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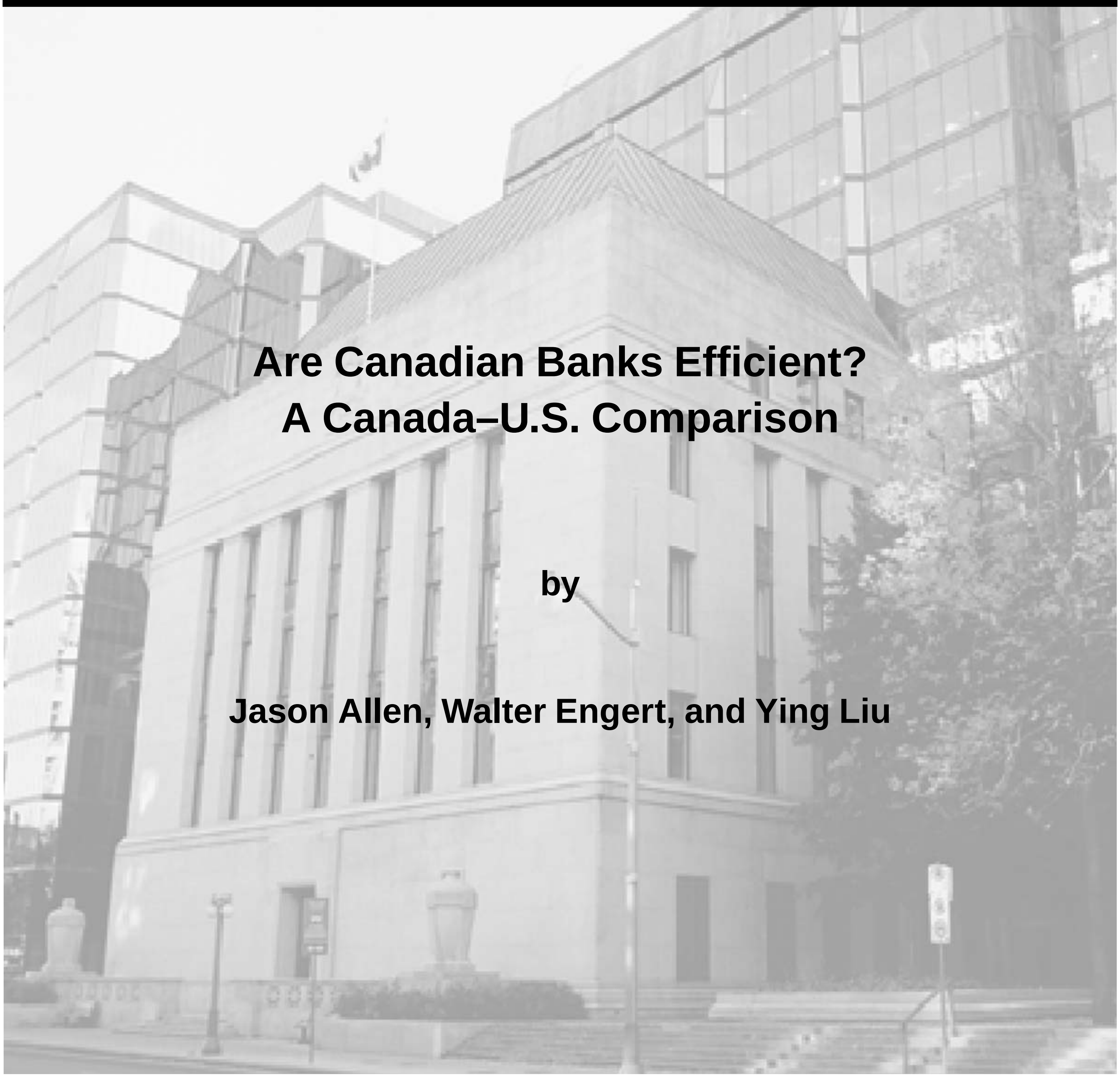

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Abstract

The authors compare the efficiency of Canada’s largest banks with U.S. commercial banks over the past 20 years. Efficiency is measured in three ways. First, the authors study key performance ratios, and find that Canadian banks are as productive as U.S. banks. Second, they investigate whether there are economies of scale in the production functions of Canadian banks and broadly comparable U.S. bank-holding companies (BHCs). They find larger economies of scale for Canadian banks than for the U.S. BHCs, which suggests that Canadian banks are less efficient in terms of scale, and have more to gain in terms of efficiency benefits from becoming larger. Third, the authors measure cost-inefficiency in Canadian banks and in U.S. BHCs relative to the domestic efficient frontier in each country (the domestic best-practice institution). They find that Canadian banks are closer to the domestic efficient frontier than are the U.S. BHCs. Canadian banks have also moved closer to the domestic efficient frontier than have the U.S. BHCs over time. Finally, the authors examine the dispersion in cost-inefficiency found in Canadian banks and attribute some of the dispersion to differences in information and communication technology investment. Comparisons are made with the U.S. BHC experience.

JEL classification: G21, D24, C33
Bank classification: Financial institutions

Résumé

Les auteurs comparent l’évolution respective de l’efficience des principales banques canadiennes et de banques commerciales américaines au cours des 20 dernières années. Trois méthodes d’évaluation sont retenues. Les auteurs examinent avec la première les grands ratios de rendement et constatent que les banques canadiennes sont aussi productives que les américaines. Avec la seconde, ils évaluent l’ampleur des économies d’échelle au sein des fonctions de production des établissements canadiens et des sociétés de portefeuille bancaires américaines à peu près comparables. L’analyse révèle l’existence d’économies d’échelle plus importantes au Canada qu’aux États-Unis, ce qui donne à penser que les banques canadiennes sont de taille moins efficiente que les sociétés américaines et qu’elles ont le plus à gagner d’une expansion. Avec la troisième méthode, les auteurs mesurent l’efficience coût des banques canadiennes et des sociétés de l’échantillon américain par rapport à l’institution qui se situe à la frontière efficiente dans le pays concerné (celle qui a les meilleures pratiques). Il ressort que les banques canadiennes sont non seulement plus près de cette frontière que ne le sont les sociétés aux États-Unis, mais aussi qu’elles s’en sont davantage rapprochées que ces dernières. Pour finir, s’intéressant à la dispersion des écarts d’efficience coût au Canada, les auteurs imputent une partie de celle-ci aux écarts d’investissement existant dans le domaine des technologies de l’information et de la communication. Ils comparent également avec la situation américaine.

Classification JEL : G21, D24, C33
Classification de la Banque : Institutions financières

1 Introduction

The efficiency of the financial system is important to the productivity and long-term growth of the economy. An extensive survey of the literature by Dolar and Meh (2002) suggests that the quality of financial service provision is a key ingredient to economic growth. Banks play a vital role in the Canadian financial system, accounting for over 70 per cent of the total assets of the financial services sector, and providing over half of the short-term business credit in Canada.[1] Accordingly, bank efficiency is crucial to the sound functioning of the Canadian financial system.

This paper focuses on Canada's six largest banks, which account for over 90 per cent of the assets in the Canadian banking sector. These Canadian banks are compared with two groups of U.S. banks: total U.S. commercial banks and a subset of 12 large U.S. bank-holding companies (BHCs). The 12 BHCs are selected from the top 20 BHCs in terms of assets; they are chosen because they have continuous data from 1986 and a business mix broadly comparable with the Canadian banks in the sample. The six large Canadian banks share more similarities with larger U.S. BHCs than with an average U.S. bank. For example, they are all significantly engaged in non-traditional businesses, such as investment banking and wealth management.

Comparing Canadian banks with U.S. banks can provide insights for other countries. Canada's financial system is more bank-based than the U.S. system, and many countries, including developing countries, have a similar system. To some extent, one can consider this study as a comparison of banks in different representative financial systems, with most countries having more similarities with the Canadian case than with the U.S. case.

We compare Canada–U.S. banking efficiency using several approaches. First, we directly compare the efficiency of Canadian banks and U.S. banks through ratios related to bank efficiency and productivity. These ratios are commonly used to compare performance among banks and across time. We find that Canada–U.S. comparisons are sensitive to how nominal output is measured. In contrast, use of different nominal output deflators does not lead to substantial differences.

