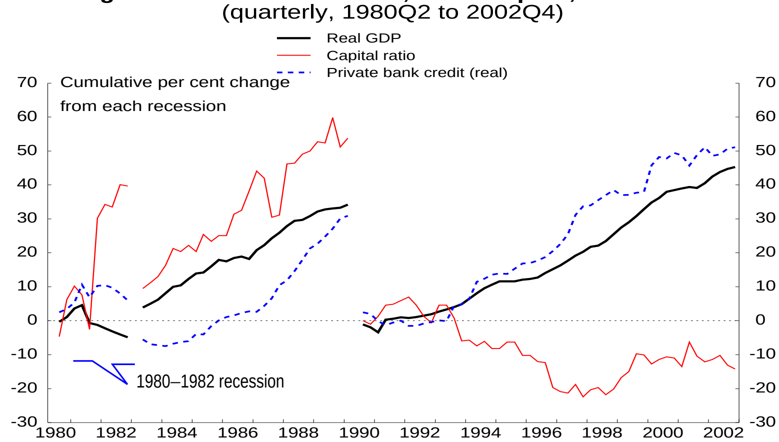
ratios, followed by weak asset growth. Capital ratios also increased sharply during the double recession of the early 1980s, which was followed by a contraction in bank lending (Figure 4).

Figure 3: Economic booms and the capital ratio
(annual, 1870 to 2002)



Sources: Bank of Canada (1950-2004), Leacy (1983), Statistics Canada (2004), Urquhart (1986), and authors' calculations

Figure 4: Economic Booms, Bank Capital, and Credit
(quarterly, 1980Q2 to 2002Q4)



Sources: Bank of Canada (1980-2004), Statistics Canada (2004), and authors' calculations

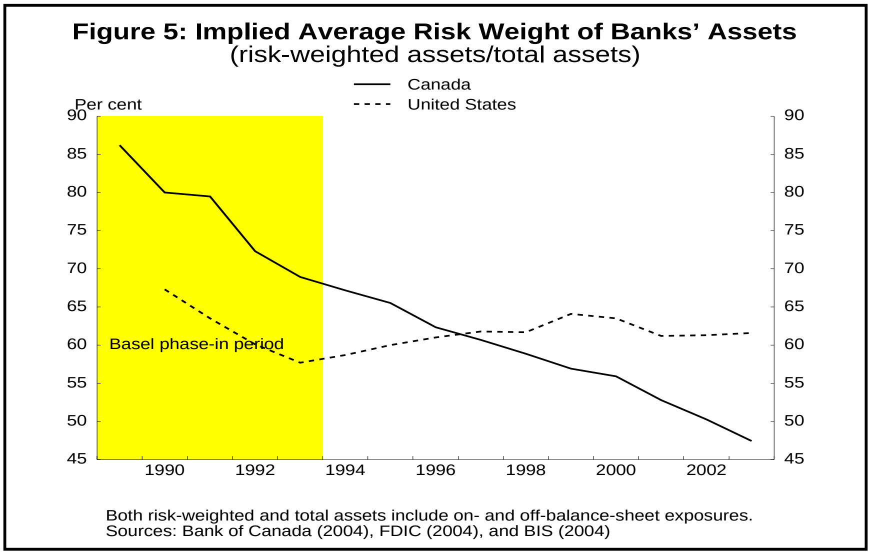
More formal statistical tests of these relationships are presented in the appendix. The evidence provided by the tests is not so clear, perhaps because capital ratios have also increased during certain periods of strong economic expansion. Indeed, the reported pairwise Granger causality tests do not detect a direct causal relationship between real output growth and changes in the capital ratio or the growth rate of capital. Furthermore, judging from simple vector autoregressions over long time horizons, output appears to be invariant to the capital ratio. In summary, although these are rather simple tests, they suggest that there is little historical evidence in Canada that either the level or growth rate of bank capital has influenced, or been influenced by, broader macroeconomic phenomena. Taken alone, this should temper some of the concerns about the sensitivity of economic growth to a change in the capital regime.

2.1 The effect of Basel I on the Canadian banking system

The phasing-in of Basel I coincided with significant regulatory changes and macroeconomic developments in Canada. The combined effect on the balance sheets of Canadian banks was pronounced. The fundamental building block of Basel I is its asset risk-weighting formula. Following the accord's introduction in 1988, Canadian banks steadily increased the proportion of their assets that carried zero or low capital charges. Such assets primarily include publicly guaranteed securities and insured or highly collateralized residential mortgages, the markets for which were growing strongly over this period.[5] Also, as a result of corporate restructuring during the recession of the early 1990s, there was a marked decline in banks' corporate exposures, which under Basel I generally carry a 100 per cent risk-weighting (equal to an 8 per cent capital charge).

The net result is illustrated in Figure 5, which shows the percentage of risk-weighted assets to total assets for Canadian banks and U.S. commercial banks. The ratio has fallen steadily in Canada, from around 90 per cent in 1989 to 50 per cent at present.[6] According to the Basel risk-classification system, therefore, the average riskiness of assets held by Canadian banks has fallen significantly. On the other hand, the ratio for U.S. commercial banks has remained relatively stable at around 60 per cent.

5. The share of insured residential mortgages, which typically carry a zero risk weight under the Basel capital-adequacy formula, has risen from around 25 per cent in 1992 to 50 per cent currently.
6. At the same time, off-balance-sheet exposures as a share of total assets have fallen from 14 per cent in 1994 to around 7 per cent currently. (Off-balance-sheet exposures are risk-weighted. Notional exposures may be considerably higher.)



The decline in the average risk-weighting of Canadian banks' assets, both on- and off-balance sheet, has helped boost their Tier 1 capital ratios from under 5 per cent in 1988 to over 9 per cent today (Figure 6). On a non-risk-weighted basis (core), however, capital ratios in Canada have remained relatively unchanged over the past 14 years (Figure 7). In contrast, Tier 1 capital ratios of U.S. commercial banks have risen sharply since the introduction of Basel I, from under 8 per cent to over 10 per cent by 1994, principally through an accumulation of core capital.

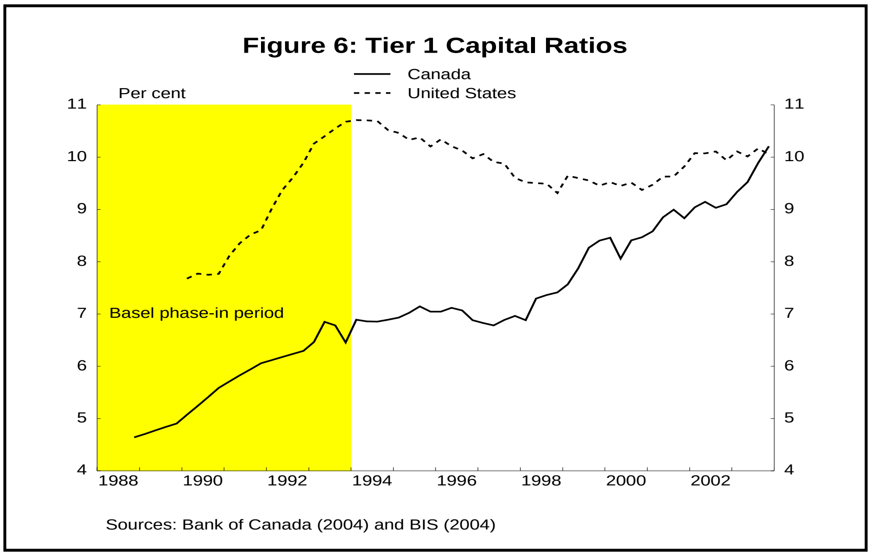
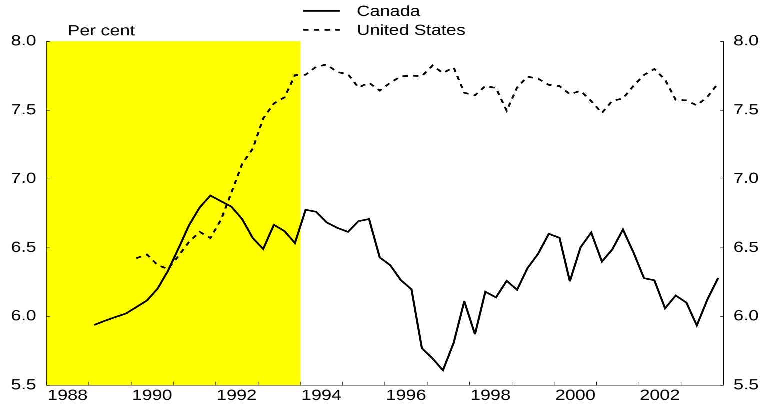


Figure 7: Core Capital Ratios
(equity/assets at book value)



Sources: Bank of Canada (2004) and BIS (2004)

3. Basel II and Potential Implications

Although neither the definition of regulatory capital under Basel II nor the minimum required ratio of 8 per cent changes, the risk weights of specific assets will vary over time. Capital requirements therefore have the potential to be countercyclical. This key element of the new accord is the primary source of concerns raised thus far, which are described in section 3.1. In section 3.2 we describe in detail the computation of capital requirements under Basel II. The sources of cyclicality in Basel II are described in section 3.3.

3.1 Objective and potential implications of Basel II

The objective of making the amount of capital that is held by a bank sensitive to the extent of the risk (in this case, credit risk) that it faces on its financial assets is both sensible and laudable (we do not attempt to define the "optimal" level of bank capital). If capital is being held by the bank to contribute to its survivability in the face of adverse circumstances, then it appears reasonable that the level of capital should bear some relationship to the likelihood of those circumstances occurring.

While the overall goal may be laudable, how best to measure risk and equate it with required capital remains a difficult question to answer. The approaches proposed in Basel II, intended to make capital requirements more sensitive to the measured riskiness of bank portfolios, have raised some concern as to their potential impact. Specifically, if the degree of risk is correlated with broad systemic events, then the risk associated with banks' asset portfolios will vary with those events. The event that is generally cited in this regard is the business cycle. If credit quality improves significantly during periods of strong economic growth, and falls during downturns, then across the aggregate bank sector the capital required under Basel II could, in principle, fall and rise in tandem. The volatility, or cyclicality, that this could conceivably create in bank capital has become an important issue.

In particular, during an economic downturn, if the required level of bank capital rises sharply, banks might choose to reduce their assets (i.e., scale back the growth of new lending or reduce existing loans) if they are either unable or unwilling to increase their capital in line with regulatory requirements. During an economic boom, if a reduction in the overall riskiness of the portfolio leads to an excess of capital, banks may be induced to further raise their lending during the boom (possibly reducing their lending standards in the process).[7] While this latter scenario may appear relatively sanguine, some observers argue that "excessive" lending lays the seeds for subsequent economic and financial "busts."[8] Thus, varying levels of capital charges may influence bank lending behaviour in a manner that would reinforce the cycle in economic activity, the so-called procyclicality issue. The new accord therefore holds potential implications for the macroeconomy, and for policy-makers concerned with macroeconomic performance.

A key issue is how severe the implications will be for procyclicality. Recall that risk sensitivity in the Basel Accord is not itself new. Basel I set minimum capital requirements for a defined set of asset "baskets," with the capital charge for each basket set broadly in line with the perceived risk for the assets it encompassed as a group. Corporate loans, for example, were placed in one basket, with a risk weight of 100 per cent, and residential claims backed by mortgages were placed in another basket, with a lower risk weight of 50 per cent.[9] Overall, Basel I required banks to hold minimum total capital equal to 8 per cent of their risk-adjusted assets (including off-balance-sheet items). With Basel II, the overall minimum required ratio remains at 8 per cent (the definition of regulatory capital also does not change).

Although Basel I introduced explicit risk sensitivity, the capital requirements associated with specific assets were invariant over time, such that the capital charge faced by the bank would change only when it changed its holdings of assets. By broadening the range of risk baskets, and

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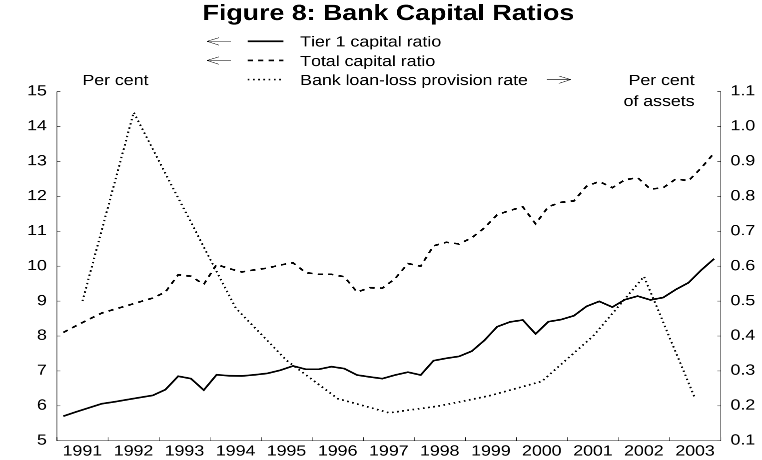
7. Induced reductions in lending standards could magnify the credit problems that banks experience during subsequent downturns.
8. See Lowe (2002, 3) for a discussion of the proposition that "risk is built up in the boom but materializes in the downturn."
9. The risk weights are defined as a per cent of the overall target for the minimum capital ratio, which is 8 per cent.

by allowing assets to potentially move between baskets to reflect changes in their risk characteristics, Basel II seeks to address some of the limitations of Basel I.

It is also the case, however, that cyclicality within the banking system is not new. Lending institutions have long faced changing credit conditions, and cyclical elements can be observed in past lending behaviour and changing provisions for doubtful loans. Thus, a fundamental issue is whether Basel II will create *additional* volatility in capital; i.e., induce behaviour not already present in the financial system (and in turn create additional volatility in bank lending). Other compensating features that reduce the impact of Basel II may also be present. For example, banks often maintain capital in excess of the Basel minimum. To the extent that they are willing to allow variation in these stocks of "buffer capital," this could, in principle, absorb some of the variation induced by a change in riskiness, and mitigate the cyclical effects of Basel II (Figure 8).

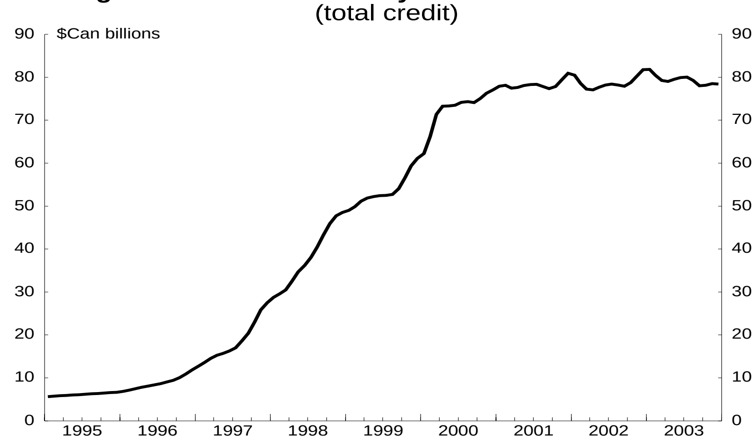
Figure 8: Bank Capital Ratios



Sources: Bank of Canada (1991-2004) and BIS (2004)

Another aspect of the original accord that Basel II seeks to address is the incentive created for capital arbitrage, in which banks may have been inclined to hold assets where the capital charge was relatively small compared with the potential return and risk. Similarly, banks would tend to minimize assets where the capital charge overstated the actual (economic) risk. Indeed, this "regulatory capital arbitrage" is viewed as one of the primary drivers behind the development of securitization markets, in Canada and elsewhere. The securitization of assets, over a progressively broader range of asset classes, has allowed banks to reduce their risk-weighted assets and raise their capital ratios (Figure 9).[10] By reducing the opportunities for capital arbitrage, Basel II could increase overall risk sensitivity.