Second, we measure economies of scale for our subset of banks in the two countries. If there are economies of scale or diseconomies of scale in bank cost structures, then banks are not operating at an efficient scale; i.e., they are not at the minimum of the average cost curve. This paper extends Allen and Liu (2005) by comparing results for Canada with those for major U.S. BHCs. Mester (1997) argues that accounting for heterogeneity is important in studies using the cost-efficiency framework. We therefore limit our sample selection to very large banks with diversified business lines. The literature provides ample research that examines the economies of scale of smaller U.S. banks and finds moderate

[1] Department of Finance Canada, http://www.fin.gc.ca/toce/2005/fact-cfsse.html

economies of scale. See, for example, Ferrier and Lovell (1990) or Berger and Humphrey (1997) for a literature review. However, we are unaware of any study that focuses on banks as large as the six major Canadian banks and the U.S. BHCs in our study.[2]

The third approach we take is to examine the amount of cost-inefficiency of the banks in each country. Cost-inefficiency is measured as a bank's cost level compared with that of the "best-practice" bank of similar size in each country (the efficient-frontier firm), controlling for the type of banking activities, the input prices it faces, and the technology with which banking inputs are transformed into outputs.

The analytical framework used to measure economies of scale and cost-inefficiency is the translog cost function. Banks are assumed to use labour, capital, and deposits to produce different types of loans and non-traditional activities. Because of the long time dimension of the data and non-stationarities, we estimate the translog cost function using a time-varying fixed-effects model, including leads and lags of the explanatory variables, known as panel dynamic ordinary least squares (PDOLS). Cost-inefficiency is obtained from the residual term of the fitted translog cost function. This exercise allows us to learn about the size and dispersion of cost-inefficiency of the banks in each country and, given the long time dimension of the data set, the evolution of that inefficiency.

The mean cost-inefficiency among Canadian banks is found to be about 10 per cent; that is, on average, Canadian banks are about 10 per cent less efficient than the most efficient domestic bank. For the U.S. sample of comparable BHCs, mean cost-inefficiency is 16 per cent. This is higher than the 10 per cent average cost-inefficiency estimated by Stiroh (2000) for a set of 661 BHCs over the period 1991–97. A typical result in the literature, including U.S. banks, is a calculation of average cost-inefficiency in the range of 15–20 per cent. These are relatively large cost-inefficiencies, suggesting that the return to organizational change at the least efficient banks to become more like the most efficient bank is high (Valverde et al. (2004)). Current research has looked at management styles, organizational structure, and technological investment to try to explain large estimated gaps in cost-efficiency. We focus on information and communication technology (ICT) investment as one way to explain the Canadian dispersion in cost-inefficiency. We focus on ICT investment because of the strong link made in the literature between ICT and productivity (Crawford (2003)).

The various financial ratios that we consider suggest that Canadian banks are at least as productive and efficient as U.S. banks, aside from having a higher expense/revenue ratio due to higher unit labour costs. We also find larger economies of scale in Canadian banks than in U.S. BHCs, which suggests that Canadian banks are less efficient in terms of scale. Controlling for economies of scale, large Canadian banks also seem to rank higher in efficiency rankings, suggesting that there is extra benefit from being

[2]There are studies that investigate separately banks of asset size of more than $1 billion. The smallest bank in both our Canadian and U.S. samples has an asset size of more than $80 billion.

bigger. We do not find the same result for U.S. banks. Finally, we find that Canadian banks are closer to the domestic efficient frontier than are the U.S. BHCs. As well, over time, Canadian banks have moved closer to the domestic efficient frontier than have their U.S. counterparts by a small margin; that is, dispersion among Canadian bank cost-inefficiency has declined by more than in the U.S. sample.

The paper is organized as follows. Section 2 provides an overview of the Canadian and U.S. banking industry, including a discussion of the evolution of the regulatory environment for banks in both countries. Section 3 compares the performance of banks in both countries by looking at key ratios related to efficiency and productivity. Section 4 considers economies of scale and cost-inefficiency for the large Canadian banks and the U.S. BHCs. Section 5 focuses on refining the estimation of the cost functions, particularly on variables related to technological progress. Section 6 concludes with suggestions for future research.

2 Industry Structure

The structures of Canadian and U.S. banking industries are substantially different. We are interested, therefore, in examining differences in efficiency of banks conditional on industry structure and regulatory environments.

Historically, the structure of the Canadian banking industry was relatively stable. For instance, from 1920 to 1980, Canada consistently had eleven banks (Bordo (1995)). By May 2005, however, after several regulatory changes removing the sharp limits on the entry of foreign banks, there were over 60 banks operating in Canada: 19 domestic banks, 23 foreign bank subsidiaries, and 21 foreign bank branches. However, banking itself is relatively concentrated: the five largest banks hold close to 90 per cent of total bank assets. Canadian banks also account for over 70 per cent of the assets of the Canadian financial services sector, which contributes over 6 per cent of Canada's gross domestic product (GDP).[3] The total assets of Canadian banks amount to around $1.9 trillion, or close to 150 per cent of GDP. Canada's chartered banks also contribute 25 per cent of total business credit in the country.

In sharp contrast to the Canadian experience, and reflecting the relatively fragmented historical context of U.S. banking, the number of U.S. commercial banks has declined sharply from around 14,000 banks in 1920 to about 8,000 in 2005–and the speed of this consolidation accelerated in the late 1980s. The assets of the top five U.S. banks account for less than 30 per cent of total banking assets in the United States. In addition, U.S. banks play a less important role in the country's financial

[3]By financial sector we mean banks, credit unions, trust companies, life and health insurance, property & casualty insurance, securities dealers, and financing/leasing companies.

system, which is more market-based than that in Canada. For example, U.S. banks account for a smaller percentage of domestic business credit compared with Canadian banks. U.S. banks provide 7 per cent of business credit. Total assets of U.S. commercial banks are US$8.4 trillion, or close to 75 per cent of U.S. GDP.

2.1 Financial legislation and regulatory development

Important contributing factors to the striking difference in the structure of the banking industry in the two countries – especially historically – are the legislative and regulatory environments. Bordo (1995) argues that these features also determine the efficiency and stability of a banking system. Focusing on the period 1920 to 1980, he argues that Canada had a more stable and efficient banking system than the United States. This is attributed largely to the prohibition of interstate (nationwide) branch banking historically in the United States, which resulted in an inability to absorb major shocks without bank failures. However, since 1980 – the period of interest in this paper – both countries have experienced substantial changes in financial legislation, which have correspondingly influenced the evolution of their respective financial services industries, and in a broadly convergent manner.

In Canada, prior to 1980, the financial services industry had been segmented (by legislation, regulation, and practice) into distinct "pillars": commercial banking, trust business and residential lending, insurance underwriting and brokerage, and securities underwriting and dealing. As well, prior to 1980 there were sharp limits on the entry of foreign banks into the Canadian market. However, in the past 25 years, with changes in both market practice and a series of revisions in the governing financial legislation, there have been significant changes in the Canadian financial services sector generally, and in banking specifically. Key characteristics have been the entry of foreign banks and the expansion of banks into a range of financial services, including the trust business, insurance underwriting and sales (although not through bank branches), and securities underwriting and dealing. And while consolidation among various financial services firms has accompanied these developments, there have been no mergers among major Canadian banks themselves in years. For discussions of these and related developments in Canada, see Daniel et al. (1992), Freedman (1998), and Engert et al. (1999).

Canadian banks are federally incorporated and regulated primarily under the federal Bank Act, which defines their range of activities. Unlike their U.S. counterparts, Canadian banks were never prohibited from conducting nationwide branching and banking. An important element of the Bank Act (and other federal financial legislation) is a "sunset" clause, which requires a periodic review of the legislation that governs Canadian financial services. This formal review process led to significant financial legislation amendments in 1980, 1987, 1992, and 1997, which have contributed to more diversified business lines and more market-oriented activities in Canadian banks. As will be seen later, the dates corresponding to some of these revisions are statistically significant in explaining the decline in banks' total costs over the sample 1983 to 2004.

In 1987 federal legislation was amended to permit Canadian banks to invest in securities dealers. All major banks subsequently made substantial investments in the securities business and purchased control of most of the existing large investment dealers. The 1987 amendments also allowed financial intermediaries to conduct brokerage activities. In 1992, Canadian banks were given the right to enter the trust business through the establishment, or acquisition, of trust companies. Most trust companies were subsequently purchased by Canada's largest banks. The financial difficulties that many trust companies experienced following the collapse of the speculative real estate boom in the late 1980s contributed to the ability of banks to acquire them. Also in 1992, banks were permitted to do in-house activities such as portfolio management and investment advice. In 1997, new legislation included various changes to update and revise the amendments made in 1992.

In contrast to Canada, the United States has had a dual system of banking in which some banks are chartered and regulated by the states, and others are federally chartered and regulated. The relatively large number of U.S. banks reflects a historical aversion in the United States to concentration of bank wealth and influence, and is reflected in the 1927 McFadden Act, which explicitly prohibited interstate branching. Despite the prohibition of interstate branching for individual banks, some institutions have long been able to cross state boundaries via a BHC.

The BHC structure allows banks in different states to operate as separate subsidiaries of a parent BHC. These institutions were not subject to substantial regulation until the Bank Holding Company Act of 1956. An important consequence of this Act was the effective elimination of interstate expansion, except for single-bank BHCs. As a result, these single-bank BHCs grew rapidly in the 1960s. However, this loophole was closed by the U.S. Congress in a 1970 amendment to the Bank Holding Company Act.

During the 1970s and 1980s, as in Canada, technological innovation, economic shocks, and deregulation fundamentally altered the banking environment in the United States and the move towards interstate and nationwide banking began in earnest. The Financial Institutions Reform, Recovery and Enforcement Act of 1989 (FIRREA) contributed to this trend by allowing BHCs to acquire savings and loan companies, conditional on certain standards.

The Riegle-Neal Interstate Banking and Branching Efficiency Act (IBBEA) of 1994 completed the consolidation trend by providing a consistent, national framework for interstate banking. Effective 29 September 1995, BHCs were allowed to acquire a bank in any state, and effective 1 June 1997, banks were authorized to merge across state lines. As Holland et al. (1996) point out, however, the IBBEA did not create interstate banking, but rather broadened the scope of the consolidation trends that were already taking place under the form of BHC ownership, which has become by far the most dominant bank ownership structure in the United States.

In addition to interstate-banking restrictions, the Glass-Steagall Act of 1933 imposed a rigid separation between commercial banking and investment banking. Between 1963 and 1987, banks challenged restrictions on their ability to underwrite securities such as municipal revenue bonds, commercial paper, and mortgage-backed securities. In most cases, the courts eventually permitted these activities for commercial banks. The U.S. Federal Reserve in April 1987 allowed BHCs to establish separate Section 20 securities affiliates as investment banks. Under the Federal Reserve Board's interpretation of the law, these Section 20 subsidiaries did not violate Section 20 of the Glass-Steagall Act under some conditions (most notably in that the revenue generated from the subsidiaries' ineligible securities activities amounted to no more than 5 per cent of the revenues they generated).

The erosion of the Glass-Steagall Act continued into the 1990s, and in 1997 commercial banks were allowed to directly acquire existing investment banks as Section 20 subsidiaries rather than establish de novo Section 20 subsidiaries. Finally, in 1999, the U.S. Congress passed the Financial Services Modernization Act which repealed the legal barriers between commercial banks, investment banks, and insurance companies, allowing financial institutions to engage in banking, securities, and insurance activities.

3 Performance Ratios

Policy-makers are often interested in the performance of domestic industries relative to the performance of similar industries in foreign countries. There is an interest in understanding the factors that determine cross-country differences in productivity, so that policies can be implemented to improve the overall standard of living in the domestic country. Also, financial and industry analysts are interested in productivity measures because an increase in productivity implies that a company or industry can produce (and sell) a given quantity using fewer inputs.

Bank output is difficult to measure, both as a conceptual and a practical matter.[4] The System of National Accounts (SNA), which is used to generate official statistics, defines bank output as net interest income plus explicit service fees booked domestically. A major difficulty in this context lies in providing for an accurate measure of net interest income. Official statistics calculate nominal output as the sum of imputed interest plus service charges. Imputed interest is calculated by estimating a representative interest margin for a given (predetermined) business line, and multiplying that margin by

[4]Measuring nominal output in all components of the National Accounts aggregation "Finance, Insurance, and Real Estate" (FIRE) is inherently difficult, since these industries are providing services and not producing goods. We focus on banking, given its prominence and the detailed data set we have on the industry.

the average annual balance outstanding for the business line. The accuracy of this approach to measure bank value-added has been called into question by researchers (see, for example, Wang (2003), and Triplett and Bosworth (2004)) as well as statistical agencies (see, for example, Daffin et al. (2002)). In addition, methodological differences among national statistical agencies' national accounts further complicate cross-country comparisons using such data.

This section compares the performance ratios of the six largest Canadian banks with a set of U.S. BHCs and total U.S. banks using different data sources than the SNA. The six Canadian banks are: Royal Bank Financial Group, Bank of Montreal, Canadian Imperial Bank of Commerce, TD Bank Financial Group, Bank of Nova Scotia, and National Bank. The 12 BHCs are JP Morgan Chase & Co., Bank of America Corp., Wachovia Corp., Wells Fargo & Co., U.S. Bancorp, SunTrust Banks Inc., National City Corp., Citizens Financial Group Inc., BB&T Corp., Fifth Third Bancorp, Keycorp, and PNC Financial Services Group Inc. The 12 BHCs are selected from the top 20 in terms of assets as of 31 December 2004; they are chosen because they have continuous data from 1986 to 2004 and a business mix broadly comparable with the Canadian banks in the sample.[5] Table 8 in the appendix presents summary statistics of the Canadian banks and the U.S. BHCs included in our sample.

The data set we use for these banks is balance-sheet and income-statement data as reported to the supervisory authorities in Canada and the United States. To compare real output per country, we deflate all variables by the consumer price index (CPI), excluding food and energy prices, in their respective country. Rao et al. (2004) suggest, after detailed calculations, a purchasing power parity (PPP) measure of 1.09 for bank value-added in 1999 for the FIRE industry in Canada. PPP is notoriously difficult to estimate; therefore, some caution should be exercised when interpreting cross-country comparisons of performance ratios. We express all series in constant 1999 dollars and then apply a PPP measure of 1.09 to all Canadian series. For simplicity, we refer to constant 1999 U.S. dollars as "dollars" in the rest of the text.

3.1 Expense ratio

The expense ratio, often referred to as the "efficiency ratio," is commonly used by industry analysts to evaluate the cost-effectiveness of banks. It is defined as the ratio of non-interest expense to net operating revenue (net interest income plus non-interest income).[6] Figure 1 compares the expense ratio of Canadian banks, the U.S. BHCs, and total U.S. banks. The expense ratio of Canadian banks

[5] We benchmark with reference to percentage of revenue from retail activities.That is, most of these BHCs have a similar proportion of revenue from retail banking as the Canadian banks.

[6] The denominator of the expense ratio – the net interest margin – depends on the risk differential between assets and liabilities. Accordingly, a change in the expense ratio can be due to changed risk-taking, and not necessarily changed efficiency. Thus, we prefer the term "expense ratio" for this measure, not "efficiency ratio," as it is sometimes called.

was lower than those of their U.S. counterparts in the late 1980s and early 1990s. The expense ratio, however, has been trending upwards in Canada and downwards in the United States over our sample period. In 2005, it stood at 68 per cent for Canadian banks, and 62 per cent and 59 per cent for the U.S. BHCs and total U.S. banks, respectively.

A breakdown of non-interest expenses provides a partial explanation for these trends. Figures 2 and 3 divide the expense ratio into the labour cost component and capital cost component, respectively. As shown in Figure 2, the labour expense ratio in Canada has been higher than in U.S. banks in most of the sample period. That ratio has been trending slightly upwards in Canadian banks, while decreasing in U.S. BHCs and even more sharply in total U.S. banks. Similar trends are observed for the capital cost expense ratio, where capital cost is non-interest expense net of labour cost. It includes mostly physical capital expense in addition to administrative expenses. Canadian banks have a much lower capital cost expense ratio than U.S. banks at the beginning of the sample. The difference narrows in the mid-1990s, as capital prices, defined as capital expenses on the stock of physical assets, increase more significantly in Canadian banks than in U.S. banks. The stronger increase in capital prices in Canadian banks may be a result of increased competition in the adoption of new technology, a subject that will be addressed further in Section 5. Overall, it seems that the difference in the expense ratios can be currently attributed to a higher labour cost component at Canadian banks.

Given the higher labour cost of Canadian banks relative to U.S. banks, we ask whether Canadian banks hire too many workers to produce the given amount of output, or pay their workers a premium. Figure 4 shows the net operating revenue per employee for the three groups of banks – a measure of labour productivity. The ratio for Canadian banks was lower than that of the U.S. banks in the late 1980s, but started to catch up in the early 1990s. In fact, the measures for the three groups of banks have converged since the late 1990s. Therefore, the current higher labour cost component in Canadian banks must come from a higher unit wage. This is apparent in Figure 5. The annual wage and benefit per employee in Canadian banks is plotted against those of the U.S. BHCs and total U.S. banks. Canadian banks compensated their average worker around 80,000 dollars in 2004, while the U.S. BHCs compensation was close to 70,000 dollars, and an average U.S. bank compensation was around 55,000 dollars.