Figure 9: Securitization by Financial Institutions
(total credit)



Source: Bank of Canada (1995-2004)

3.2 Computing capital requirements under Basel II

The key change under the first pillar of Basel II is that the risk associated with a particular asset, and therefore the capital charge assigned to it, can vary over time.[11] If a reassessment shifts an asset to a riskier asset bucket, that asset will draw a higher capital charge. The cyclicality of Basel II will be determined by the way in which the accord calculates the riskiness of asset portfolios over time and the resulting capital charge. To calculate the riskiness of an asset, two general approaches are proposed under Basel II: the standardized approach, and, for banks deemed to have sufficiently sophisticated risk-management systems, the internal ratings-based (IRB) approach. Under the standardized approach, the probability of default, or riskiness, will be derived from the ratings established by external credit rating agencies, where available.[12] Table 1 summarizes the proposed risk weights for corporate exposures.

10. Standard & Poor's estimate that, in the third quarter of 2002, the securitization activity of the five largest Canadian banks allowed them to improve their average capital ratio by approximately half a percentage point (Standard & Poor's 2002). See BIS (1999, 21–26) for a related discussion.
11. Basel II will also introduce a capital charge for operational risk (BIS 2003a, 2003c). The treatment for market risk, introduced in the 1996 amendment, will remain unchanged.
12. The potential influence this gives credit rating agencies within the financial system has been the source of considerable discussion.

Table 1: Proposed Risk Weights for Corporate Exposures

Rating	**AAA to AA–**	**A+ to A–**	**BBB+ to BB–**	**Below BB–**	**Unrated**	**Past due**
Risk weight[a]	20	50	100	150	100	150

a. As a percentage of the 8 per cent minimum capital ratio

Under the IRB approach, the capital (K) charge for wholesale exposures (i.e., commercial and industrial, interbank, and sovereign) is,

$$K = LGD \times N\left(\frac{N^{-1}(PD) + \rho^{1/2}N^{-1}(0.999)}{\sqrt{1-\rho}}\right) \times EAD - (PD \cdot LGD \cdot EAD), \tag{1}$$

where N is the normal cumulative distribution function, LGD is loss given default, and EAD is exposure at default.[13] As the equation shows, the Basel Committee on Banking Supervision has selected a 99.9 per cent confidence threshold. The correlation between exposures, ρ, is determined by the committee and given by,

$$\rho(PD) = 0.12 \times \left(\frac{1 - e^{-50 \times PD}}{1 - e^{-50}}\right) + 0.24 \times \left(1 - \frac{1 - e^{-50 \times PD}}{1 - e^{-50}}\right). \tag{2}$$

The term subtracted from the right-hand side of equation (1) is the expected loss. The remainder is the unexpected loss. Since banks in most advanced countries are already required to provision against expected loss, it has been agreed that having to hold capital against this amount as well is redundant (Kupiec 2003). As a result, the Basel Committee announced in October 2003 that the IRB approaches will capitalize only unexpected losses (hence the appearance of the subtracted term). Any shortfall, however, between the sum of a bank's general and specific loan-loss provisions and the estimated expected loss will have to be capitalized.[14]

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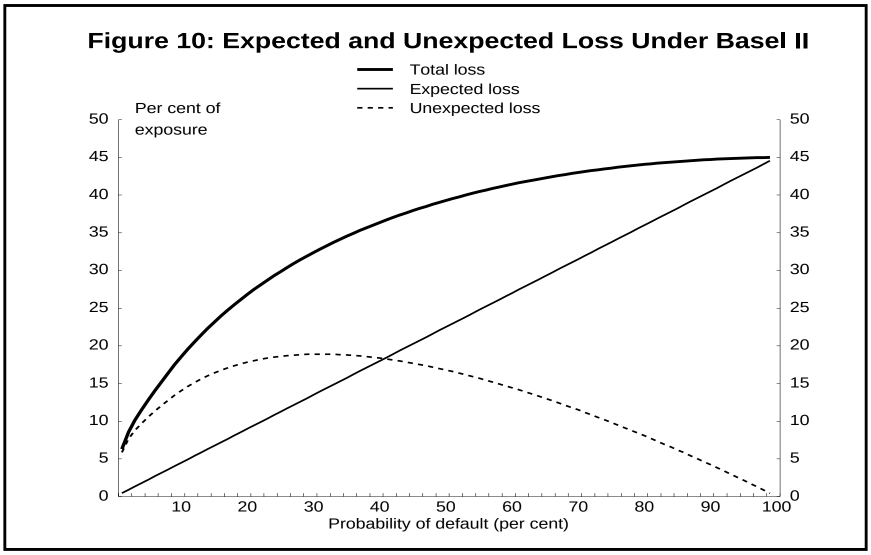
13. N(x) denotes the cumulative distribution function for a standard normal random variable (i.e., the probability that a normal random variable with mean zero and variance of one is less than or equal to x). N^{-1}(z) denotes the inverse cumulative distribution function for a standard normal random variable (i.e., the value of x such that $N(x) = z$) (BIS 2002).
14. Currently, half of the shortfall could be made up for with Tier 2 capital. A debate is ongoing, however, as to whether Tier 2 capital should be admissible for IRB capital requirements.

The amount required to be allocated to provisions for expected loss and the amount required to be held as regulatory capital for unexpected loss are shown in Figure 10 as a function of the probability of default. An LGD of 45 per cent is assumed in this example.



Under the advanced IRB approach, LGD can be estimated by the individual institutions. Under the foundation IRB approach, it will be set at 45 per cent, which is the loss rate we will use in the following counterfactual exercises. Based on current anecdotal information, however, 45 per cent may be at the high end of the range for Canadian banks.[15]

Under the advanced IRB approach, exposure at default can be estimated by the individual institutions. Under the foundation IRB approach, it is a function of the probability of default and maturity, where longer maturities require more capital,

$$EAD = (1 - 1.5 \times b(PD))^{-1} \times (1 + (M - 2.5) \times b(PD)) , \tag{3}$$

where b is an adjustment to the maturity,

$$b = (0.08451 - 0.05898 \times \log(PD))^2 . \tag{4}$$

15. In our counterfactual analysis, we err on the side of prudence and therefore use 45 per cent.

The minimum maturity allowed for calculations is one year, and the maximum is five years. Anecdotally, average portfolio maturities for Canadian banks are around two years. In the following counterfactual analysis, we err on the side of prudence and use the somewhat more conservative assumption of an average maturity of 2.5 years.

3.3 Sources of cyclicality in Basel II

In this section, we discuss potential sources of cyclicality inherent within the three different capital approaches of Basel II: standardized, foundation IRB, and advanced IRB. Under the standardized approach, cyclical effects could enter through the potential for the relevant credit ratings to deteriorate during economic downturns (or to improve during upturns). Credit rating agencies argue that they take a "through-the-cycle" approach to ratings; that is, the rating should be based on the assumption of an adverse confluence of events of a typical severity and probability, regardless of current economic conditions. There is ample evidence, however, that the current state of the business cycle affects ratings.[16] If no external rating is applied (possibly because it is not available), in most cases a risk weighting of 100 per cent is used. For unrated loans, there would be no direct cyclical impact on asset riskiness (unless the loan became past due owing to deteriorating economic circumstances, such that the risk weighting was raised to 150 per cent).[17]

Under the alternative IRB approaches, qualified banks will be allowed to estimate the default probabilities themselves, which are then translated into a capital charge, according to the formulae described in section 3.2 (with the specific calculation varying somewhat across exposure types). The risk weights that arise from the IRB approach form a continuum of weights (recall Figure 10). Table 2 describes the key risk components that underlie the calculations that influence the presence of cyclicality.

It is less clear how important cyclical effects will be under the IRB approach, where banks can use their own credit-risk models. To the extent that their own risk assessments mimic those of the credit rating agencies, however, the same cyclicality issues arise. Some large financial institutions have made increasing use of value-at-risk (VAR) models. These models, tending to reflect a "point-in-time" assessment, and possibly using volatile variables such as equity prices, can potentially produce quite strong cyclical effects.

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16. Amato and Furfine (2003) provide extensive evidence on the sensitivity of credit ratings to business cycle conditions.
17. Under the standardized approach, the greater the proportion of assets that do not have external ratings, the more Basel II reduces to the original accord.

Table 2: Key Risk Components

PD	Probability of default	The likelihood that the borrower will default over a given time horizon
LGD	Loss given default	The proportion of the exposure that will be lost if a default occurs
EAD	Exposure at default	Book value of the asset less effects from credit-risk mitigation
M	Maturity	Remaining economic maturity of the exposure in years

The variables described in Table 2 are set by the Basel Committee with respect to the standardized approach. For example, under current proposals, the LGD would be set at 45 per cent for unsecured general credit obligations, and at 75 per cent for subordinated exposures. The IRB approach, however, allows for progressively greater input by qualified banks in calculating portfolio riskiness (within certain constraints). Under the foundation IRB approach, banks would set the values of LGD for each asset. For banks that apply the advanced IRB approach, they would also set EAD and M.[18] There is strong empirical evidence that percentage losses tend to rise during economic contractions, such that further cyclicality could in principle be introduced by changes in LGD correlated with the economic cycle (rising, for example, during an economic downturn). Similarly, if borrowers are more likely to draw down loan commitments during times of economic stress, EAD could change as well (via the conversion factor that translates loan commitments into current exposures). The capital charge formulae also incorporate an asset correlation factor (an assumption regarding the correlations among the default probabilities of different asset pools), which could vary with the economic cycle.[19]

While these other potential sources of cyclicality raise issues as to the structure of the formulae and the most appropriate values for the inputs, they may have little impact in practice on cyclicality, since they are unlikely to be changed dramatically from period to period by the banks under the IRB approach (and are held constant under the standardized approach). In addition, even under the advanced IRB approach the formulae are specified by the Basel Committee, such that the banks are still constrained in determining the capital charge.[20] Nevertheless, even if the

18. The EAD includes any additional credit facilities that the borrower will likely draw down in the future.
19. There is some empirical evidence that asset correlations tend to rise during periods of financial stress. These potential sources of cyclicality are reviewed in Lowe (2002).
20. There are also constraints on the other inputs. For example, LGD should represent the expected loss under adverse economic conditions, while M must be between one and five years.

values of these inputs are held invariant over the cycle, the precise values selected by the Basel Committee may influence the impact of cyclical changes in PD on the calculation of asset riskiness.

Basel II explicitly addresses the issue of securitization. Otherwise, the new accord “would remain vulnerable to capital arbitrage,” as under Basel I, where banks were able in certain cases “to avoid maintaining capital commensurate with the risk to which they are exposed” (BIS 2003a, 7). Basel II is much more explicit regarding the risk weights to be applied to securitization exposures. It also addresses the recognition of provisions and the issue of credit-risk mitigants (including a range of credit-risk transfer instruments). A key issue will be whether credit-risk mitigation, including provisioning, will to some extent offset any additional cyclicality introduced by Basel II. In other words, credit-risk mitigation techniques currently being implemented by banks as a group may act as a partial offset to the cyclicality that arises from a changing probability of default.

4. A Review of the Literature

A substantial literature has developed around Basel I, including research on the potential impact of procyclical effects to which it might have given rise. These effects are summarized in BIS (1999), where it is concluded there is some evidence that, in specific instances, bank lending has been constrained by capital requirements, but that the overall macroeconomic impact appears limited. It is not entirely clear that the constraints would not have appeared anyway in the absence of the Basel Accord; i.e., it is not clear that Basel I exacerbated the cyclicality that already existed in the financial system. Catarineu-Rabell, Jackson, and Tsomocos (2003, 10), for example, argue that the effects of Basel I on economic cycles “is likely to be muted because earnings are the first buffer against the need to raise provisions or write off loans.” In addition, “modest falls in capital may be covered by increased use of subordinated debt which is included under Tier 2 capital.”

The potential for cyclical effects on bank capital, however, appears to be much greater under Basel II. This issue (in addition to that of a possible one-time shift in the level of bank capital created by the accord) has been the subject of a small but growing body of empirical literature, which we review here.

Carpenter, Whitesell, and Zakrajsek (2001) provide some empirical estimates of the potential cyclicality of capital based on the standardized approach. From a sample of U.S., non-financial issuers, they develop quarterly transition matrices for credit ratings from 1970 through 2000.[21] By

21. The matrices are based on the number of issues and not the total value of debt. While the lack of value-weighted transition matrices is unfortunate, it is unlikely to be important for large samples.

applying Basel II over this period,[22] Carpenter, Whitesell, and Zakrajsek are able to derive the level of capital charges that would have occurred had the accord applied at that time. In particular, they are able to examine how the capital charges would have evolved over complete business cycles.

Carpenter, Whitesell, and Zakrajsek emphasize several important findings regarding credit ratings. Technically, credit ratings are based on a borrower's ability to meet debt obligations during adverse economic circumstances, and do not correspond to a probability of default over a one-year horizon. While this suggests a "through-the-cycle" approach, the information available during actual downturns suggests that credit ratings in fact reflect some cyclical effects (this may be particularly true if the cycle has some unusual characteristics, such as the bursting of the hi-tech bubble and corporate governance issues). The withdrawal of credit ratings for particular issues also potentially affects the data. The authors note, however, that the large majority of credit rating withdrawals occur because the security is maturing or otherwise being called, and not because of a deterioration in credit quality (thus, excluding these issues is unlikely to introduce significant bias).

Their results show that, from 1998 to 2000, the required level of capital was less than that stipulated under Basel I (8 per cent). They attribute the drop in capital in part to a possible tightening by banks of standards for business lending in response to the deteriorating quality of loan portfolios during this period (which is a typical cyclical pattern of bank behaviour that is independent of capital requirements). An additional factor that may contribute to this result (not discussed by Carpenter, Whitesell, and Zakrajsek) is that, if the Basel Committee's overall objective of maintaining the same minimum capital requirement as Basel I is to be achieved, then the new capital charge for operational risk implies that the aggregate charge for credit risk must be proportionally less under Basel II. Nevertheless, these results suggest that banks will effectively have a capital buffer with which any cyclical effects might conceivably be dampened.