Two important wage differentials should be noted here, where by "wage" we mean salaries and benefits. The first is the difference between wages at the large banks (i.e., Canadian banks and U.S. BHCs) and those at total U.S. banks, which significantly arise only after 1993. This trend coincides with the increase in market-based activities of the Canadian banks and BHCs in the early 1990s. This increased wage differential may imply that the banks' engagement in market-based activities has created more high-paying positions, like investment bankers, advisers, and brokers, particularly in the bull market of the 1990s.

The second wage differential of note is between Canadian banks and the U.S. BHCs. Given that both groups of banks have a similar business mix, the overall wage differential is unlikely to come from the different skill sets employed by large banks in the two countries. While we do not have sufficient data to explain the apparent wage premium received by Canadian bankers, this wage differential itself does not imply disparities in efficiency levels. Therefore, a perception that Canadian banks are less efficient than U.S. banks, which is based on the comparison of the expense ratio (Figure 1), can be misleading. A more valid comparison should be based on other measures, such as those that consider productivity more directly.

3.2 Productivity ratios

Another measure of efficiency is labour productivity, which is defined as output per hour of labour worked. A more productive bank can provide services in a more cost-effective way. Furthermore, productivity gains of banks contribute significantly to total productivity growth in the economy.

The measurement of banking output is a challenge and of constant debate, including at the National Accounts level. The 1993 SNA recommends measuring nominal bank output by combining net interest income with explicit services fees booked domestically. Both Canada and the United States use this approach to measure nominal bank output in their respective National Accounts. Each country, however, uses a different method to measure the volume of bank output; that is, real output. In 1999, the U.S. Bureau of Economic Analysis (BEA) adopted a quantity indicator of bank output developed by the Bureau of Labour Statistics (BLS) to track volumes of banking transactions, such as the number of cheques written or the number of transactions on automated banking machines, to better capture the growing number of transactions. In Canada, the volume of bank output is calculated by simply deflating the nominal bank output measure by the aggregate consumer price index (CPI).

No known study has estimated the discrepancy created by the different methodologies adopted by the two countries. Published National Accounts data allow us to compare the annual output and price deflator for an aggregation of “monetary authorities and credit intermediaries” in the two countries from 1997. Figure 6 shows the two price deflators used in the National Accounts measure of banking output in Canada and the United States. If 1999 is used as the base year, then it is apparent that using the specific “credit intermediation deflator” itself can imply higher banking output in the United States relative to the methodology used in Canada.

Since a measure of the output of banks is not available from the National Accounts, we define banking output in both countries as net operating revenue (net interest income plus non-interest income booked worldwide). In principle, this should be fairly close to the conceptual definition of nominal banking output in the 1993 SNA, although our measure of output is on a consolidated, global basis.[7]

As noted earlier, to avoid a discrepancy created by the use of different deflators, we deflate our measure of banking output by CPI excluding food and energy in both countries. Assuming a constant number of hours in a work week, we compare the ratio of net operating revenue per full-time-equivalent employee across the three groups of banks.

Again, Figure 4 shows the net operating revenue per full-time-equivalent employee in Canadian banks, large U.S. BHCs, and total U.S. banks in constant 1999 U.S. dollars. According to this measure, Canadian banking workers were less productive than U.S. banking workers in the late 1980s, but started to catch up in the early 1990s. In fact, labour productivity in the three groups of banks has converged since the late 1990s, suggesting that, currently, Canadian banks are as productive as their U.S. counterparts. Factors that may have contributed to such a catching-up of Canadian banks include their change of business mix towards more market-oriented activities, and their investment in technology. We will investigate the possibility of the latter in Section 5.

Figure 7 compares total assets per full-time-equivalent employee across Canadian banks, the U.S. BHCs, and total U.S. banks. Total assets is the typical definition of bank output in econometric studies of cost and profit functions (see Berger and Humphrey (1997) for a review of the literature). Using total assets as a measure of bank output, we calculate that a Canadian bank employee produced almost 40 per cent more assets than a U.S. bank employee in the past decade. The divergence also took place in the early 1990s, consistent with our other measure of banking productivity. Based on this measure, Canadian banks are much more productive than U.S. banks.

As was the case of using the expense ratio as a measure of efficiency, there are also challenges inherent in using assets per employee as a measure of productivity. The decision of banks to have loans, for example, on-balance sheet or off-balance sheet (via securitization) is an optimal response to historical, institutional, and regulatory differences across countries. It is possible therefore that banks use different approaches to generate similar profits. Freedman and Engert (2003) discuss different patterns of securitization in Canadian and U.S. banking, and reasons for these differences. The point is clearest when comparing net operating revenues. Canadian and U.S. banks have similar net operating revenues per employee, as shown in Figure 4.

[7] Wang (2003) takes a fundamentally different approach to measuring bank output. She develops a model of bank operations that excludes risk-related returns on borrowing and lending from the definition of value-added. This measure, however, is not yet practical for making cross-country comparisons. Future work might benefit from using Wang's definition of banking output to measure labour productivity, since it appears (at least conceptually) to be a truer measure of banking activity than provided by National Accounts measures.

Finally, for completeness, Figure 8 adds to total assets from Figure 7 a measure of off-balance-sheet (OBS) assets. The value of OBS assets is estimated using the approach of Boyd and Gertler (1994), explained below. Figures 7 and 8 suggest that Canadian banks are more productive than U.S. banks, whether or not one includes OBS activities.

4 Measuring Economies of Scale and X-efficiency

Allen and Liu (2005) measure economies of scale and cost-efficiency for Canada's six largest banks. A multi-output translog cost function is estimated using quarterly data from 1983 to the third quarter of 2003. In this paper, we apply the same framework to the group of 12 U.S. BHCs and re-estimate the cost function for the large Canadian banks using data up to and including the fourth quarter of 2004.

4.1 Specification and estimation

Banks in both countries are assumed to use three inputs (labour, capital, and deposits) and to produce five outputs (consumer loans, non-mortgage loans, mortgage loans, other financial assets, and non-traditional banking activities, including OBS) , each defined in the appendix. This intermediation approach of Sealey and Lindley (1997) is now standard in the banking literature.

We define bank output as the book value of total bank assets booked worldwide. This definition is adopted in almost all empirical research on bank economies of scale and efficiency. This measure is relatively easy to collect and there is little ambiguity in the definition. One problem with this measure, however, is that non-traditional banking activities, especially those related to OBS activities, are not captured. As a solution, Boyd and Gertler (1994) suggest generating a hypothetical portfolio that would be required to generate non-interest income. We use this approach, with one caveat. The underlying assumption required to construct the hypothetical portfolio is that off-balance-sheet assets yield the same rate of return as on-balance-sheet assets. This ignores differences in risk. For robustness we provide a range of estimates for economies of scale based on different assumptions regarding the return to OBS activities.

The translog cost function (Christensen et al. (1971), Diewert (1974)) is given below:

$$c(q,w) = \alpha_0 + \sum_{l=1}^{m} \alpha_l q_l + \sum_{j=1}^{k} \beta_j w_j + \frac{1}{2} \sum_{l=1}^{m} \sum_{j=1}^{m} \sigma_{lj} q_l q_j + \sum_{l=1}^{m} \sum_{j=1}^{k} \gamma_{lj} q_l w_j + \frac{1}{2} \sum_{l=1}^{k} \sum_{j=1}^{k} \delta_{lj} w_l w_j + \sum_{l=1}^{L} \theta_l G_l + \xi + \varepsilon, \quad (1)$$

where variables are in logarithms and certain restrictions apply: $\sum_j^k \beta_j = 1$, $\sum_j^k \gamma_{lj} = 0$, and $\sum_j^k \delta_{lj} = 0$ (homogeneity). Due to multicollinearity, we also impose $\sigma_{lj} = 0$. Variable cost is given by c, outputs denoted by q, inputs denoted by w, exogenous variables denoted by G, the firm fixed effect denoted by ε, and the error term denoted by ξ. Examples of G include, in the Canadian case, the 1987 and 1997 changes to the Bank Act ($G1_{CAN}$ and $G3_{CAN}$, respectively) and the complete implementation of the IBBEA in the United States by 1997 ($G3_{US}$).

Economies of scale are defined as:

$$\zeta = \left(\sum_{l=1}^{k} \alpha_l + \sum_{l=1}^{k} \sum_{i=2}^{k} \gamma_{ij} \log(W_l/W_j) \right)^{-1}. \quad (2)$$

There are increasing returns to scale if $\zeta > 1$, constant returns to scale if $\zeta = 1$, and decreasing returns to scale if $\zeta < 1$.