An even more interesting finding is that the level of total capital requirements under Basel II would be slightly less volatile for the banking sector as a whole. This suggests that cyclicality in the capital charge could be less, not more, relative to Basel I, and Carpenter, Whitesell, and Zakrajsek conclude that, for the standardized approach, "the new Accord is unlikely to induce material increases in procyclicality" (p. 24). To understand this finding, it is important to recall that the aggregate level of the capital charge is the result of both the size and quality distribution

22. The authors of this and other papers use the proposed Basel II rules that were available at the time they completed their work. These proposals have steadily evolved, and in some cases the changes have been specifically designed to reduce the potential for cyclical effects in capital charges.

of the asset portfolio. The authors suggest that, when loans are growing rapidly, there may be a compensating tendency for the distribution of loans to shift to less-risky loans. This would be consistent with an improving economic environment that reduced the probability of default. With the reduced riskiness being reflected under Basel II, the implied capital charge would rise less (in response to the increase in loans) than under Basel I. The reverse would presumably be the case if loans grew less rapidly during economic downturns (with deteriorating credit quality at least partly offsetting the slower growth in loans).

A concern with the above historical approach, however, is that it does not capture the induced effect that procyclicality might have on the lending behaviour of banks. When loan portfolios are growing rapidly, if improving credit quality reduces the corresponding growth in capital requirements, might not banks be induced to lend even more? During economic downturns, because deteriorating credit quality means that the capital charge does not fall (or slow in growth) as much as otherwise would have been the case, might not banks further reduce their lending? By definition, these induced feedback effects on the aggregate level of loans, and therefore on capital, are not captured by historical episodes, and thus the question of procyclicality is not fully answered.

To abstract from the above problem, some authors have examined only the effect on the capital charge that arises from a change in credit quality, using an asset portfolio of constant magnitude (other than defaults). Ervin and Wilde (2001), drawing upon a U.S. transition matrix for 1990, when there was a general deterioration in credit quality, calculate that the Basel II rules, as proposed in 2001, would have required a large increase in capital over that short time span (about 20 per cent). Purhonen (2002) also examines the potential impact of changes in credit quality that are reflected in public credit ratings (ignoring, as others often do, the impact of credit-risk mitigation and credit loss, for example). Using Basel II, Purhonen finds that an approach that reflects the standardized approach produces “surprisingly low” volatility in the capital charge. He argues that this is because of the relative stability in the ratings of the large issuers contained in his sample. Using a VAR approach designed to reflect the IRB approach, however, he finds exceptional volatility (30 per cent over a single quarter in one case).

Carling et al. (2002) assess the IRB approach, employing a rich data set drawn from the loan portfolio of a single bank (using quarterly data between 1994 and 2000). Their data reveal considerable movement over time in the average default rate of the bank’s portfolio (the default rate also varies across loan types and industries). In an approach designed to mimic the Basel II IRB approach, they estimate a reduced-form credit-risk model that produces a VAR measure for the bank’s corporate loan portfolio. Default probabilities are taken from 1-, 4-, and 12-quarter moving averages of historical default frequencies and the credit-risk model estimates. Consistent with the findings above, Carling et al. find substantial quarterly volatility in the capital charge (although in some periods the level of the capital charge appears to fall to unrealistically low levels).

Catarineu-Rabell, Jackson, and Tsomocos (2003) evaluate the impact on the capital charge between two different credit quality "states" in more detail. They examine the capital requirements that emerge from internal ratings based on (i) a ratings industry approach, and (ii) a Merton-type VAR model. Using four different portfolio distributions for corporate exposures (from the United States, Europe, and the G-10 countries) that are generally drawn from a period of strong economic growth, Catarineu-Rabell, Jackson, and Tsomocos apply credit rating transition matrices based on an average of economic downturns, and on the early 1990s recession, to produce stressed quality distributions. The change in capital requirements is then calculated between the two credit quality distributions. Based on the proposals as of October 2002, they find an increase in capital requirements ranging from 10 to 18 per cent. However, if provisions are allowed to be applied against defaulted loans, then capital requirements for the non-defaulted portfolio would be largely unchanged.[23] Catarineu-Rabell, Jackson, and Tsomocos find that results under a Merton-type VAR model are much more volatile.

A number of authors have suggested that the potential influence of Basel II on cyclicality in capital requirements will be partially, or entirely, mitigated by the presence of capital buffers; i.e., the excess capital typically held by many banks. Bikker and Hu (2002) observe that capital and reserves in G-10 countries are typically higher, and often significantly higher, than the minimum capital requirements. They suggest that this may occur because banks are aiming at higher external credit ratings than would correspond with the minimum requirements. They also suggest that banks look farther out than the one-year default horizon in Basel II when provisioning, in part to smooth their profits. As a result of "countercyclical" provisioning (i.e., setting aside provisions in boom times), banks are significantly less procyclical than the business cycle might suggest. Peura and Jokivuolle (2003) also suggest that banks will hold significant stocks of buffer capital, perhaps because they are encouraged to do so under the second pillar of Basel II.[24] They develop a dynamic model of capital buffers based on historical data (which incorporates "stressful" events). The degree of confidence desired with respect to not dropping below the minimum capital level will affect the desired level of buffer capital. They find, however, that under the IRB

23. Although Catarineu-Rabell, Jackson, and Tsomocos designed their approach before the Basel Committee removed expected loss from the capital formulae, their treatment is roughly similar to the new requirements for provisions.
24. This highlights the point that the actions of national regulators under the second pillar could have an important impact on outcomes under Basel II.

approach the total amount of capital is likely to increase under Basel II. Similar to results reported above, the required buffer capital would be larger than under the standardized approach.

Other papers emphasize the potential for cyclical impacts to arise from sources other than the rated credit quality of the asset. This is particularly relevant to banks that intend to apply the advanced IRB approach, where they potentially can determine the values of other variables that enter into the risk-weight formula (especially LGD, but also variables such as EAD and M). Lowe (2002) provides an extensive analysis of cyclical effects that could arise, in particular owing to changes in expected loss (or LGD) at different points in the cycle. However, it is also emphasized that the way in which regulators choose to implement Basel II (for example, to what extent they require banks to maintain typical levels of capital above the Basel minimum requirements) will influence importantly the degree of cyclicality. While Lowe concludes that VAR models implemented under the advanced IRB approach have the potential to introduce substantial level changes and volatility into expected default rates, this may be mitigated by other factors, such as improvements in credit-risk management, capital buffers over regulatory minimums, and changes in supervisory practices.

Allen and Saunders (2003) suggest that the growing use of credit-risk measurement models (e.g., Merton-type models) may accentuate the procyclical tendencies that already exist within the banking sector, regardless of what is required by Basel II. For example, these models will tend to produce “overly optimistic” estimates of default risk during booms, reinforcing the tendency to overlend. This emphasizes the important point that what is critical from the perspective of Basel II (but not necessarily from the perspective of regulators) is the additional cyclicality that it will introduce into a system that already has cyclical tendencies. As with Lowe, it is also noted that under the IRB approach, cyclical influences can emerge from a range of variables that ultimately contribute to the estimates of default probability.

The work by Allen and Saunders, and others, stresses the particularly important impact that changes in the assumed value of LGD could have on the required capital charge. Altman, Resti, and Sironi (2002) undertake an extensive simulation exercise, applying annual ratings transition matrices over the period 1981–2000 to a somewhat stylized loan portfolio. They contrast a scenario where the value of LGD is held constant at 50 per cent, to one where LGD is correlated with changes in default rates and allowed to vary between 40 and 60 per cent. In the latter scenario, the positive correlation between LGD and default rates brings about a sharp increase in the cyclicality of capital charges under Basel II. Cave et al. (2003) also emphasize the potentially central role of LGD estimates for banks applying the advanced IRB approach. They show that, under the proposed formula, the capital charge would be directly proportional to the loan’s estimated LGD. They also calculate the capital charge that would arise for an “average” portfolio and a “stressed” portfolio that draws on data from 2002, when credit quality was under downward pressure. These scenarios all produce lower minimum capital requirements than Basel I (excluding the proposed charge for operational risk), but the reduction is significantly less under the stressed scenario, which implies the presence of cyclicality.

Altman, Resti, and Sironi (2002) and Cave et al. (2003) again emphasize that supervisory involvement in the implementation of Basel II will have a significant impact on outcomes. For example, banks using the advanced IRB approach (and their regulators) may use a longer-term view of LGD that would mitigate its potential cyclical impact. As Altman, Resti, and Sironi point out, however, this could trade stability for precision, because banks maintain a less up-to-date picture of their risks. Cave et al. suggest that the intent is to use a period of financial stress to generate representative LGDs. Similarly, while PD has a one-year horizon, it is expected that banks will be encouraged to take a conservative view of PDs such that loans originating from cyclically vulnerable industries could be slotted into a lower rating grade than long-run average PDs would indicate.

French (2004) estimates the capital impact of Basel II’s advanced internal ratings-based approach for all FDIC-insured commercial banks. The reference period is similar to our own, 1984–2002. The author develops several scenarios for a range of risk parameters that banks might use in the capital formulae. The scenarios are conducted for four portfolios, including wholesale loans, aggregated across all banks. The net charge-off rate is used as a proxy of expected loss, from which a corresponding unexpected loss is derived. French finds that Basel II capital requirements will likely be much lower in level terms than those of Basel I; in fact, they will be “well below the levels needed for current Prompt Corrective Action (PCA) purposes.” French also reports very large swings in capital ratios over the cycle for wholesale lending, in excess of five percentage points.

5. Highlights from the Basel Committee’s Third Quantitative Impact Study

The BIS has undertaken several quantitative assessments of the impact that Basel II will have on banks’ actual capital requirements. The first quantitative impact study (QIS) was completed in 2000 (Table 3). The third full QIS (QIS 3) was initiated in October 2002, and the summary results published in May 2003 (BIS 2003b). In total, 365 banks from 43 countries participated in QIS 3. Results are reported for several different groups of banks, and this discussion follows those reported for the “G-10 Group 1” banks, which the committee believes is “broadly representative of the large, internationally active banks in these countries [the G-10].” Among the available groups, it is likely to be most representative of the situation that the major Canadian banks are facing.

Table 3: The Quantitative Impact Studies

QIS	Started	Results published	Banks participating
1[a]	July 2000	–	–
2	April 2001	November 2001	138
2.5	November 2001	June 2002	38[b]
3	October 2002	May 2003	365

a. QIS 1 was a relatively limited exercise used to inform the calibration of subsequent impact studies.
b. Although QIS 2.5 involved a smaller number of banks than QIS 2, it focused on those that were among the largest and most internationally active.

A key aspect of Basel II is that it retains Basel I’s minimum 8 per cent required ratio of capital to risk-adjusted assets. In other words, although the proposed revisions are intended to substantially increase the sensitivity of capital to the riskiness of assets (in addition to introducing an explicit capital charge for operational risk), they are not intended to introduce a significant change, up or down, in the aggregate level of capital held by banks. Thus, the committee emphasizes in its summary results the degree of change, or lack thereof, from the current minimum capital requirements.

The results from QIS 3 indicate that, for the G-10 Group 1 banks, the overall capital charge would rise somewhat for banks that use the standardized approach, but remain largely unchanged if the IRB approach (either foundation or advanced) was used (Table 4).[25] Banks implementing the IRB approach experienced particularly large reductions in capital requirements on their retail exposure, leading to an overall decline in the capital charge for credit risk. This was offset by the new capital charge for operational risk. The impact can vary dramatically for individual banks, owing to differences in portfolio composition (see the last two columns of Table 4). With respect to the overall results, however, the committee concludes that “the framework as currently calibrated produces capital requirements broadly consistent with the Committee’s objectives.”

25. The results are based on Basel II as it existed in late 2002. Actual results will change in line with changes to Basel II.

Table 4: Per Cent Change in Capital Requirements for "G-10 Group 1" Banks

	Average	Credit risk	Operational risk	Maximum	Minimum
Standardized	11	0	10	84	–15
IRB foundation	3	–7	10	55	–32
IRB advanced	–2	–13	11	46	–36

Source: BIS (2003b, page 3, Table 1)

The results from the QIS studies do not allow us to assess the variation in capital requirements that might be created by cyclical movements in credit quality over time. Each QIS, by design, provides only a "snapshot" of the minimum capital requirements at a specific point in time. In addition, given the committee's objective of achieving a largely unchanged level of required capital in aggregate, they have deliberately adjusted the criteria to meet this objective (with QIS 3, for example, moving substantially closer than QIS 2, which was completed in 2001).

This highlights an important limitation of inferring the impact of the proposed Basel II accord from the QIS studies. By design they are static analyses. They do not show the sensitivity of the capital charges to variations over time in the riskiness of bank portfolios. Furthermore, they do not capture the induced behavioural response of banks (in terms of the assets they will hold in their portfolios) to the changed (and changing over time) incentives created by Basel II. The counterfactual analyses of the Canadian banking system provided in later sections of this paper address the first concern, demonstrating the change in capital levels in response to historical changes over time in the riskiness of assets, but they do not capture the induced behavioural impact of Basel II.

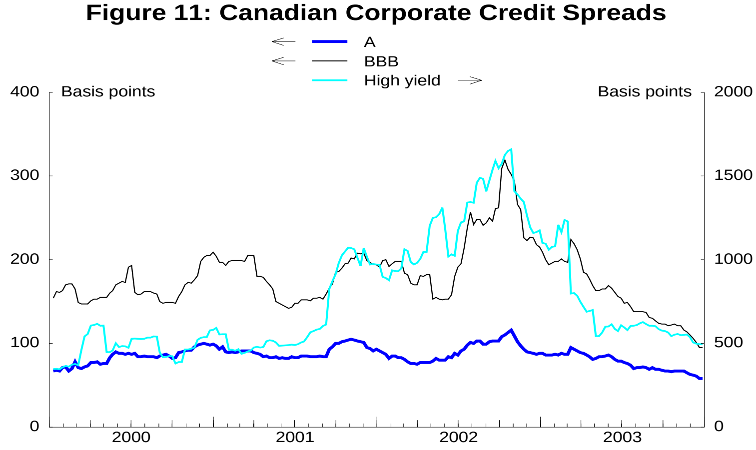
A second concern is that the state of the cycle will affect the calibration of the capital calculation formulae in Basel II. If, for example, the Basel formulae are being calibrated to achieve an 8 per cent minimum capital requirement at a time when credit quality is worse than normal, then presumably the calibration parameters will have to be adjusted accordingly; i.e., set at "easier" levels, in order not to exceed the 8 per cent target, despite poor credit quality. This, in turn, implies that, owing to the risk sensitivity inherent in the Basel Accord, over the entire cycle the average required level of capital will be lower than 8 per cent (the reverse would be true if the formula were calibrated at a time of better-than-average credit quality). The four QIS studies were initiated between mid-2000 and late-2002, a period of declining credit quality. Indeed, the recent cyclical low in credit quality was reached at roughly the time of QIS 3. The recent cycle in credit quality is discussed further in section 6.

6. Recent Developments in the Credit Cycle

The recent cycle in credit quality provides a useful period upon which to test the effects of Basel II. Over the period 2001–02, corporations experienced a marked deterioration in credit quality, both globally and within Canada. The diverse factors that contributed to this included the bursting of the "bubble" in equity prices beginning in 2002 (particularly for stocks in the hi-tech sectors); revelations of questionable corporate accounting and governance practices, which damaged investor confidence in financial statements and led to a reassessment of the financial strength of a number of corporations;[26] heightened geopolitical concerns following the 11 September terrorist attacks in the United States; and sluggish global economic growth.

In this environment of increased uncertainty, changing perceptions of risk associated with financial assets and declining investor willingness to take on risk (i.e., rising risk aversion) contributed to the movements in equity and bond prices. Spreads on high-yield (i.e., relatively risky) bonds, another indicator of credit quality, rose particularly sharply (Figure 11). The most recent period therefore provides an important "stress test," allowing us to assess the impact of a significant "real world" variation in credit quality on bank capital under the rules outlined in Basel II.

Figure 11: Canadian Corporate Credit Spreads



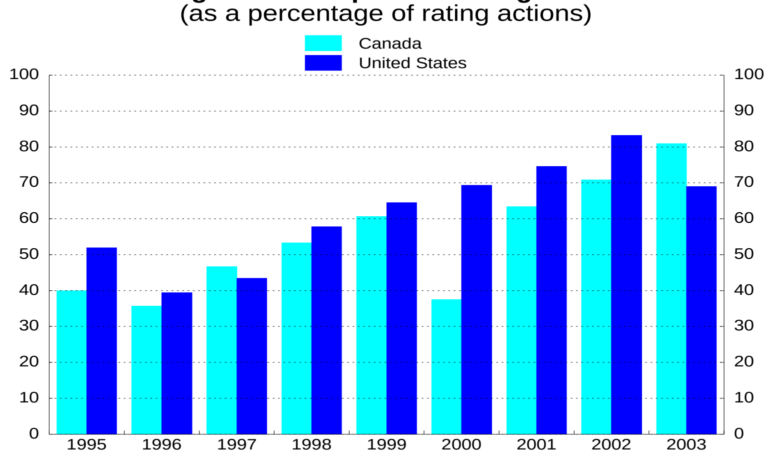
Source: Merrill Lynch (2004)

26. Enron, for example, declared bankruptcy in December 2001.

Rated bond issues provide the external credit ratings that are used in the standardized approach, and which might possibly be used to proxy the IRB approach. Outstanding Canadian bond issuance rose steadily through the 1980s and 1990s, flattening in 2002 as issuance slowed in response to deteriorating credit conditions and perhaps reduced demand for funds. The proportion of corporate bond issuers assigned a credit rating by rating agencies has risen. Moody's (Hamilton and Ou 2003), for example, rated 51 Canadian corporate bond issuers in 1989, and 193 in 2002. The value of rated issues over this period rose from $6.4 billion to $50.8 billion.

The severity of the latest cycle in credit quality is indicated by shifts in credit ratings and developments regarding bond defaults and recovery rates. During periods of heightened financial stress, we would anticipate that the number of credit rating upgrades would diminish relative to downgrades. Figure 12 shows that credit rating downgrades have increased markedly. Credit rating drift, which summarizes the aggregate movement in credit ratings, has moved in the direction of lower overall ratings. Globally, the percentage of issuers downgraded reached record highs in 2001 and 2002 (based on Moody's data). The deterioration in the rating of investment-grade issues, while remaining much lower than for speculative-grade issues, was particularly intense compared with earlier periods of declining credit quality.

Figure 12: Corporate Downgrades
(as a percentage of rating actions)



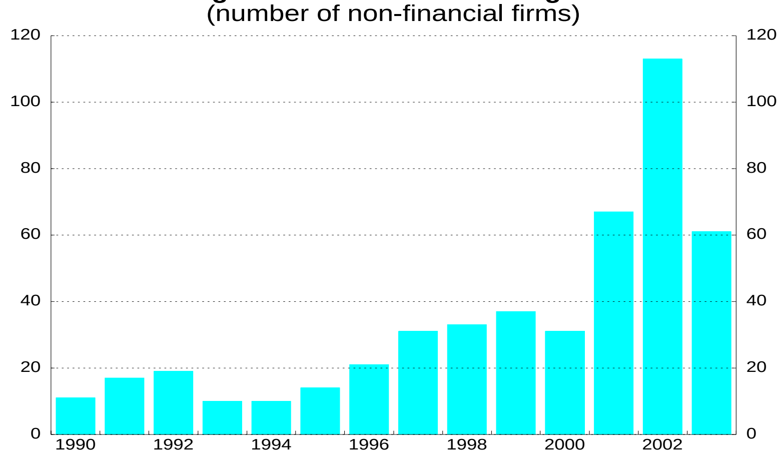
Source: Moody's (2004)

The deteriorating trend in default rates during the current credit cycle is even more evident. Globally, the dollar value of defaults rose sharply, well beyond earlier experience. The total value of defaults on rated issues rose to US$163 billion (Moody's data), and rated defaults in Canada rose sharply to Can$14 billion.[27] Rising defaults in absolute terms may simply be the result of an

27. In Canada, defaulted issues were heavily concentrated in the telecommunications sector.

increase in the rated universe of bonds, such that default rates provide a better indication of the likelihood of default. Although one must be cautious of small-sample properties, default rates in Canada spiked upward in 2000–03, beyond that observed in earlier periods. A relatively large proportion of "fallen angels," issues moving from an investment grade to a speculative grade, typifies the current global cycle (Figure 13).

Figure 13: Global Fallen Angels
(number of non-financial firms)



Source: Moody's (2004)

With respect to recovery rates, over the period 1989–2002, the average, dollar-weighted recovery rate for Canadian bonds was 26 per cent, compared with 35 per cent for U.S. bonds. The smaller sample size for Canadian bonds may explain part of this difference, although a heavy concentration in telecommunications firms (telecoms) is also a factor. Excluding telecoms, recovery rates in Canada and the United States are similar. The 1999–2002 period heavily influences these figures, given the cyclically high default rates and cyclically low recovery rates (Table 5).

As discussed above, the historical propensity for bonds with a particular credit rating to be shifted to another rating over a specified time horizon, or to fall into default, can be summarized within a transition matrix (section 7.3 describes transition matrices in detail). Over a one-year horizon, most issues will tend to retain their beginning rating at the end of the period. The available data, however, suggest that downgrades and defaults become more prominent during periods of macroeconomic weakness; i.e., they display cyclicality, which under Basel II has the potential to be reflected in banks' minimum capital requirements.

We use historical transition matrices to represent the evolution of credit ratings assigned to assets in bank portfolios, against which the bank must hold capital. Of course, the bond assets that underpin the transition matrices are, at best, a rough proxy for the assets held by the domestic banking system. In particular, under the standardized approach, many bank assets would not have a rating, and would therefore be assigned a 100 per cent capital weight under the proposed rules. Thus, the use of transition matrices can best be thought of as proxying the capital requirements for a group of banks that are using the IRB approach; i.e., the banks are assigning internally derived ratings to most of their assets in a manner that would be similar to what external credit rating agencies would do (if they had assigned ratings to all bank assets). If we assume that LGD is constant, then this would most closely simulate the foundation IRB approach. Note from the above, however, that there is evidence that the recovery rates for bonds and bank loans are correlated with default rates, which represents a potentially important additional source of cyclicality.

Table 5: Average Defaulted Bond Recovery Rates, 1989–2002

	Sample size	Issue-weighted mean (per cent)	Dollar-weighted mean (per cent)
Canada all bonds	67	32.6	26.0
Canada excluding telecoms	50	38.9	36.6
United States	1379	39.5	35.2

Note: Based on estimates by Hamilton and Ou (2003) of bond prices in the secondary market one month after the default date. The issue-weighted mean is the sum of each bond's recovery rate divided by the number of bond issues. The dollar-weighted mean is the sum of each bond's face value multiplied by its recovery rate, divided by the sum of all face values.

7. Counterfactual Analysis of Basel II Minimum Capital Requirements

In this section, we compute counterfactual capital requirements for Canadian banks' wholesale exposures over the 1984–2003 period using Basel II rules. While this approach captures the impact of changes in the riskiness of banks' asset portfolios based on historical data, an important caveat is that these simulations do not allow for changes created by Basel II to the behavioural response of banks (i.e., how the banks would modify their portfolios, initially and over time, in response to a change in the regulatory regime). Sensitivity analysis, however, can provide some insight into the potential behavioural impact.

We apply the advanced IRB formulae discussed in section 3 to various hypothetical portfolios based on Canadian banking system data. We focus on wholesale exposures, defined as loans, securities, and other claims on commercial and industrial firms, other banks, and sovereigns, because these exposures contribute the most to banking system losses. Indeed, despite the decline in wholesale exposures as a percentage of overall banking system assets, from 60 per cent in 1984 to 35 per cent in 2003, they still accounted for 94 per cent of losses, on average, over the 1994–2003 period.[28] Consequently, wholesale exposures are expected to generate the greatest variation in Basel II required capital and provisions, and are thus of the greatest analytic interest.

The first step in constructing counterfactual requirements is to estimate the credit quality of the banks' wholesale portfolios. These estimates provide us with the key credit-risk parameters required for the Basel II capital formula. We describe two estimation techniques in the following sections: one approximates a point-in-time ratings approach, and the other approximates a through-the-cycle ratings approach. Sovereign exposures are discussed separately, because we are able to provide more precise estimates of their credit quality. We input the exposures and risk parameters into the Basel II expected and unexpected loss formulae and analyze the results under different scenarios.

7.1 Estimating the credit quality of wholesale exposures

Canadian banks that opt to use ratings from external credit rating agencies will likely see little change from the current rules of Basel I; because only rated borrowers will receive varying capital treatment, and there are relatively few rated borrowers in Canada. For example, only about 200 Canadian corporations had bond ratings from either Moody's, Standard & Poor's, or DBRS in 2002 (Hamilton and Ou 2003). As a result, most Canadian commercial and industrial exposures are to firms without external credit ratings.[29] For the time being, therefore, the largest impact from Basel II will be on banks that use internal ratings.[30]

Since the banks' internal ratings are unknown, we must estimate the quality distribution of their commercial and industrial, and interbank, exposures to calculate counterfactual capital requirements. Data on exposures to individual sovereigns are available, however, so no estimation is needed.[31] The point-in-time approach is approximated by using market-implied ratings. The

28. Loan-loss allowances for mortgages account for most of the remainder. Of these, slightly over half are for non-residential mortgages. A detailed breakdown of losses by sector prior to 1994 is not available. However, 94 per cent likely represents a minimum, because residential mortgage losses as a share of total losses peaked in 1995.
29. Slightly over 52 per cent of business loans in Canada have authorizations of under $5 million, a threshold that is well below the size of loans typically rated by credit rating agencies.
30. On the other hand, most sovereigns and banks have externally available credit ratings.
31. We assume that banks' internal credit assessments of sovereign borrowers are, on average, the same as those from the major rating agencies.

through-the-cycle approach is approximated by using ratings from the major credit rating agencies. Our principal working assumption is that aggregate measures of credit quality are broadly representative of the aggregate portfolios of chartered banks.

7.2 Market-implied estimates of credit quality

We consider two popular techniques used to estimate credit quality based on market data.[32] The first approach is in the spirit of Cantor and Mann (2003), who translate the bond yield for a given borrower into a credit rating. This "mapping" technique essentially involves minimizing the squared difference between the bond yield and the average yield on bonds with known alphanumeric credit ratings (i.e., AAA, AA+, AA,..., C) of similar duration at each point in time.

This approach is equivalent to a through-the-cycle rating, since the mappings fluctuate in tandem with the cyclical movements in yields (and, therefore, risk weights change only when there is a relative change in yields). In our case, we disaggregate the Canadian banks' commercial and industrial exposures into 17 sectors (interbank exposures are included in the "financial services" sector).[33] We then map the market-weighted average yield on bonds in that sector (a proxy for yields on overall bank claims) to an alphanumeric rating.[34] For example, if the average yield on bonds in the communications sector was 9 per cent in 2002, and this most closely matched the average yield on BB-rated bonds, then exposures to the communications sector in 2002 would be assigned a mean rating of BB. A similar exercise is carried out for sovereign borrowers.[35]

A second approach used to estimate credit quality based on market data follows Buckle, Cunningham, and Davis (2000), who derive one-year expected credit losses from bond-yield spreads with no adjustment for their cyclical fluctuations. This is equivalent to a point-in-time ratings approach. Specifically, assuming investors are risk neutral, the one-year no arbitrage expected credit-loss (ECL) condition can be expressed as,

$$ECL = \beta \cdot (1 - \rho) = \frac{(y - r)}{(1 + y)} , \tag{5}$$

32. A third technique is to use a Merton model of firms' distance-to-default based on their share prices and balance-sheet data. We leave this approach to future work, given the significant data requirements.
33. Chemicals, communications, multi-product conglomerates, construction, food processing, general industrial, hotels and food service, metals, mining, pipelines, refining, retail, miscellaneous services, textiles, transportation and warehousing, utilities (non-gas, non-telecom), and financial services.
34. In both cases, Merrill Lynch bond indices from Datastream are used.
35. If a sovereign bond yield is unavailable, we use the nearest comparable yield based on credit rating, geographical proximity, or economic similarity.

where β is the probability of default, ρ is the recovery rate, the numerator is the yield spread, and the denominator is the gross yield. In the case of commercial and industrial, and interbank, exposures, y is proxied by the average yield to maturity on bonds in each of the 17 sectors, where the bonds have a median duration of five years.

In the case of exposures to emerging-market sovereigns, y is proxied by the U.S.-dollar-denominated bond yield for each sovereign, or the closest available representative yield.[36] In the case of highly developed nations, a zero-yield spread is assumed (i.e., zero expected loss). Finally, r is the risk-free rate proxied by the no-coupon benchmark 5-year government yield. Table A6 in the appendix reports the results of applying this methodology to Canadian banks' sovereign exposures.

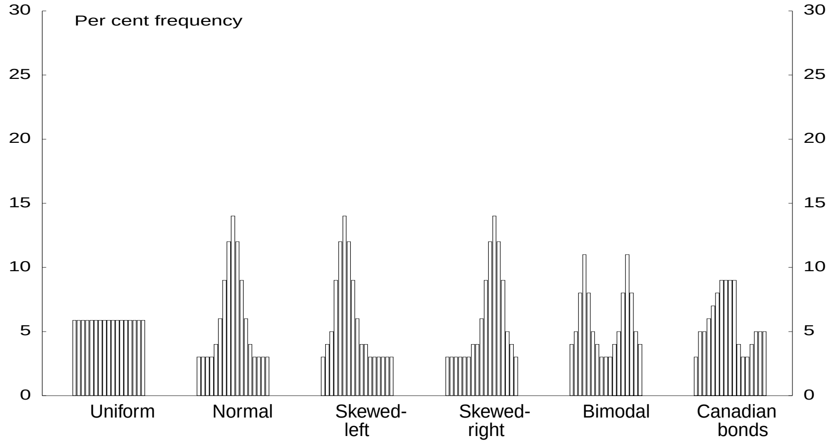
Yield spreads also incorporate non-credit risk factors, such as premiums for liquidity and market risks, and the degree of investor risk aversion. These factors represent a proportionately larger share of the total yield spread on investment-grade debt than on speculative-grade debt, resulting in upwardly biased estimates of credit loss for high-quality borrowers. To adjust for these factors, O'Kane, Schloegl, and Greenberg (2003) estimate non-credit risk spread premiums by alphanumeric rating. The premium is equal to the difference between the actual spread and the ECL based on actuarial loss. We use their approach to correct the ECL estimates from equation (5). Note that the expected credit-loss measure implicitly incorporates a variable LGD, which is permitted under the advanced IRB approach.