To derive a measure of cost-efficiency, the cost frontier intercept is first defined as $\hat{\alpha}_{0t} = \min_j(\hat{\xi}_{jt})$, and inefficiency is given by $\hat{\varepsilon}_{it} = \hat{\xi}_{it} - \hat{\alpha}_{0t}$. The time-invariant case is nested if the same firm is selected for all t. Cost-efficiency is derived as:

$$CE_{it} = \exp\{-\hat{\varepsilon}_{it}\}.$$

Estimation of cost-efficiency with the translog cost function is based on the error term from equation (1). Accordingly, reliable inference regarding cost-efficiency depends on accurately estimating the cost-function. To avoid confounding the estimates of cost-efficiency, information on Canadian banks and U.S. BHCs is not pooled, but rather separate cost functions are estimated for each country. Given, among other things, differences in institutional and regulatory environments, pooling the data would reduce the accuracy of the parameter estimates and render the error term uninterpretable. The approach we take is consistent with Mester (1997), who argues that, in estimating cost functions, the measure of X-efficiency is sensitive to the amount of heterogeneity in the bank sample.

An additional parameter of interest is technology, which we proxy by a quadratic time trend. The derivative of cost with respect to time is a measure of technological progress. Although interesting as a first step, we present alternatives in Section 5.

For robustness, we present two estimators. A fixed-effects model is estimated by generalized least squares and by panel dynamic ordinary least squares (PDOLS). Given the non-stationarity of the data, however, the PDOLS estimator is the only one that gives consistent parameter estimates and correct standard errors. Kao and Chaing (2000) also show, via Monte Carlo simulations, that PDOLS outperforms other similar estimators, such as bias-corrected least squares and fully-modified least squares.

Allen and Liu (2005) show that the standard estimator, which ignores the non-stationarity of the data, can substantially overestimate economies of scale. Consider a generic fixed-effects model:

$$y_{it} = X_{it}'\beta + \xi_{it} + u_{it}, \tag{3}$$

where ξ_{it} are the potentially time-varying fixed effects and u_{it} are the residuals. Assume that the regressors follow a unit root process:

$$X_{it} = X_{it-1} + \nu_{it}.$$

We rewrite equation (3) to estimate β consistently:

$$y_{it} = \xi_i + X_{it}'\beta + \sum_{j=-q}^{q} c_{ij}\Delta X_{it+j} + \omega_{it}. \tag{4}$$

The PDOLS estimator is:

$$\hat{\beta}_{PDOLS} = \left[N^{-1} \sum_{i=1}^{N} \left(\sum_{t=1}^{T} z_{it} z_{it} \right)^{-1} \left(\sum_{t=1}^{T} z_{it} \tilde{y}_{it} \right) \right]_1,$$

where z_{it} is the $2 \times (q+1) \times 1$ vector of regressors, $z_{it} = [x_{it} - \bar{x}_i, \Delta x_{i,t-q}, \ldots, \Delta x_{i,t+q}]$, $\tilde{y}_{it} = y_{it} - \bar{y}_i$, and the subscript 1 on the outside brackets indicates that we take only the first elements of the vector.

4.2 Results

Estimates of economies of scale in Canada for the period 1983 to 2004 are presented in Table 1. The estimate of economies of scale is 6.2 per cent in "Model REG" and 8.2 per cent in "Model T". Model REG includes dummy variables to capture the effects of periodic regulatory changes in Canada, and Model T includes a quadratic time trend to capture technological progress. The potential dummies for regulatory changes, first mentioned in Section 2.1, are: 1987Q2, 1989Q1, 1991Q1, 1992Q1, 1994Q1, and 1997Q1. The dummies are zero before these dates, and one afterwards. Regulatory changes that took place in 1987 and 1997 are statistically significant. We also include a third specification, which includes both the regulatory dummies and time trend ($REG+T$). Parameter estimates for Model $REG+T$ are presented in the appendix in Table 9. In this case, economies of scale are approximately 7.1 per cent. In all cases, we reject constant returns to scale at the 5 per cent significance level.[8] The estimates of economies of scale are not statistically affected by our assumption regarding the return of OBS activities.

[8]The parameters in this paper are estimated more precisely, given the extra data and the revisions, than in Allen and Liu (2005), but are qualitatively the same.

Table 1
Economies of Scale for Canadian Banks

Model	ζ	$H_0 : \zeta = 1$	
		Statistic	P-value
Model REG	1.062	6.109	0.0134
Model T	1.082	10.36	0.0013
Model REG and T	1.071	7.922	0.0049

Note: The restriction imposed on equation (1) is actually $\zeta^{-1} = 1$ and $\sum_j \delta_{lj} = 0 \ \forall \ l$, since returns to scale is defined as $\frac{\partial C}{\partial q_l} = \sum_l \alpha_l + \sum \sum \delta_{lj} \log(\bar{W}_j / \bar{W}_1)$ where $\bar{\cdot}$ is the sample mean.

In addition to economies of scale, we also find a strong correlation between bank size and bank efficiency, and relatively large coefficients on technological progress (1.28 per cent per quarter in Model T). Furthermore, the cost-efficiency gap between the most efficient Canadian bank and the average bank is approximately 10 per cent. Figure 9 shows the time-varying cost-efficiency measures for the six Canadian banks in Model REG. Bank identities are not disclosed, for confidentiality reasons. Time-varying cost-efficiency is plotted relative to bank "B," which is why the estimate can be greater than one.

The same exercise is repeated for the 12 U.S. BHCs. Model REG includes regulatory dummy variables. Four potential regulatory dates seem a priori important: 19872Q2, 1989Q1, 1997Q3, and 1999Q1. Statistically, the only significant date is 1997Q3, and therefore we report only the estimation results with a 1997Q3 dummy variable. Recall that, at the time, banks were officially allowed to merge across state lines. The second model (Model T) includes a quadratic time trend. The time trend is statistically significant. We also have a third model that combines both the regulatory dummy and the time trend. Parameter estimates are presented in Table 9 in the appendix.

Similar to the Canadian case, the variables in the cost function for U.S. BHCs are found to be non-stationary through unit root tests.[9] By conducting unit root tests on the residuals from the cost function (1), we do find, however, that the cost function is co-integrated. Table 2 reports results for the null hypothesis that the residuals of the cost-function for the U.S. BHCs are non-stationary. We report the Fisher test and modified augmented Dickey-Fuller test (MADF), introduced by Maddala and Wu (1999) and Sarno and Taylor (1998), respectively. The null hypothesis that all residuals are non-stationary is rejected at the 5 per cent level.[10]

[9] Results are available upon request.

[10] The null hypothesis is set up such that if there are some residuals that are stationary, then the null hypothesis is rejected. There is no clear approach to determine whether "some" means all or less than all.

Table 2
Unit Root Tests on the U.S. BHC Cost Function Residuals

	Fisher test	MADF
Model *BASE*		
Test statistic	38.31	70.25
P-value	0.032	0.000
Model *REG*		
Test statistic	36.45	70.31
p-value	0.050	0.000
Model *T*		
Test statistic	42.05	79.61
p-value	0.013	0.000
Model *REG* and *T*		
Test statistic	45.24	82.18
p-value	0.006	0.000

Note: The Fisher test uses the least-squares estimator and an augmented Dickey-Fuller test with four lags, and is distributed χ^2_{12}. Under the null hypothesis, each cross-section is non-stationary. The MADF test also has a null hypothesis of non-stationarity. Estimation is done using the seemingly unrelated regression estimator, and the distribution of the test statistic is achieved via simulation.

The data on U.S. BHCs are not as clean as those for Canadian banks. A reason for this is the relatively large number of bank mergers in the sample, and, more specifically, how banks treat them in their quarterly reports. A BHC can either account for the acquisition as a purchase or as a pooling of interests. In the former case, BHCs report a large increase in cost due to the merger followed by a sharp decrease in cost when operations are back to "normal." Data reporting when banks pool interests is more complicated. Rather than report large changes in reported variables, BHCs typically spread the gains and the large costs of a merger over what is potentially several years. This reporting scheme allows researchers to examine banks without structural breaks in the data.[11] Most mergers are treated as pooling of interests and therefore the balance-sheet data are smoothed over the period of the merger. There are, however, some episodes where purchases result in excess volatility of balance-sheet items. These changes in balance-sheet items are removed from the regression analysis by using dummy variables.[12] Specifically, we remove (i) 1998 for Bank of America, since that coincided with

[11] A detailed breakdown of mergers/acquisitions for BHCs can be provided upon request.