In the case of commercial and industrial, and interbank, exposures, the distribution about each sector's mean rating is unknown. Therefore, we experiment with several hypothetical distributions that cover a plausible range of possibilities (Figure 14). If the quality of bank exposures is more or less spread out evenly across the ratings spectrum, for example, then the uniform distribution would be a fair approximation. It is more likely, however, that credit quality is clustered around one or more particular rating categories. In this case, either the normal, skewed-left, skewed-right, or bimodal distributions would be a better approximation. The distribution of exposures could also resemble the known distribution of Canadian bonds.[37]

36. For example, if a sovereign does not borrow in U.S. dollars, or if data are unavailable for a given year, then we substitute the yield on debt that has the closest alphanumeric rating to the sovereign that year. Table A7 in the appendix for a description of sovereign credit ratings.

37. For sovereign exposures, the distribution is known.

Figure 14: Hypothetical Distributions of Loan Ratings



Source: Hamilton and Ou (2003) and authors' calculations

In fact, based on current anecdotal evidence, the quality of Canadian bank exposures is roughly normally distributed, with slightly less than one-third of the distribution within one rating notch of BBB+, two-thirds within four notches, and 95 per cent within seven notches. Thus, a little more than two-thirds of bank exposures would be rated investment grade (i.e., BBB– or higher), as shown in the "normal" column of Table 6. This corresponds roughly to the quality distribution of corporate bonds in 2002.[38] It also closely matches the portfolio distribution for "high-quality" U.S. banks, according to a Federal Reserve Board (FRB) survey reported by Catarineu-Rabell, Jackson, and Tsomocos (2003). That survey also reported a distribution for "average-quality" U.S. banks, which is close to our hypothetical "skewed-right" distribution.[39]

If banks target a higher or lower average-quality borrower in the future, then the distribution will become skewed. Table 6 reports a "skewed-left" distribution that has a median portfolio rating of A2, with 78 per cent of exposures rated investment grade. The "skewed-right" distribution has a median portfolio rating of BB, with 41 per cent rated investment grade. Alternatively, the market may be segmented such that there are clusters of high- and low-quality borrowers, or risk-averse and risk-taking lenders. In these situations, a bimodal distribution may be a better approximation (not shown in the table). A possibility that we do not consider is a time-dependent distribution. For example, the rating distribution of firms seeking credit may be skewed left during an

38. Moody's data are based on the number of issuers, rather than dollar volumes, which exaggerates the weight on the B and C categories.

39. The Basel Committee (BIS 2001) reports that the average distribution of commercial and industrial bank loans in industrialized countries is split between 20 per cent A credits, 19 per cent B and past-due credits, and 61 per cent non-rated credits.

economic boom and skewed right during a recession. In our counterfactual scenarios, we assume that new exposures have the same distribution as the original portfolio.

Table 6: Various Estimates of the Quality Distribution of Bank Portfolios

	Actual Canadian bond distribution (%)†		Hypothetical bank portfolio distribution (%)			FRB survey of U.S. banks 2002 (%)*	
	1989	2002	Skewed left	Normal	Skewed right	High quality	Average quality
AAA	16	3	3	3	3	4	3
AA	35	16	18	9	9	6	5
A	27	24	38	19	10	29	13
BBB	14	27	19	38	19	36	29
BB	2	11	10	19	38	21	35
B	6	14	9	9	18	3	12
C	0	5	3	3	3	1	3
Investment grade	92	70	78	69	41	75	50
Speculative grade	8	30	22	31	69	25	50
Median rating	AA	BBB	A	BBB	BB	BBB	BB

†Source: Hamilton and Ou (2003), by number of financial and non-financial corporate bond issuers (dollar volume not available)
*Source: Catarineu-Rabell, Jackson, and Tsomocos (2003), by dollar volume of corporate loans

7.3 Estimates of credit quality from credit ratings filtered through transition matrices

Rating-transition matrices provide an alternative approach to estimating the historical evolution of credit quality. A transition matrix maps the evolution of a portfolio's debt ratings over a given time horizon. We apply a sequence of one-year transition matrices, starting in 1983 and ending in 2003, to the 17 sectoral portfolios. The initial distributions of the portfolios have to be estimated (as above), but the subsequent distributions are based on the transition probabilities. Each element of each matrix is computed as,

$$P_t(R_t = \beta|\alpha) = \sum_{i=1}^{n} \frac{R^{\beta}_{i,t}}{R^{\alpha}_{i,t-1}} \qquad \forall\alpha = Aa1\ldots C \qquad and \qquad \forall\beta = Aa1\ldots D\,, \tag{6}$$

where P is the probability at time t of having rating R, n is the number of rated issuers, α is the 17-point alphanumeric ratings vector [*AAA*, *AA+*, *AA*,..., *B*, *B*–, *C*], and β is the same vector with an additional default (D) element.[40]

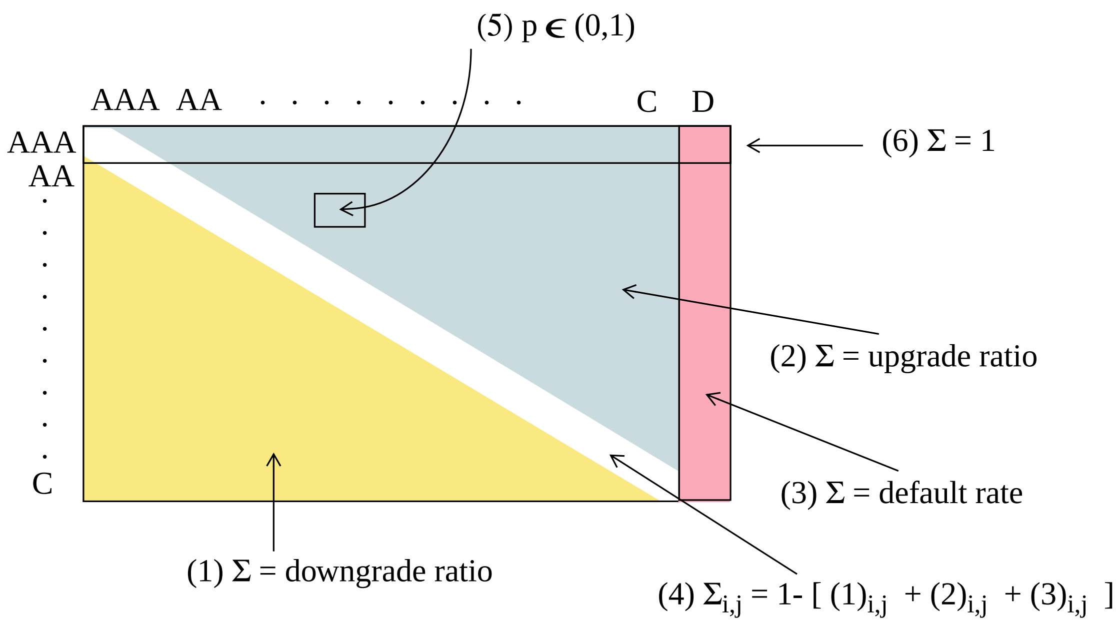
Exposures that transition to default (D) are assumed to be replaced in the following year by new exposures with the same distribution as the portfolio (the bracketed term in equation (7)). Therefore, the estimated value of exposures (V) in year t for sector j, with a sectoral portfolio growth rate of g, and having a rating of β, is,

$$V^{\beta}{}_{j,t} = V_{j,t-1}{}^{\beta} \cdot \left[1 + \frac{V^{D}{}_{j,t-1}}{\sum_{\beta = Aaa}^{D} V^{\beta}{}_{j,t-1}} \right] \cdot P_t(R_t = \beta|\alpha) \cdot g_{j,t} \,. \qquad (7)$$

Hamilton and Ou (2003) calculate transition matrices for Canadian corporate bonds for the 1989–2002 period, which we use as a proxy for the transition matrices of bank exposures in general. These matrices have low statistical power, because they are based on very few observations in the initial years, but they are nevertheless remarkably similar to U.S. corporate transition matrices. Therefore, for missing years, we iteratively estimate Canadian matrices using the available U.S. matrices subject to six constraints: (1) the sum of the probabilities of transitioning to a lower rating equals the observed downgrade ratio for Canada; (2) similarly, the sum of the probabilities of transitioning to a higher rating equals the observed upgrade ratio of Canada; (3) the sum of the probabilities of defaulting equals the Canadian default rate; (4) the probability of retaining the same credit rating equals 1 minus the probability of transitioning based on the above constraints; (5) all probabilities lie in the interval (0,1); and (6) the sum of all probabilities in a given row of each matrix equals 1. These constraints are illustrated for a stylized transition matrix in Figure 15.

40. Transition matrices also typically include a “withdrawn” category. The probability of a withdrawal increases at lower rating levels, often because firms wish to avoid a downgrade. We have chosen to reallocate the probability of withdrawal (usually around 4–8 per cent) to the other categories.

Figure 15: Interpolating Transition Probabilities for Years with Missing Data Points



We consider two Canada-specific default rate series: one based on Canadian bond defaults, the other based on Canadian bank loans data. The latter are estimated by dividing aggregate bank provisions for wholesale exposures by a historical time-varying recovery rate.[41] As is the case with U.S. and global transition matrices, the Canadian matrices exhibit a small downward ratings "drift" over time (i.e., downgrades have exceeded upgrades over this period). Nevertheless, even for very low quality distributions, the drift in mean credit ratings amounts to only one rating notch after 20 years.

7.4 Sovereign exposures: Estimates of credit quality from credit ratings

In the case of sovereign exposures, we use the actual ratings over history, rather than transition matrices. The availability of sovereign credit ratings has increased dramatically over the past 15 years (Table A7 in the appendix). Emerging-market economy (EME) sovereign ratings, however, were scarce in the early part of our reference period. As a result, only 34 per cent of Canadian banks' sovereign exposures on a dollar-weighted basis were to countries that already had external credit ratings in 1984 (Table A5 in the appendix). By 1990, however, fewer than

41. The time-varying recovery rate is based on the average price of defaulted U.S. bonds measured 30 days after default. Hamilton and Ou (2003) report that the historical recovery rate for Canadian bonds is not statistically different from that for U.S. bonds. A time series is publicly available only for the latter, however.

10 per cent of exposures were unrated. Therefore, from 1990 onwards, our estimates of the credit quality of the Canadian banks' sovereign exposures are largely data-determined.

7.5 The treatment of expected and unexpected losses

As discussed in section 3.3, expected and unexpected portfolio losses will have to be offset with minimum provisions and capital, respectively. We have chosen to report combined results for required capital and provisions, because a shortfall in provisions will have to be capitalized under Basel II. Although the tax treatment of, and the mix of securities that will be eligible to meet, any shortfall in provisions will be different, both provisioning and required capital represent a burden on earnings. The combination of the two requirements does not qualitatively alter the results, because both losses move largely in tandem. In fact, the quantitative results are not substantially different, because the expected loss component is relatively small compared with that for unexpected loss. To make a fair comparison between effective Basel I and Basel II requirements, therefore, we add provisions for defaulted claims to the reported Basel I requirements. Thus, we consider the total burden on earnings of both regimes.

7.6 Counterfactual capital and provisions requirements based on credit quality

We can now estimate what the required capital and provisions on Canadian banks' wholesale exposures would have been over the past 20 years if Basel II had been in effect. Table 7 reports the results for a "base-case" portfolio using through-the-cycle and point-in-time risk assessments. As one would expect, the results depend heavily on the assumptions made above. We therefore conduct a variety of sensitivity analyses. As a general rule, we err on the side of prudence by making conservative assumptions such that our estimates are, if biased at all, biased slightly upward and towards less variability.

For the purposes of this paper, the aggregate commercial and industrial portfolio includes exposures to small and medium-sized (SME) firms, even though these exposures will attract slightly lower regulatory capital than exposures to large firms of comparable credit quality.[42] Loans with authorizations of under $1 million, which is an approximation for SME exposures, represented 21.1 per cent of commercial and industrial exposures at year-end 2002. If we have made the correct assumption about the credit-quality distribution of the aggregate portfolio, then

42. The risk of their exposure to SME firms is considered to be more idiosyncratic (i.e., less correlated with other assets). Thus, the relief comes from reducing ρ via equation (2). Exposures to SMEs are defined under Basel II as firms that have sales less than €50 million. (Certain other measures may be used if sales volumes do not accurately reflect the size of the business.)

including the SME exposures will bias our results upward slightly. However, uncertainty about the true distribution, which can go in either direction, likely outweighs the loss of precision by treating these exposures identically.

As discussed at the beginning of section 3, required capital and provisions will also depend on the average maturity of the loans and the expected LGD. Asterisks in Table 7 indicate how robust the results are to changes in these assumptions. Each asterisk indicates how many changes to the maturity and LGD assumptions one has to make, in increments of six months and 10 percentage points, respectively, for the counterfactual Basel II capital ratio to exceed that of Basel I. For example, one asterisk (*) means that the requirement under Basel II would be greater if we assumed a 3-year average portfolio maturity (rather than 2.5 years), ceteris paribus, or an LGD of 55 per cent (rather than 45 per cent).

Table 7: Basel II Counterfactual Capital Ratios (includes required provisions and operational risk charge)

Shaded cells indicate that the Basel II requirement would be higher than the Basel I capital requirement (including provisions). Asterisks denote the robustness of each result.

Portfolio	Risk-assessment technique	Basel II counterfactual capital ratios (% of exposures)			
		1984	1989	1993	2003
Commercial and industrial, and interbank, exposures	Through-the-cycle	6.6***	4.3***	5.6***	5.2**
	Point-in-time	4.2***	5.7***	7.3*	7.3
Sovereign exposures	Through-the-cycle	6.7	10.2***	4.9**	1.9*
	Point-in-time	5.7	6.8***	3.2	1.6
Memorandum item: Actual banking system capital plus total general and specific provisions as a percentage of total assets		6.5	8.1	8.5	6.5

*** Robust to three or more incremental changes in LGD or maturity assumptions
** Robust to two or more incremental changes in LGD or maturity assumptions
* Robust to one incremental change in LGD or maturity assumptions

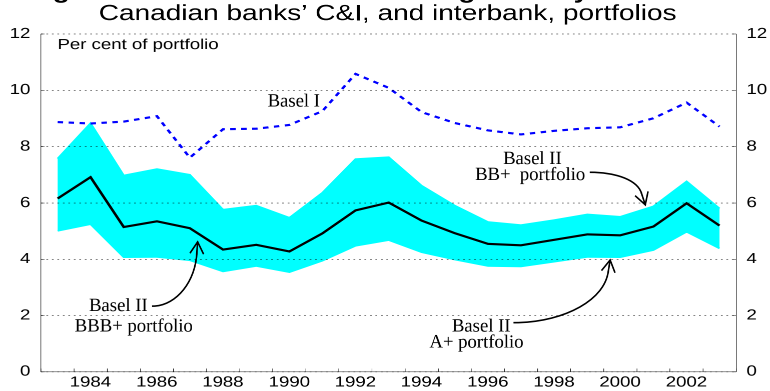
Notes: The comparison is based on Basel I requirement plus general and specific provisions for the given year. Basel I requirements are estimated prior to 1988. Basel II ratios include required capital for unexpected loss, required provisions for expected loss, and an operational charge as per the basic indicator approach outlined in BIS (2003d).

The base-case scenario uses a normally distributed commercial and industrial, and interbank, portfolio with an initial median rating of BBB+ and a time-varying default rate that is consistent with historical Canadian bank loan losses. The base case uses the actual aggregate sovereign portfolio and default rate.

We use the basic indicator approach to calculate an operational risk charge. Although details of this method have yet to be finalized, the current basic formula suggests that 15 per cent of the 3-year moving average of gross income should be held as capital to offset operational risk. On the margin, the moving-average component of this method adds to the cyclicality of capital requirements, because income is procyclical. However, the variation over the cycle is small enough in absolute terms that it does not meaningfully affect our results.

Figure 16 illustrates how the capital ratio can vary by changing the assumed median quality of the portfolio using a through-the-cycle ratings approach. (Our base-case commercial and industrial, and interbank, portfolio is normally distributed with an initial median rating of BBB+.) One interesting result is that the evolution of the portfolio over the cycle can still result in level shifts that are greater than the initial-level differences between the variously rated portfolios. A possible implication of this cyclical effect is that banks may not be able to contain their capital requirements during recessions, even if they dramatically shift their portfolios towards higher-rated exposures.

Figure 16: Basel I versus "Through-the-Cycle" Basel II
Canadian banks' C&I, and interbank, portfolios

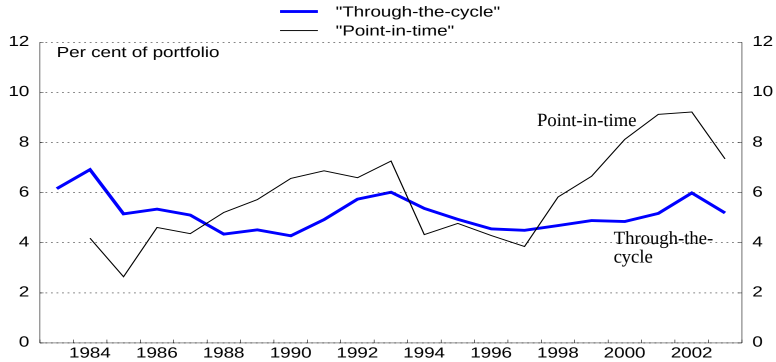


Basel I ratio includes capital plus general and specific provisions.
Basel II ratio includes required capital for unexpected loss, required specific provisions for expected loss, and an operational risk charge.
Source: Authors' calculations based on BIS (2003d)

This result is even stronger if we consider a point-in-time ratings approach. Figure 17 contrasts the evolution of required capital and provisions for Canadian banks' wholesale portfolios using through-the-cycle and point-in-time ratings approaches. Both assume a BBB+ median-rated portfolio.The steep increase from 3.9 per cent in 1997 to 9.2 per cent in 2002 is indicative of the considerable scope within the Basel II framework for required capital and provisions to vary with the cycle. Recall that our point-in-time approach is based on bond market-implied credit risk. An approach based on equity prices, such as a Merton-based model, would have likely produced a similar swing in requirements. It is hard to imagine, therefore, that any bank will choose to rely solely on point-in-time ratings to compute their requirements.

Another interesting result is that counterfactual required capital and provisions were at cyclical highs in 2002, according to both approaches. One may wish to treat the results from QIS 3 with some caution, therefore, since they were calculated using 2002 parameters. In particular, the banks' own estimates of the impact of Basel II may well have been lower had the exercise been carried out at a different point in the cycle.

Figure 17: Simulated Basel II Ratios
Canadian banks' C&I, and interbank, portfolios



Both ratios include required capital for unexpected loss, required specific provisions for expected loss, and an operational risk charge.
A median portfolio rating of BBB+, and an LGD of 45 per cent, are assumed.
Source: Authors' calculations based on BIS (2003d)

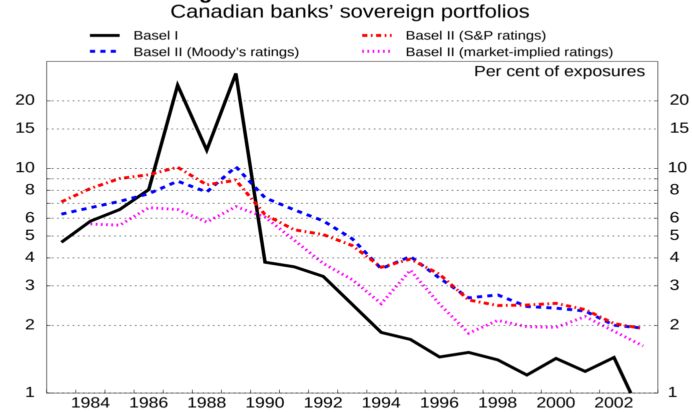
Using a through-the-cycle approach, the counterfactual capital requirements for commercial and industrial, and interbank, loans would be lower under Basel II than under Basel I, ranging from 35 per cent lower for our base case to 45 per cent lower under optimistic assumptions. Using a point-in-time approach, the base case produces a counterfactual requirement that is comparable with that in Basel I. Kiesel, Perraudin, and Taylor (2003), who use a credit VAR measure of economic capital applied to representative U.S. bank portfolios, report even lower capital ratios: between 60 per cent lower for high-quality portfolios and 38 per cent lower for mid-quality portfolios. French (2004), using a broadly similar approach to ours for U.S. banks, finds average reductions of between 14 and 29 per cent.

The results are also quite robust to increases in the maturity and LGD assumptions (as shown by the prevalence of two and three asterisks in Table 7). Even under "low-quality" portfolio scenarios (not shown here), the counterfactual capital requirements would generally be lower.

Using a point-in-time approach (i.e., implied credit risk), capital requirements would have increased markedly in the 1990s, and been greater in 2002 than under the through-the-cycle approach. This is because certain sectors to which the banks were heavily exposed experienced large deteriorations in credit quality, coinciding with a downturn in the business cycle (e.g., construction in the early 1990s and communications in the early 2000s). As a result, not only did their relative credit quality deteriorate, but also their absolute credit quality, which accounts for the divergence of the through-the-cycle and point-in-time approaches.

The results for sovereign exposures suggest that Basel II capital ratios would have been generally higher than capital requirements under Basel I, including country-specific provisions (Figure 18). Owing to large writedowns of LDC loans, however, which had been doubtful or effectively non-performing for several years prior, the Basel I ratio, including specific provisions, jumped to 23 per cent in 1987 and 26 per cent in 1989. Some of these writedowns were later recovered. The counterfactual Basel II requirements were higher leading up to the writedowns, reflecting the relatively high degree of credit risk. The secular decline in capital ratios for sovereign exposures over the past 14 years reflects the rising share of U.S. government claims, which have a zero risk weight in all four cases, and the declining share of exposures to riskier sovereigns in general.[43]

Figure 18: Basel I versus Basel II
Canadian banks' sovereign portfolios



*Basel I ratio includes capital plus country-specific provisions.
Basel II ratio includes required capital for unexpected loss, required specific provisions for expected loss, and an operational risk charge.
Sources: BIS (2003d), Moody's (2004), and Standard and Poor's (2004), and authors' calculations

In summary, it appears that the level of required capital for Canadian banks' commercial and industrial, and interbank, exposures will be lower under Basel II, except perhaps during economic downturns if they adopt credit rating methodologies with strong point-in-time characteristics. The level of required capital for sovereign exposures will likely be higher than under Basel I, although most of the difference can be explained by the charge for operational risk. Perhaps a more

43. There is a weakly positive relationship between the change in the claims on a given sovereign and the change in its bond-yield spread or its external credit rating, which suggests that, within the non-OECD category, Canadian banks have generally shifted their portfolios to less-risky sovereigns over time.

interesting question, however, is whether the proposed capital requirements will be significantly more volatile and cyclical than under Basel I.

8. Volatility of Counterfactual Capital Requirements under Basel II

The capital requirements under Basel II are designed to be risk-sensitive, and therefore have the potential to be more volatile than under Basel I. Moreover, since downgrades, risky yields, and defaults (Cantor, Mahoney, and Mann 2003), as well as bank loan losses, are countercyclical, we might expect Basel II capital to be countercyclical (i.e., increase during recessions).

Table 8 illustrates the standard deviation of Basel I and II capital ratios under several of the more interesting scenarios we consider. Basel II capital ratios for commercial and industrial, and interbank, loans appear to be more volatile under a point-in-time ratings approach, but not substantially more variable under a through-the-cycle approach. Note that the mean level of required capital for sovereigns is not stationary over the sample period, owing to the shift out of riskier sovereign exposures discussed earlier. Thus, the standard deviations for sovereign exposures are not reported.

Table 8: Volatility of Counterfactual Capital
(includes required provisions and operational risk charge)

Portfolio	**Portfolio quality**	**Standard deviation of required capital ratios in percentage points (1984–2003)***		
		Basel I including provisions	**Basel II** through-the-cycle	**Basel II** point-in-time
Commercial and industrial, and interbank, exposures	A-median	0.39	0.44	1.49
	Baa-median	0.60	0.65	1.80
	Ba-median	0.86	0.96	2.71
Memorandum item: Observed standard deviation of Canadian banks' loss buffers†			0.90	

*Basel I requirements are estimated prior to 1988. Basel II ratios include capital for unexpected loss, required provisions for expected loss, and an operational charge as per the basic indicator approach outlined in BIS (2003d).
†Loss buffers are calculated as total actual eligible capital plus provisions.

Table 9 reports the average absolute annual change in required capital as a percentage of pre-tax profits. This is a more economically meaningful measure of volatility, since banks primarily build capital through retained earnings. Because the absolute level of counterfactual Basel II capital is considerably lower, it is not surprising that the changes in capital relative to earnings are also generally smaller than under Basel I. As one would expect, lower-quality portfolios and market-implied risk-based capital approaches are more volatile in terms of earnings.

Counterfactual requirements for sovereign exposures are considerably less volatile than under Basel I if we include provisions for impaired exposures: the level of capital required by Basel I would have been insufficient to cover the losses generated by the large increase in impaired sovereign loans in the late 1980s (recall that Basel I had not yet been implemented, so these, too, are counterfactual results). Consequently, the losses would have had to have been absorbed through provisions, which indeed was the case. In contrast, the level of required capital and provisions under Basel II rules would have been higher leading up to the sovereign loan defaults, and would have thus absorbed the losses with a less-pronounced impact on capital. The higher level under Basel II reflects the fact that, according to publicly available credit ratings at the time, the sovereign exposures posed a high degree of credit risk. Under this counterfactual scenario, therefore, Basel II rules dampen fluctuations in capital.

The actual volatility of capital observed over this period was somewhat higher than the estimated volatility in all the through-the-cycle scenarios, and in all but one (somewhat unlikely) point-in-time scenario. This suggests that the impact of Basel II on earnings may be no greater than the impact of other phenomena over the past 20 years.

Table 9: Volatility of Counterfactual Capital Relative to Earnings
(includes required provisions and operational risk charge)

Portfolio	**Portfolio quality assumption**	**Average absolute annual change as a % of pre-tax profits (1984–2003)**		
		Basel I including provisions	**Basel II** through-the-cycle	**Basel II** point-in-time
Commercial and industrial, and interbank, exposures	A-median	39	22	43
	Baa-median	50	33	47
	Ba-median	61	43	132
Sovereign exposures		16	3	3
Memorandum items: Average absolute annual change of actual capital as a % of pre-tax profits				
a. Pro-rated for the size of the commercial and industrial, and interbank, portfolio				38
b. Pro-rated for the size of the sovereign portfolio				6

Note: The comparison is based on Basel I requirements plus general and specific provisions for the given year. Basel I requirements are estimated prior to 1988. Basel II ratios include capital for unexpected loss, required provisions for expected loss, and an operational charge as per the basic indicator approach outlined in BIS (2003d).

Table 10 reports the correlation between the year-over-year percentage growth rates in GDP and required capital and provisions. The requirements under both Basel I and II are negatively correlated with the economic cycle. The correlations for the combined Basel I measure, however, are not significant at the 90 per cent level for commercial and industrial, and interbank, exposures. The significant positive correlation of 42 per cent for sovereign exposures under Basel I is spurious, because it is largely driven by the previously mentioned LDC writedowns. The writedowns happened to coincide with the peak of the 1980s economic expansion in Canada, hence the positive correlation.

The significant and negative correlation of Basel II capital requirements and GDP is largely due to the unexpected loss component. The expected loss requirements are negatively correlated with the economic cycle, but not at a statistically significant level (on the other hand, the expected loss component is more volatile in terms of earnings). Although the point-in-time ratings approach yields requirements that are more volatile, they are not more correlated with the economic cycle. Also note that the correlation based on the actual growth rate of capital over this period is of roughly the same magnitude. Again, this suggests that the impact of Basel II may be no greater than other phenomena observed over the past 20 years.

Table 10: Correlation of Counterfactual Capital and GDP
(includes required provisions and operational risk charge)

Portfolio	**Portfolio quality assumption**	**Correlation between changes in requirements and GDP (1984–2003) (per cent)**		
		Basel I including provisions	**Basel II** through-the-cycle	**Basel II** point-in-time
Commercial and industrial, and interbank, exposures	A-median	–7	–29*	–23
	Baa-median	0	–31*	–26
	Ba-median	–3	–27	–24
Sovereign exposures		42**	–17	–32*
Memorandum items: Correlation between changes in actual level of capital and GDP (%)				–24

Note: Asterisks denote statistically significant at the 90% (*), 95% (**), and 99% (***) confidence levels.
The test statistic for the correlation coefficient is $\rho\,[n/(1-\rho^2)]^{1/2}$, ~t(0,σ).
The comparison is based on Basel I requirements plus general and specific provisions for the given year. Basel I requirements are estimated prior to 1988. Basel II ratios include capital for unexpected loss, required provisions for expected loss, and an operational charge as per the basic indicator approach outlined in BIS (2003d).