[12] Focarelli and Panetta (2003) find that there are long-term efficiency gains from mergers and acquisitions using Italian bank deposit data. Panetta et al. (2005), using the same Italian data set, find further that informational benefits, which reduce costs, arise from mergers and acquisitions. Cost savings are related to informational processing. In a review of case studies, Rhoades (1998) reports that four out of nine mergers in the United States resulted in cost-efficiency gains, while five mergers

the purchase of Barnett Bank Inc; (ii) 1999 and 2001 for Fifth Third, to account for the purchase of Peoples Bank Corporation of Indianapolis, and acquisitions in 2001 accounting for $25 billion in assets; and (iii) 2000 for Wachovia, to account for the purchase of Everen.[13]

Results on economies of scale for the U.S. case are presented in Table 3. The null hypothesis of constant returns to scale is rejected. Evaluated at the sample mean, the measured economies of scale are 7.5 per cent for Model *REG* and 2.4 per cent for Model T. The model that combines both the regulatory dummy variable and the time trend also produces an economy-of-scale measure that is significantly different from zero, approximately 2.2 per cent.[14]

We also consider the sensitivity of these results to different assumptions regarding the return associated with OBS activities. The measure developed by Boyd and Gertler (1994) necessarily assumes that the return on assets for OBS activities is the same as for on-balance-sheet activities. This is a natural assumption regarding the portfolio of banks, but does ignore risk. With respect to the estimate of economies of scale, this assumption turns out to be innocuous. We consider the effect of increasing the return on assets for OBS activities by 5 to 10 percentage points; the effect is marginal and not statistically significant.

In addition to measuring economies of scale, we report measures of cost-efficiency. The time-invariant measures of cost-efficiency are given in Table 4. Wells Fargo is consistently the most cost-efficient bank across models. Other banks that are fairly close include National City and U.S. Bancorp. The identity of the least cost-efficient bank depends on the model. Consistently poor performers, however, include Citizens Bank and Fifth Third.

The time-varying measures of cost-efficiency are presented graphically in Figure 10. Most of the BHCs are at least 10 per cent less efficient than the frontier bank. Furthermore, the gap between the most cost-efficient bank, Wells Fargo, and the other banks appears to have been increasing over time.[15] Indeed, several banks were more cost-efficient than Wells Fargo at the beginning of the sample.

In addition, for Model T, the measure of technological progress is estimated to be approximately 0.26–0.29 per cent per quarter. This is substantially less than for Canadian banks, which is estimated

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were not cost-efficient. Rather than perform case studies of each merger, we smooth the data or remove volatile periods caused by a merger or acquisition.

[13]Obviously, there is some subjectivity regarding which episodes to remove from the regression analysis. However, results are robust to different specifications related to mergers and acquisitions. A detailed list of bank merger activity from 1980 to 1998 is provided by Rhoades (2000).

[14]The estimates for economies of scale are slightly larger if purchase-type mergers/acquisitions are not treated properly. The differences, however, are small.

[15]Berger and Mester (2003) find that the cost-efficiency of U.S. banks decreased over the period 1991–97. They also find that profit efficiency improved in that period, and argue that banks provided better quality of service at a higher cost but raised revenue by more than the cost increase. While we are aware of the advantages of estimating a profit function, it would be hard to justify the use of the DOLS estimator, which would suggest a non-zero profit in the long run.

to be approximately 1.28 per cent per quarter. We examine technological progress more closely in the following section.

As another robustness check, we compare the estimates for ordinary least squares to dynamic least squares for the 12 U.S. BHCs in the sample. Allen and Liu (2005) compare estimates of economies of scale for the Canadian banks using the standard least squares estimator (which ignores non-stationarity) to the dynamic least-squares estimator and, as stated earlier, find substantial bias in the former estimator. For example, in a Canadian-bank cost function with regulatory dummies, the least-squares estimate of economies of scale is close to 20 per cent, whereas if one uses the correct dynamic least-squares estimator, the estimate is approximately 6.2 per cent. Phillips and Moon (1999) suggest that as the number of cross-sectional observations increases, the noise in the cross-section should attenuate the persistence in the time series. That is, the least-squares estimate should become "better" as the number of cross-sectional observations increases. It is an open question as to the finite sample properties of panel least squares in the presence of non-stationarity.

We find that for the sample of U.S. BHCs the bias of the ordinary least squares estimate of economies of scale is negligible and the cost-efficiency rankings are only marginally affected. It may therefore be sufficient to use the standard estimator for even moderate sample sizes, as in the case of the U.S. BHCs. One would not want to use the PDOLS estimator for smaller sample sizes, as in the case of Canadian banks.

Table 3
Economies of Scale for U.S. BHCs

Model	ζ	$H_0 : \zeta = 1$	
		Statistic	*P*-value
Model *REG*	1.075	89.04	0.0000
Model *T*	1.024	9.307	0.0023
Model *REG* and *T*	1.022	8.715	0.0032

Note: The restriction imposed on equation (1) is actually $\zeta^{-1} = 1$ and $\sum_j \delta_{lj} = 0 \; \forall \; l$, since returns to scale is defined as $\frac{\partial C}{\partial q_l} = \sum_l \alpha_l + \sum\sum \delta_{lj} \log(\bar{W}_j/\bar{W}_1)$ where $\bar{\cdot}$ is the sample mean.

So far, we have shown, using the translog cost function, that: economies of scale are larger in the Canadian sample relative to the U.S. sample; average cost-inefficiency is lower in the Canadian sample; and the time trend, which proxies technological progress, is four times larger in the Canadian sample relative to the U.S. sample.[16] A natural question is whether banks in the respective countries

[16]Research on productivity growth in FIRE (for example, by Tang and Wang (2004)) also suggests that such growth has been larger in Canada than in the United States, although not by a large margin.

Table 4
Cost-Efficiency for U.S. BHCs

Bank	**Cost-Efficiency**		
	Model *REG*	Model *T*	Model *REG* and *T*
Wells Fargo	100	100	100
National City	89.4	93.0	92.7
U.S. Bancorp	88.3	89.9	89.3
Keycorp	85.9	88.9	88.8
BB&T Corp.	79.3	87.4	87.84
SunTrust	87.7	87.9	87.83
Wachovia	89.8	86.8	86.6
PNC Financial	83.5	84.6	84.2
Citizens Bank	73.1	82.4	83.2
Fifth Third	73.6	82.1	81.8
Bank of America	85.0	81.9	81.5
JP Morgan Chase	87.1	80.4	79.5

Note: The most efficient bank has a ranking of 100 per cent and the cost-efficiency of other banks is relative to that bank.

face different cost structures that could lead to different rates of technological progress. Figures 11 and 12 show cross-sectional averages of the cost breakdown (capital, labour, and deposits) for Canadian banks and U.S. BHCs, respectively. The cost structures appear to be similar, with Canadian banks experiencing a slightly higher cost of deposits for most of the sample. Given the similarity between cost structures across countries, we consider more closely the substantially larger rate of technological progress estimated for Canadian banks. The model attributes most of the increase in Canada's relative productivity (Figure 8) to faster technological progress in Canada.

5 Capturing the Canadian Time Trend

Thus far, we have proxied technological progress using a quadratic time variable and find that technological progress is approximately 1.28 per cent per quarter for Canada's banks, and between 0.26 and 0.29 per cent per quarter for the U.S. BHCs. In this section, we consider several explanatory variables that help explain within-Canada technological progress, and provide some intuition for between-country differences.

The average cost-inefficiency in the Canadian banking sector is roughly 10 per cent, and in the United States it is about 16 per cent, after controlling for size, factor inputs, output composition, and the regulatory environment. These are relatively large cost-inefficiencies, suggesting that the return to organizational change at the least efficient banks to become like the most efficient bank is high (Valverde et al. (2004)).

We examine whether ICT investments made by Canadian banks can explain the dispersion in cost-efficiency. A review of the literature suggests that productivity growth and ICT investment are tightly linked (Crawford (2003)). For example, Stiroh (2002) finds a strong correlation between ICT investments and the post-1995 productivity revival in the United States. Financial intermediation is an information technology-intensive industry, with front-office operations such as branch, telephone, and Internet banking, and back-office operations such as payments clearing and settlement. Accordingly, banks use advances in technology to cut costs and increase revenues. ICT can raise productivity by improving information processing and delivery, and by improving the quality and range of products offered (Berger (2003)). ICT investments, therefore, can increase productivity and improve the cost-efficiency of the banking industry. Anecdotal evidence provided during interviews with Canada's large banks suggests that ICT investments are largely made for cost-efficiency reasons. The impact on productivity of these investments is claimed to be substantial. Quantifying the impact of ICT investment in a service industry such as banking is, however, difficult.