9. Conclusions

Based on a counterfactual application of the advanced internal ratings-based rules under the new Basel Capital Accord (Basel II), which will provide banks with the greatest flexibility in calculating their capital requirements, we find that required capital and provisions for Canadian banks' commercial and industrial, and interbank, exposures could fall by 35 per cent. Conversely, requirements for sovereign exposures could increase by 45 per cent, albeit from very low levels. The combined effect would be a reduction in overall required capital and provisions for banks' wholesale portfolios in the order of 30 per cent, under certain assumptions.

These identified reductions in capital required under Basel II would be only partly offset by the new, additional, capital charge for operational risk. Note that the aggregate reduction in required capital, relative to Basel I, persists even during periods of significant deterioration in credit quality, such as the marked deterioration in corporate credit quality that occurred in 2001–02.[44] This reduction is in contrast to the most recent quantitative impact study (QIS 3), which produced a result showing that banks' aggregate capital requirement under Basel II is essentially unchanged from that under Basel I.[45] Ultimately, however, the required level of capital within the banking system will be determined by national authorities. In Canada, current national minimum standards are well above those that appear to result from Basel II.

From the perspective of macroeconomic policy, however, the more important issue is potentially the volatility introduced into capital requirements, and ultimately into bank lending. Our counterfactual analysis demonstrates the change in bank capital levels in response to historical changes in the level and distribution of bank assets, although, by definition, it does not capture the behavioural changes that would be induced by the different incentives under Basel II (to some extent, however, sensitivity analysis can indicate the potential behavioural impact). We find that required capital could be more volatile than under Basel I. The increase is greater the lower the quality of the banks' loan portfolio, and the greater the tendency of banks to evaluate credit quality with a point-in-time approach versus a through-the-cycle approach (recall Figure 17 and Table 8). In one example, using a medium-quality portfolio and a point-in-time approach, required capital would have more than doubled between 1997 and 2002.

If the increased risk sensitivity in Basel II produces changes in required capital that are unacceptable to the banks, they may try to mitigate this by adjusting their lending (reducing it

44. This may not be the case, however, if banks were to apply a more aggressive point-in-time approach to calculating capital requirements.
45. It is important to recall that one of the objectives of Basel II is to maintain the same minimum capital requirement (of 8 per cent) as Basel I, even while increasing sensitivity to risk.

during periods of deteriorating credit quality), or by adjusting the quality distribution of their portfolio (shifting towards higher-quality assets). They may also choose to increase their buffer capital (the amount of actual capital held in excess of the regulatory minimum). Thus, the actual observed volatility in capital may not change significantly once Basel II is implemented, but perhaps only because banks are adjusting their loan portfolios accordingly. This is precisely the procyclical behaviour that concerns policy-makers.

Several factors may mitigate the potential impact of Basel II on the cyclical behaviour of capital. Substantial cyclicality is already present in the banking system. Indeed, the actual volatility of bank capital over the 1984–2002 period was already high compared with our base-case scenario and most of the alternatives examined, suggesting that other phenomena are also important factors influencing volatility in bank capital. Nevertheless, to the extent that the volatility in Basel II is additive to existing sources of volatility in bank capital, concern remains over the potential impact on capital. For most of the scenarios examined, however, volatility in capital as a percentage of pre-tax profits was essentially the same for Basel I and II.

Our analysis also shows that much depends on precisely how banks calculate their capital requirements, which will be influenced by accounting and tax regimes that vary across countries. Our expectation is that they would tend towards a through-the-cycle approach, although it effectively reduces the short-term sensitivity to changes in risk. The requirements of Basel II also appear to leave banks, in aggregate, with substantial buffer stocks of capital. To the extent that they are able and willing to allow the magnitude of these buffer stocks to vary through the cycle, as determined by the supervisory authorities, this could reduce the impact of volatility in required capital.

Indeed, much could depend on precisely how supervisory authorities choose to implement the requirements of Basel II. One would expect that banks opting to implement the advanced IRB approach to the calculation of capital (assuming they satisfy the necessary requirements) will typically do so because it provides them with potential efficiency gains, owing to lower required levels of capital (as defined by Basel II) than otherwise. If banks are allowed to offset any increase in volatility that arises from using the advanced IRB approach by allowing greater variation in the remaining buffer stocks of capital (such that the volatility of capital is higher, but its average level is lower, than previously), then, even under adverse scenarios, there may be very little induced cyclicality in lending via this channel.

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Appendix: Statistical Properties of Historical Banking System and Economic Data

Tables A1 and A2 show the results of unit-root tests on key macroeconomic and financial variables, such as equity to assets (a simple capital ratio), loan-loss provisions to assets (a proxy for the portfolio loss ratio), and bankruptcy liabilities to GDP (a measure of overall credit risk). The tests are divided into full sample and post-World War II. The results indicate that most macroeconomic and banking system variables are random walks integrated of order 1; therefore, their first-differences are used in subsequent empirical tests that require stationarity. This also holds true using quarterly data, where available. As a caveat, the power of unit-root tests diminishes when there are structural breaks in the data, which is almost certainly the case here. This means that we may have falsely rejected stationarity in the levels of certain variables, and are thus losing some information.

Pairwise Granger causality tests are performed to evaluate the timing of the relationships among these variables. If lagged values of a variable contain statistically significant information about another variable, over and above its own lagged values, then the former is said to Granger cause the latter. Note that Granger causality can run in both directions. A shaded entry in Table A3 or Table A4 indicates that the variable in the left column Granger causes the variable in the top row (all variables are log differenced).

At the annual frequency, a weighted average of world crude-oil prices contains the most leading information about the other variables considered, including real bank capital, and can thus be interpreted as the most exogenous variable to the system. The only other variables found to Granger cause either bank capital or the capital ratio are the Toronto stock market (TSX) index and the term spread. At the quarterly frequency, these also contain leading information about the capital ratio, as do the components of the capital ratio itself (i.e., bank capital and assets).

We can reject Granger causality from real output to the capital ratio at any level of confidence below 10 per cent. In turn, the capital ratio contains only leading information about real bank profits at an annual frequency. Thus, pairwise Granger causality tests suggest that there is no direct causal relationship between real output growth and changes in the capital ratio or the growth rate of capital. Output growth and changes in the capital ratio, however, are negatively correlated (–0.26). Furthermore, output does Granger cause quarterly asset growth, which will help explain the dynamics of the vector autoregression (VAR) discussed below.

The Granger causality tests provide several other interesting results. Real business bankruptcy liabilities and oil prices contain significant leading information about bank profits. Similarly, real bank asset growth Granger causes consumer, house, and oil price inflation. Bank provisioning for loan losses appears to be unrelated to any of the other phenomena considered.

Alternatively, the relationship between bank capital and the macroeconomy can be analyzed through a VAR framework. A reduced-form unconstrained VAR is constructed to quantify the historical relationship in Canada between growth in real GDP (y), changes in the short-term interest rate (r), and growth in the capital ratio (k) of banks. The relationship is estimated using annual data over the 1874–2002 period, and quarterly data from 1946Q1 to 2002Q4. Both sets of results produce very similar impulse-response functions under a one standard-deviation shock to the system (Figures A and B). The Cholesky factor of the residual covariance matrix is used to orthogonalize the impulses, imposing the ordering of y, r, k. This ordering is based on the results of the Granger causality results, even though, a priori, one might have expected y to be the most endogenous variable. Nevertheless, the ordering does not turn out to have a significant effect on the responses. Plus and minus two standard-deviation confidence bands are also plotted (shaded region).

The key result is that output appears to be invariant to the capital ratio. This can be seen from the non-significant response of y to k. On the other hand, the capital ratio has tended to fall subsequent to positive economic shocks (k response to y) over a one-year horizon. The explanation is that bank assets tend to grow more rapidly than capital during economic expansions, and to contract more rapidly during recessions. Therefore, whether banks have intentionally reduced credit during downturns to maintain their capital ratios, this evidence suggests that banks have played a passive role in the Canadian economy over history. The capital ratio has typically risen following a positive real interest rate shock. The output and interest rate responses are standard: shocks to real output have tended to be persistent and put upward pressure on real short-term interest rates, while increases in the short-term interest rate have tended to depress output.

In summary, although these are rather simple tests, they suggest that there is only weak-to-little historical evidence in Canada that either the level or growth rate of bank capital has influenced or been influenced by broader macroeconomic phenomena.

Table A1: Unit-Root Tests (full sample)

Most of the raw data are integrated of order 1. This table reports unit-root test statistics for the annual log differences of the series, based on their full-sample range. The transformed series are integrated of order zero at the 10% (*), 5% (**), or 1% (***) significance level. If no star appears, it means that higher-order integration may be present. The Schwartz information criterion is used to select the optimum lag length for both the augmented Dickey-Fuller (ADF) test statistic and the Elliot-Rothenberg-Stock (ERS) point optimal test statistic. The Newey-West bandwidth optimum lag truncation for the Phillips-Perron (PP) test statistic is reported.

Variable (annual, log, first difference)	Sample range	ADF	PP	ERS
Real GDP	1870-2002	-6.47***	-6.54***	0.41***
Nominal GDP	1870-2002	-4.91***	-4.28***	0.50***
GDP deflator	1870-2002	-8.37***	-8.70***	0.49***
CPI	1850-2002	-9.44***	-9.65***	0.45***
Long-term government bond yield[a]	1900-2002	-7.54***	-7.54***	0.61***
Term spread[a,b]	1900-2002	-3.79***	-2.95**	2.63**
Toronto stock index	1914-2002	-7.25***	-7.25***	0.76***
Banking sector stock index	1914-2002	-8.11***	-8.11***	0.60***
Real average house price	1872-2002	-6.95***	-9.92***	0.23***
Nominal average house price	1872-2002	-4.60***	-6.10***	0.81***
Real bank assets	1856-2002	-3.82***	-8.27***	1.76***
Nominal bank assets	1856-2002	-1.42	-2.94***	6.70
Real bank equity	1856-2002	-8.94***	-9.46***	0.48***
Nominal bank equity	1856-2002	-2.19**	-4.75***	2.43**
Real bank profits	1929-2002	-11.2***	-11.12***	1.07***
Nominal bank profits	1929-2002	-3.05***	-9.78***	1.54***
Real bank provisions for losses	1871-2002	-10.57***	-18.01***	0.00***
Nominal bank provisions for losses	1871-2002	-9.92***	-25.62***	0.04***
Real corporate profits	1926-2002	-6.7***	-6.49***	0.47***
Nominal corporate profits	1926-2002	-3.46***	-5.88***	0.22***
Real liabilities of bankrupt firms	1884-2002	-9.72***	-9.67***	0.49***
Nominal liabilities of bankrupt firms	1884-2002	-3.59***	-9.6***	4.38
Number of bankruptcies	1884-2002	-6.75***	-7.25***	0.76***
Bank capital/assets	1856-2002	-8.83***	-9.02***	2.48**
Bank provisions/assets[a]	1871-2002	-3.8***	-2.17**	15.24
Bank provisions/capital[a]	1871-2002	-4.97***	-4.97***	2.95***
Banking sector stock index/Toronto stock index	1914-2002	-9.20***	-9.58***	0.62***
Bankruptcy liabilities/GDP	1884-2002	-9.26***	-9.25***	0.58***
Corporate profits/GDP	1926-2002	-6.23***	-7.03***	0.46***

a. Level differences

b. Long-term government bond yield minus 3-month commercial paper rate (proxied with U.S. data)

Sources: Bank of Canada (1950–2004); Curtis (1931); Energy Information Administration (2004); Leacy (1983); NBER (2004); Statistics Canada (1974–2004); Urquhart (1986); and authors' calculations.

Table A2: Unit-Root Tests (post-World War II)

Most of the raw data are integrated of order 1. This table reports unit-root test statistics for the annual log differences of the series, based on post-World War II Canadian data. The transformed series are integrated of order zero at the 10% (*), 5% (**), or 1% (***) significance level. If no star appears, it means that higher-order integration may be present. The Schwartz information criterion is used to select the optimum lag length for both the augmented Dickey-Fuller (ADF) test statistic and the Elliot-Rothenberg-Stock (ERS) point optimal test statistic. The Phillips-Perron (PP) test statistic uses the Newey-West bandwidth optimum lag truncation.

Variable (annual, log, first difference)	Sample range	ADF	PP	ERS
Real GDP	1946-2002	-3.51***	-6.02***	9.80
Nominal GDP	"	-4.13***	-4.19***	3.73*
GDP deflator	"	-3.28**	-3.28**	1.74***
CPI	"	-3.47**	-3.48**	1.54***
Long-term government bond yield[a]	"	-5.83***	-5.78***	0.98***
Term spread[a,b]	"	-4.57***	-2.96**	0.76***
Toronto stock index	"	-6.96***	-6.96***	1.28***
Banking sector stock index	"	-6.98***	-7.12***	2.37**
Real average house price	"	-6.25***	-6.25***	8.19
Nominal average house price	"	-2.70***	-4.25***	8.20
Real bank assets	"	-5.11***	-5.10***	1.13***
Nominal bank assets	"	-4.05***	-3.96***	1.59***
Real bank equity	"	-5.87***	-6.05***	1.23***
Nominal bank equity	"	-2.45	-5.77***	4.47
Real bank profits	"	-9.78***	-9.67***	0.75***
Nominal bank profits	"	-2.65**	-8.52***	0.73***
Real bank provisions for losses	"	-7.67***	-11.2***	0.11***
Nominal bank provisions for losses	"	-9.90***	-9.61***	0.02***
Real corporate profits	"	-6.23***	-5.11***	0.50***
Nominal corporate profits	"	-4.98***	-4.75***	0.49***
Real liabilities of bankrupt firms	"	-4.83***	-8.17***	1.83***
Nominal liabilities of bankrupt firms	"	-4.19***	-7.25***	1.71***
Number of bankruptcies	"	-4.18***	-4.19***	1.18***
Bank capital/assets	"	-6.26***	-6.49***	1.48***
Bank provisions/assets[a]	"	-3.05**	-3.00**	2.74**
Bank provisions/capital[a]	"	-3.23**	-3.11**	2.85**
Banking sector stock index/Toronto stock index	"	-8.29***	-8.49***	1.31***
Bankruptcy liabilities/GDP[a]	"	-4.36**	-4.36**	4.46**
Corporate profits/GDP	"	-5.96***	-4.78***	0.92***

a. Level differences

b. Long-term government bond yield minus 3-month commercial paper rate (proxied with U.S. data)

Sources: See Table A1

Table A3: Pairwise Granger Causality Tests
Three lags of annual first-differenced log of each variable (1946–2002)

Each entry shows the *p*-value (in percentage points) for an F-test that the lags of the regressor do not Granger cause the dependent variable. The shaded entries indicate that the regressor causes the dependent variable, using a threshold confidence level of 10%.