Figure 9 presents the time-varying cost-efficiency measures of Canada fit to a fourth-order time polynomial of Model *REG*. Furthermore, if we include the time trend explicitly in the cost function, the average cost-inefficiency is small relative to what is reported in the literature and relative to a model without the time trend. Very little understanding of banks, however, is obtained by simply using time trends. Instead, we want to consider measurable advances in technology. Our measure of technological progress therefore should capture the movements of cost-efficiency over time, as well as have an economic interpretation. In the results reported in this section, therefore, we do not include the time trend.

Canadian banks, unlike their U.S. counterparts, have for the past 20 years reported consolidated expenditures on "computers and equipment." This includes depreciation of computers and equipment, maintenance, equipment purchases, software, and network costs. We include in the cost-function estimation of Model *REG* the log of the ratio of technology expenditures to the capital stock (ITK). The notion is that if, over time, banks have more heavily invested in new technology (which is more cost-efficient than older technologies), then costs should fall in the long run. The contemporaneous coefficient is, however, small (-0.013) and not statistically significant.

In addition to considering the contemporaneous effect of IT investment, we look at lagged effects. IT executives of the big Canadian banks suggest that there is typically a lag between implementing new technology and reaping productivity gains from the new technology. Leung (2004) provides empirical evidence of this phenomena for Canadian firms. We therefore include four lags of the ITK ratio in the cost function. Results are reported in Table 5. The results are consistent with the anecdotal evidence. That is, at short lags an investment in technology is correlated with higher costs (although not statistically significant), and at longer lags it is correlated with lower costs.

Table 5
IT Investment

ITK	Coefficient	Standard error
$t-1$	0.0374	0.0229
$t-2$	0.0102	0.0236
$t-3$	-0.0607†	0.0231
$t-4$	-0.0271	0.0215

Note: Estimates are for Model *REG*. † is significant at the 5 per cent level.

Given that measured investment in new technology is not substantially significant, we consider some other reasonable proxies for technological change. Results are collected in Table 6. For example, we proxy banks' effective adoption of technology using expenditures on employee training. New technology requires new training, and the better the training the larger should be the gains of adoption. Adding training expenditures on employees has two effects on the estimation of the cost function. First, it can partially capture movements previously captured by the quadratic time trend. Secondly, training expenditures can partially explain the cost-inefficiency differences between Canadian banks. The mean cost-inefficiency drops from 7.3 per cent to 6.4 per cent.

Next we consider the number of automated banking machines (ABM) per number of bank branches. Data for Canada are reported annually in the bank annual reports. This ratio in Canada has increased from an average of 0.2 in 1985 to over 2 in 2004. ABMs are a low-cost distribution channel compared with brick-and-mortar branches. Assuming that two banks have the same number of customers, the bank that has the largest ABM network should have a higher proportion of customers using ABMs. The bank with a high ratio of ABMs to branches, therefore, should be more cost-effective. Humphrey et al. (2006) find substantial cost-savings in a sample of 12 European countries from investments in ABMs relative to branches. On the other hand, Bernhardt and Massoud (2002) show that there could be an overprovision of ABMs, which would reduce bank profitability. Stavins (2000) documents that there have been very little cost-savings gained by U.S. banks by expanding their ABM network. Consumers have simply responded to the increased convenience of ABMs by increasing their overall number of transactions. We find that the coefficient on the number of ABMs per bank branch is negative (-0.064) and significantly different from zero. This implies that a 1 per cent increase in ABMs relative to bank branches decreases bank costs over the sample period by 6.4 per cent. Including the number of ABMs per branch also reduces the amount of unexplained technological progress attributed to the time trend in the model. It was previously 1.28 per cent and is now 1.04 per cent. Finally, the number of ABMs per branch can also reduce the estimate of the cost-inefficiency differences across Canadian banks.[17] The average cost-inefficiency falls from 7.33 per cent to 6.66 per cent.

Table 6
Average Cost-Inefficiency for Canadian Banks

Model	Average cost-inefficiency (%)
Base	10.02
Regulatory dummies	7.32
Regulatory dummies and time trend	4.36
Regulatory dummies and training	6.36
Regulatory dummies and ABM per branch	6.66

Note: The "Base" model does not include any regulatory variable or time trend.

6 Conclusion

This paper examines banking efficiency for Canada and the United States in three ways. First, we compare key performance ratios, and find that Canadian banks are as productive as U.S. banks. Second, we investigate whether there are economies of scale in the production functions of Canadian banks and comparable U.S. bank-holding companies (BHCs). We find larger economies of scale for Canadian banks than for U.S. BHCs, which suggests that Canadian banks are less efficient in terms of scale, and have more to gain in terms of efficiency benefits from becoming larger. Third, we measure cost-inefficiency in Canadian banks and in U.S. BHCs relative to the domestic efficient frontier in each country (the domestic best-practice institution). We find that Canadian banks are closer to the domestic efficient frontier and relatively close to each other in terms of cost-efficiency – closer than the U.S. BHCs.

Finally, how can one interpret the large estimate of technological progress for Canadian banks relative to the U.S. BHCs? In Canada, the estimate of technological progress is 1.04 per cent in the most detailed model. The comparable estimate for the U.S. is 0.3 per cent, substantially lower than in Canada. It is possible that the trend is capturing a substantial increase in total assets per labour input for Canadian banks over the sample period, evident in Figure 8. As well, the time trend might be capturing improvements in Canada's payments system, including the establishment of an efficient large-value payments system in the late 1990s. In this regard, for example, Milne (2006) provides a

[17] We find in analyzing the U.S. BHC experience from 1995 to 2004 a negative but not statistically significant coefficient on the ratio of ABMs to branches. Annual data are reported for U.S. banks either in their annual reports or 10K forms required at the Securities and Exchange Commission. The reporting of the size of a bank's ABM network is rather poor, which is the reason for the small sample size and why we do not put much weight in the result.

theoretical model to explain the empirical observation that countries with higher banking concentration (such as Canada) have more efficient payments systems. These and other possibilities might explain the substantial measure of trend progress in the cost function. Given the current lack of relevant data, but the increasing amount of data collection, it is hoped that these questions can be addressed in future research.

References

Allen, J. and Y. Liu. 2005. "Efficiency and Economies of Scale of Large Canadian Banks." Bank of Canada Working Paper No. 2005-13. Also forthcoming in *Canadian Journal of Economics*.

Berger, A. 2003. "The Economic Effects of Technological Progress: Evidence from the Banking Industry." *Journal of Money, Credit, and Banking* 35: 141–176.

Berger, A. and D. Humphrey. 1997. "Efficiency of Financial Institutions: International Survey and Directions for Future Research." *European Journal of Operational Research* 98: 175–212.

Berger, A. and L. Mester. 2003. "Explaining the Dramatic Changes in Performance of U.S. Banks: Technological Change, Deregulation, and Dynamic Changes in Competition." *Journal of Financial Intermediation* 12: 57–95.

Bernhardt, D. and N. Massoud. 2002. "Endogenous ATM Location and Pricing." Mimeo.

Bordo, M. 1995. "Regulation and Bank Stability: Canada and the United States, 1870–1980." World Bank Working Paper No. 1532.

Boyd, J. and M. Gertler. 1994. "Are Banks Dead? Or Are the Reports Greatly Exaggerated." *Federal Reserve Bank of Minneapolis Quarterly Review* 18(3): 2–23.

Christensen, L., D. Jorgenson, and L. Lau. 1971. "Conjugate Duality and the Transcendental Logarithmic Production Function." *Econometrica* 39: 255–56.

Crawford, A. 2003. *Sustaining Global Growth and Development*, chapter 3. Productivity Growth in Canada and the G-7. England: Ashgate Publishing.

Daffin, C., G. Reed, and P. Vaze. 2002. "Labour Productivity Measures for the Non-Production Industries." Economic Trends No. 579.

Daniel, F., C. Freedman, and C. Goodlet. 1992. "Restructuring the Canadian Financial Industry." *Bank of Canada Review* (Winter): 21–45.

Diewert, W. 1974. "Applications of Duality Theory." In *Frontiers of Quantitative Economics*. Amsterdam: North Holland.

Dolar, V. and C. Meh. 2002. "Financial Structure and Economic Growth: A Non-Technical Survey." Bank of Canada Working Paper No. 2002-24.

Engert, W., B. Fung, L. Nott, and J. Selody. 1999. "Restructuring the Canadian Financial System: Explanations and Implications." In *The Monetary and Regulatory Implications of Changes in the Banking Industry*. Bank for International Settlements.