Regressor: \ Dependent:	GDP	Capital ratio	Bank capital	Bank assets	Bank profits	Bank provisions	Corporate profits	Bankruptcy liabilities	CPI inflation	Oil price	House prices	Bank index	TSX index	Bond yield	Term spread
GDP		69	26	26	39	88	11	25	19	58	12	74	87	7	38
Capital ratio	83		20	80	4	86	21	91	9	19	95	89	61	39	36
Bank capital	59	52		80	7	89	40	81	59	94	18	91	23	14	93
Bank assets	83	52	20		90	98	66	65	6	2	3	32	75	29	46
Bank profits	68	25	17	11		66	92	2	69	57	86	0	95	28	24
Bank provisions	99	98	91	92	71		91	40	92	85	83	93	64	71	89
Corporate profits	54	55	79	75	57	73		66	10	22	48	78	71	7	8
Bankruptcy liabilities	27	19	47	10	1	30	17		19	66	86	35	23	13	34
CPI inflation	97	48	23	96	71	10	27	39		46	43	36	27	20	78
Oil price	3	24	3	37	2	31	0	26	61		42	10	32	60	30
House prices	16	25	50	52	42	21	34	67	23	50		34	65	10	100
Bank index	72	17	33	10	92	57	56	83	25	83	33		70	55	58
TSX index	3	1	45	8	97	50	33	30	34	73	49	81		0	39
Bond yield	5	29	34	85	39	23	0	26	35	14	28	99	37		16
Term spread	42	7	62	49	35	38	27	1	25	3	91	18	2	8	

Sources: See Table A1

Table A4: Pairwise Granger Causality Tests
Six lags of quarterly first-differenced log of each variable (1946Q1 to 2002Q4)

Each entry shows the *p*-value (in percentage points) for an F-test that the lags of the regressor do not Granger cause the dependent variable. The shaded entries indicate that the regressor causes the dependent variable, using a threshold confidence level of 10%.

Regressor: \ Dependent:	GDP	Capital ratio	Bank capital	Bank assets	CPI inflation	Oil price	Bank index	TSX index	Bond yield	Term spread
GDP		10	43	2	2	74	63	72	22	12
Capital ratio	96		21	31	11	62	35	30	33	84
Bank capital	32	1		30	55	88	56	31	4	69
Bank assets	29	1	18		0	47	30	7	54	88
CPI inflation	28	55	70	10		5	49	55	25	58
Oil price	5	78	78	48	0		97	28	4	72
Bank index	10	42	69	2	54	76		50	0	28
TSX index	0	1	9	1	73	97	39		0	1
Bond yield	16	8	0	40	70	59	74	27		0
Term spread	51	0	0	17	86	75	39	5	0	

Sources: See Table A1

Table A5: Canadian Bank Exposures to Sovereign Borrowers and the Availability of External Credit Ratings

Ranked by earliest rating from either S&P or Moody's. The fourth column is the maximum exposure to the given country between 1984 (the start of the reference period) and the first year that the sovereign obtained an external credit rating.

Sovereign	Year of first rating from Standard & Poors	Year of first rating from Moody's	Maximum exposure prior to rating	Cumulative exposure as of 2002
The following sovereign exposures had external credit ratings before 1984...				
UNITED STATES	1941	1993		64.4
PANAMA	1997	1958		64.43
AUSTRALIA	1975	1962		67.13
NEW ZEALAND	1976	1965		67.36
DENMARK	1981	1967		67.39
JAPAN	1975	1993		71.91
FRANCE	1975	1992		72.9
AUSTRIA	1975	1977		73.46
NORWAY	1975	1978		73.7
FINLAND	1977	1977		73.71
VENEZUELA	1977	1987		74.19
SWEDEN	1977	1977		74.49
UNITED KINGDOM	1978	1978		78.71
PUERTO RICO	1980			78.71
GERMANY	1983	1993		79.45
SPAIN	1984	1988		79.85
...by 1984, 34% of Canadian bank exposures had external credit ratings.				
IRELAND	1986	1987	1.37	79.85
ITALY	1986	1986	4.69	80.78
ARGENTINA	1993	1986	3.14	81.14
BRAZIL	1994	1986	15.5	82.64
MALAYSIA	1989	1986	1.56	82.95
PORTUGAL	1987	1986	1.47	83.13
GREECE	1987	1994	1.77	83.64
SINGAPORE	1987	1998	0.17	83.67
...by year-end 1987, 61% of Canadian bank exposures had external credit ratings.				
BELGIUM	1988	1988	3.73	84.09
CHINA	1988	1988	0.11	84.17
KOREA	1988	1998	2.92	84.24
HONG KONG	1988		0.51	84.4
ISRAEL	1988	1995	0.11	84.87
LUXEMBOURG	1988	1999	0.16	85.72
THAILAND	1989	1989	0.57	85.93
TAIWAN	1989	1998	0.66	85.94
NETHERLANDS	1989	1998	0.17	86.39
INDIA	1990	1998	0.4	86.64
MEXICO	1991	1990	21.2	92.12
...by year-end 1990, 90.5% of Canadian bank exposures had external credit ratings.				
INDONESIA	1992	1994	1.68	92.12
CHILE	1992	1999	1.31	93
TRINIDAD TOBAGO	1996	1993	0.77	93.27
COLOMBIA	1993	1993	2.43	93.29
PHILIPPINES	1993	1993	1.29	93.56
SOUTH AFRICA	1994	1994	0.17	93.93
BARBADOS	1999	1994	1.18	94.06
POLAND	1995	1995	2.24	94.18
DOMINICAN REPUBLIC	1997	2001	0.84	94.23
BAHAMAS		1997	1.72	94.68
CAYMAN ISLANDS		1997	0.47	97.08
JAMAICA	1999	1998	2.09	98.1
SAUDI ARABIA	2003	1999	0.47	98.1

Sources: Authors' calculations based on Moody's (2003) and Standard and Poor's (2003)

Table A6: Counterfactual Basel II Requirements for Sovereign Exposures Based on Bond Market-Implied Default Rates

Ranked by mean implied ratio of required capital and provisions to total assets. Sovereign exposures include all Canadian bank claims on public entities resident in the given country, converted to Canadian dollars at prevailing year-end market exchange rates. 48 countries representing 98% of sovereign claims are listed.[a] Highly developed countries are assigned a 0 implied ratio.

Sovereign	1980-2002 mean capital ratio (%)	Standard deviation about the mean	2002 capital ratio (%)	Percentage share of total sovereign exposures		
				1984-2002 mean	1984	2002
AUSTRALIA	0	+/-0	0	1.0	0.7	2.7
AUSTRIA	0	+/-0	0	0.2	0.2	0.6
BELGIUM	0	+/-0	0	0.8	3.7	0.4
DENMARK	0	+/-0	0	0.2	0.6	0.0
FINLAND	0	+/-0	0	0.2	0.2	0.0
FRANCE	0	+/-0	0	1.0	3.7	1.0
GERMANY	0	+/-0	0	1.5	0.4	0.7
IRELAND	0	+/-0	0	0.4	1.4	0.0
ITALY	0	+/-0	0	1.1	4.7	0.9
JAPAN	0	+/-0	0	2.5	0.1	4.5
LUXEMBOURG	0	+/-0	0	0.2	0.0	0.9
NETHERLANDS	0	+/-0	0	0.3	0.1	0.4
NEW ZEALAND	0	+/-0	0	0.2	0.3	0.2
NORWAY	0	+/-0	0	0.2	0.1	0.2
PORTUGAL	0	+/-0	0	0.3	1.5	0.2
PUERTO RICO[b]	0	+/-0	0	0.4	0.5	0.0
SPAIN	0	+/-0	0	0.8	4.4	0.4
SWEDEN	0	+/-0	0	0.5	1.3	0.3
UNITED KINGDOM	0	+/-0	0	2.3	1.6	4.2
UNITED STATES	0	+/-0	0	47.2	12.5	64.4
HIGHLY DEVELOPED	**0**	**+/-0**	**0**	**63.6**	**38.0**	**82.0**
SINGAPORE	2.5	+/-1.2	0	0.1	0.1	0.0
CAYMAN ISLANDS	3.1	+/-1.6	5.5	0.3	0.1	2.4
TAIWAN	3.1	+/-1.6	5.5	0.2	0.7	0.0
GREECE	3.5	+/-2.1	0	0.7	1.3	0.5
HONG KONG	4.2	+/-2	7.9	0.3	0.1	0.2
ISRAEL	4.3	+/-1.5	6.5	0.2	0.0	0.5
BAHAMAS	4.4	+/-1.7	7.9	1.1	0.8	0.4
CHINA	4.5	+/-1.7	7.9	0.2	0.1	0.1
KOREA	4.5	+/-3.6	4	0.5	2.9	0.1
MALAYSIA	4.5	+/-2	6.7	0.6	1.6	0.3
THAILAND	4.9	+/-3.2	11.1	0.2	0.6	0.2
SOUTH AFRICA	5.3	+/-1.9	9.6	0.2	0.1	0.4
SAUDI ARABIA	6.4	+/-2.1	11.1	0.1	0.0	0.0
POLAND	9.1	+/-2.4	7.6	0.8	0.8	0.1
INDONESIA	9.4	+/-6.4	21	0.4	1.7	0.0
INDIA	10	+/-3.2	15.2	0.2	0.3	0.3
BARBADOS	10.1	+/-2.6	9.6	0.6	0.3	0.1
TRINIDAD TOBAGO	10.1	+/-2.7	11.1	0.4	0.8	0.3
JAMAICA	12.3	+/-2.5	15.2	1.4	1.1	1.0
PANAMA	12.8	+/-2.5	13.2	0.4	0.7	0.0
PHILIPPINES	13.3	+/-2.6	14.8	0.5	0.9	0.3
DOMINICAN REPUBLIC	15.4	+/-2.5	14.6	0.2	0.3	0.0
MEXICO	18.6	+/-4.5	11.1	10.7	13.1	5.5
COLOMBIA	20	+/-5.3	20.2	1.2	2.2	0.0
CHILE	20.7	+/-3.4	21.4	0.5	0.8	0.9
VENEZUELA	20.7	+/-4.6	28.1	4.0	7.1	0.5
BRAZIL	22.1	+/-3.4	24.1	6.5	12.9	1.5
ARGENTINA	23.8	+/-12	65.1	2.2	2.7	0.4
LARGE EXPOSURES TO OTHERS	**10.1**	**+/-2.7**	**13.4**	**32.1**	**54.1**	**16.0**
ALL OTHERS NOT ABOVE[c]	**8.0**	**+/-0.0**	**8.0**	**4.2**	**8.1**	**1.9**

a. The criteria for inclusion was that claims had to have been greater than $200 million in either 2002 or on average over the reference period.
b. Puerto Rico sovereign debts are assumed to be guaranteed by the United States.
c. All other sovereign exposures are assigned an 8% risk weight.
Sources: Merrill Lynch (2004); Datastream (2004)

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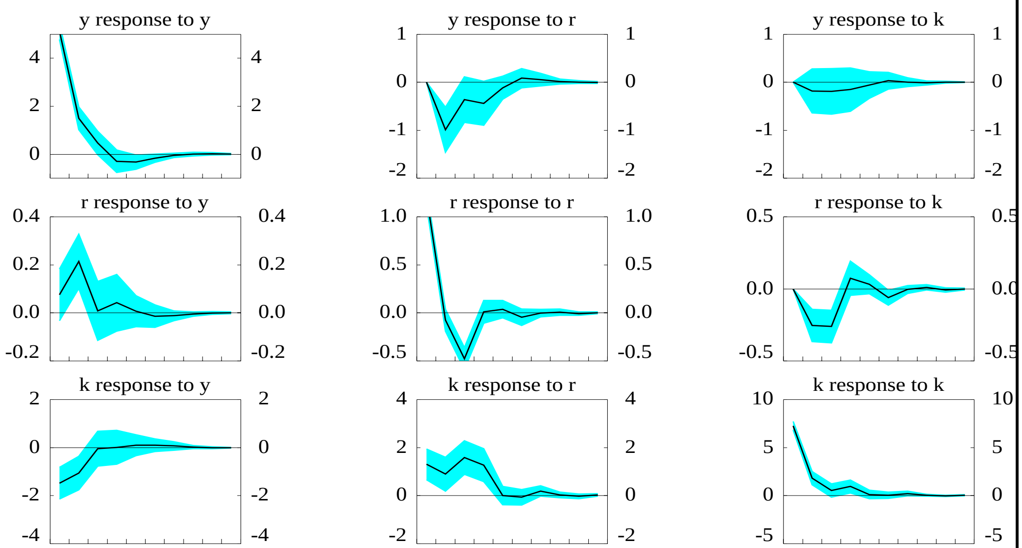
Table A7: Number of Sovereign Borrowers with Credit Ratings

Year	Moody's		Standard & Poors	
	Emerging-market sovereigns	Highly developed sovereigns	Emerging-market sovereigns	Highly developed sovereigns
1985	2	9	2	14
1990	9	15	13	22
1995	22	19	32	22
2000	67	22	61	23
2003	69	22	71	25

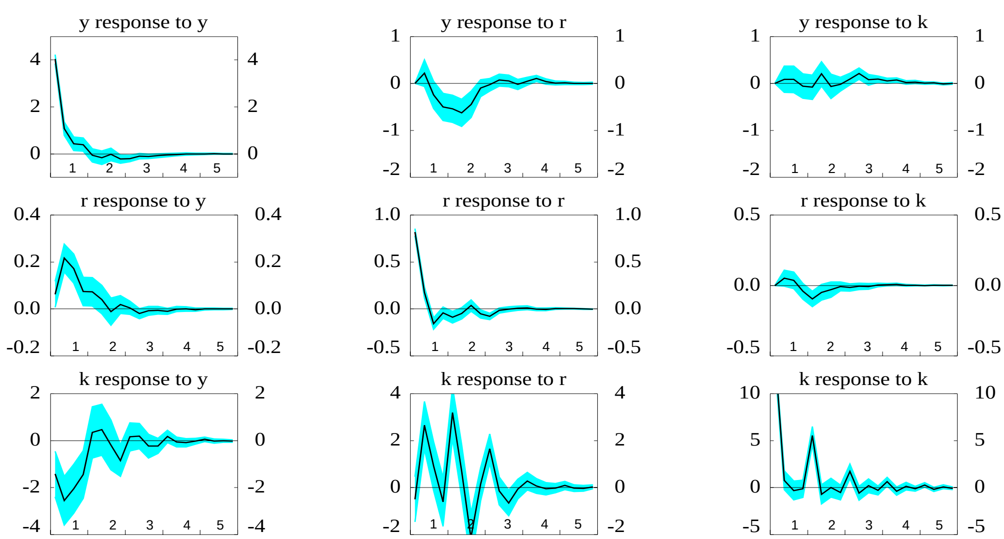
Sources: Moody's (2003); Standard & Poor's (2003)

Figure A: Annual impulse response functions
(one standard deviation shock, in percent)



*Based on a VAR of annual data from 1874-2002 (in year over year percent changes): real GDP (y), real 90-day commercial paper rate (r), and bank capital-asset ratio (k).

Figure B: Quarterly impulse response functions
(one standard deviation shock, in percent)



*Based on a VAR of quarterly data from 1946-2002 (in quarterly percent changes at annual rates): real GDP (y), real 90-day commercial paper rate (r), and bank capital-asset ratio (k).

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