Ferrier, G. and C. Lovell. 1990. "Measuring Cost Efficiency in Banking." *Journal of Econometrics* 46: 229–45.

Focarelli, D. and F. Panetta. 2003. "Are Mergers Beneficial to Consumers? Evidence from the Market for Bank Deposits." *American Economic Review* 93: 1152–1172.

Freedman, C. 1998. *The Canadian Banking System*. Technical Report No. 81, Bank of Canada.

Freedman, C. and W. Engert. 2003. "Financial Developments in Canada: Past Trends and Future Challenges." *Bank of Canada Review* (Summer): 3–16.

Holland, D., D. Inscoe, R. Waldrop, and W. Kuta. 1996. "Interstate Banking: The Past, Present, and Future." *FDIC Banking Review* (Fall): 1–17.

Humphrey, D., M. Willesson, G. Bergendahl, and T. Lindblom. 2006. "Benefits from a Changing Payment Technology in European Banking." *Journal of Banking & Finance* 30: 1631–1652.

Kao, C. and M. Chaing. 2000. "On the Estimation and Inference of a Cointegrated Regression in Panel Data." *Advances in Econometrics* 15: 179–222.

Leung, D. 2004. "The Effects of Adjustment Costs and Organizational Change on Productivity in Canada: Evidence from Aggregate Data." Bank of Canada Working Paper No. 2004-1.

Maddala, G. and S. Wu. 1999. "A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test." *Oxford Bulletin of Economics and Statistics* 61: 631–52.

Mester, L. 1997. "Measuring Efficiency at U.S. Banks: Accounting for Heterogeneity Is Important." *European Journal of Operational Research* 98: 230–42.

Milne, A. 2006. "What is in it for Us? Network Effects and Bank Payment Innovation." *Journal of Banking & Finance* 30: 1613–1630.

Panetta, F., F. Schivardi, and M. Shum. 2005. "Do Mergers Improve Information? Evidence from the Loan Market." CEPR Discussion Paper No. 4961.

Phillips, P. and H. Moon. 1999. "Linear Regression Limit Theory for Nonstationary Panel Data." *Econometrica* 67: 1057–1111.

Rao, S., T. Tang, and W. Wang. 2004. “Productivity Levels Between Canadian and U.S. Industries.” Industry Canada Working Paper.

Rhoades, S. 1998. “The Efficiency Effects of Bank Mergers: An Overview of Case Studies of Nine Mergers.” *Journal of Banking & Finance* 22: 273–291.

———. 2000. “Bank Mergers and Banking Structure in the United States, 1980-1998.” Board of Governors Staff Study No. 174.

Sarno, T. and M. Taylor. 1998. “Real Exchange Rates Under the Current Float: Unequivocal Evidence of Mean Reversion.” *Economic Letters* 60: 131–37.

Sealey, C. and J. Lindley. 1997. “Inputs, Outputs, and Theory of Production Cost at Depository Financial Institutions.” *Journal of Finance* 32: 1251–1266.

Stavins, J. 2000. “ATM Fees: Does Bank Size Matter?” *New England Economic Review* (January/February): 13–24.

Stiroh, K. 2000. “How Did Bank Holding Companies Prosper in the (1990)s?” *Journal of Banking and Finance* 24: 1703–47.

———. 2002. “Information Technology and the U.S. Productivity Revival: What Do the Industry Data Say?” *American Economic Review* 92: 1559–1576.

Tang, J. and W. Wang. 2004. “Sources of Aggregate Labour Productivity Growth in Canada and the United States.” *Canadian Journal of Economics* 37: 421–444.

Triplett, J. and B. Bosworth. 2004. *Productivity in the U.S. Services Sector: New Sources of Economic Growth*. Brookings Institute.

Valverde, S., D. Humphrey, and R. del Paso. 2004. “Opening the Black Box: Finding the Source of Cost Inefficiency.” Working Paper.

Wang, J. 2003. “Loanable Funds, Risk, and Bank Service Output.” Federal Reserve Bank of Boston Working Paper No. 03-4.

Appendix: Data Description

Table 7
Data Description

	Variable definitions	
Y1	Consumer loans	Dollar value of personal loans for non-business purposes
Y2	Non-mortgage loans	Dollar value of secured call and other loans to investment dealers and brokers + loans to regulated financial institutions + loans to domestic and foreign governments + lease receivables + reverse repurchase agreements + loans to individuals and others for business purposes
Y3	Mortgage loans	Dollar value of residential and non-residential mortgage loans
Y4	Other	Dollar value of other financial assets on a bank's balance sheet
Y5	OBS	Asset-equivalent measure of off-balance-sheet activities
L	Price of labour	Total salaries, pensions, and other staff benefits divided by the number of full-time-equivalent employees and hours in a year
K	Price of capital	Rental expense on real estate and depreciation on premises, furniture, fixture, computer and equipment divided by total stock of land, buildings, and equipment, less accumulated depreciation
D	Price of deposits	Total interest expense on deposits divided by the total dollar amount of deposits
C	Total costs	Interest cost + labour expenses + capital costs

Appendix: Tables

Table 8
Summary Statistics of Large Canadian Banks and U.S. BHCs

Bank	Total asset	Percentage of revenue from retail banking	Number of service delivery units	Number of province or state operating
Canadian banks	(millions of C$)			
Royal Bank	451.4	48	2084	10
TD Canada Trust	311.0	50	1290	10
Bank of Nova Scotia	279.2	42	1871	10
CIBC	278.8	44.5	1073	10
Bank of Montreal	265.2	42.5	1174	10
National Bank	88.8	47	462	10
U.S. BHCs	(millions of US$)			
JP Morgan Chase	1157.2	24	2508	17
Bank of America	1112.0	54	5889	29
Wachovia	493.3	45	3604	49
Wells Fargo	427.8	60	6046	50
U.S. Bancorp	195.1	42	2370	24
SunTrust	159.1	45	1710	9
National City	139.3	69	1650	43
Citizens Bank	136.8	61	1613	13
BB&T Corp.	100.5	77	1413	20
Fifth Third	94.5	51	1011	9
Keycorp	90.7	37	940	45
PNC Financial	79.7	40	875	36

Note: Based on 2004 annual reports. Retail banking refers primarily to deposit and loan services to individuals and small businesses. Non-retail banking includes wealth management, investment banking, insurance, brokerage, corporate lending, etc. Service delivery units include branches and client service centres.

Table 9
DOLS: Model $REG + T$

Variable	Canada **Coefficient**	Canada T-statistic	United States **Coefficient**	United States T-statistic
θ_1	-0.01291		-0.00291	
θ_2	0.000075		-0.000022	
$G1_{CAN}$	-0.03010**	3.396	–	–
$G3_{CAN}$	-0.08245**	8.279	–	–
$G3_{US}$	–	–	-0.02123*	2.224
α_1	1.48064**	3.006	0.46124**	8.314
α_2	3.19045**	7.600	0.23874**	4.264
α_3	-2.01638**	5.576	0.29250**	4.993
α_4	-0.99546*	2.013	0.06982	1.253
α_5	0.44801*	1.931	0.35296**	6.526
β_2	7.62442**	10.701	-0.86630**	4.890
β_3	-2.14519*	2.145	1.28352**	4.992
δ_{12}	0.37314**	8.240	-0.06397*	2.012
δ_{13}	-0.23642**	12.934	-0.04440*	2.175
δ_{23}	0.04150*	2.029	-0.08306**	4.132
γ_{12}	-0.10954**	2.706	-0.02290**	4.367
γ_{13}	0.04102*	1.919	0.05888**	4.106
γ_{22}	-0.25280**	7.304	0.00923*	1.720
γ_{23}	0.02299†	1.384	0.07377**	5.121
γ_{32}	0.17858**	6.015	-0.00054	0.101
γ_{33}	-0.09905**	4.816	-0.02692**	2.372
γ_{42}	0.09591*	2.309	0.024700**	4.534
γ_{43}	-0.06914**	3.550	0.01993†	1.372
γ_{52}	-0.00779	0.418	-0.04131**	7.883
γ_{53}	0.13484**	12.093	-0.09494**	6.785

Note: **, *, †: significant at the 1, 5, and 10 per cent levels, respectively. The T-statistic is for the null hypothesis that the parameter is zero and is defined as: $T-stat = \frac{\sqrt{N}(T-lags-leads-1)\hat{\Theta}}{sqrt(VAR(\hat{\Theta}))}$ where $\hat{\Theta}$ is the vector of parameter estimates.

Appendix: Figures

Figure 1. Expense Ratio

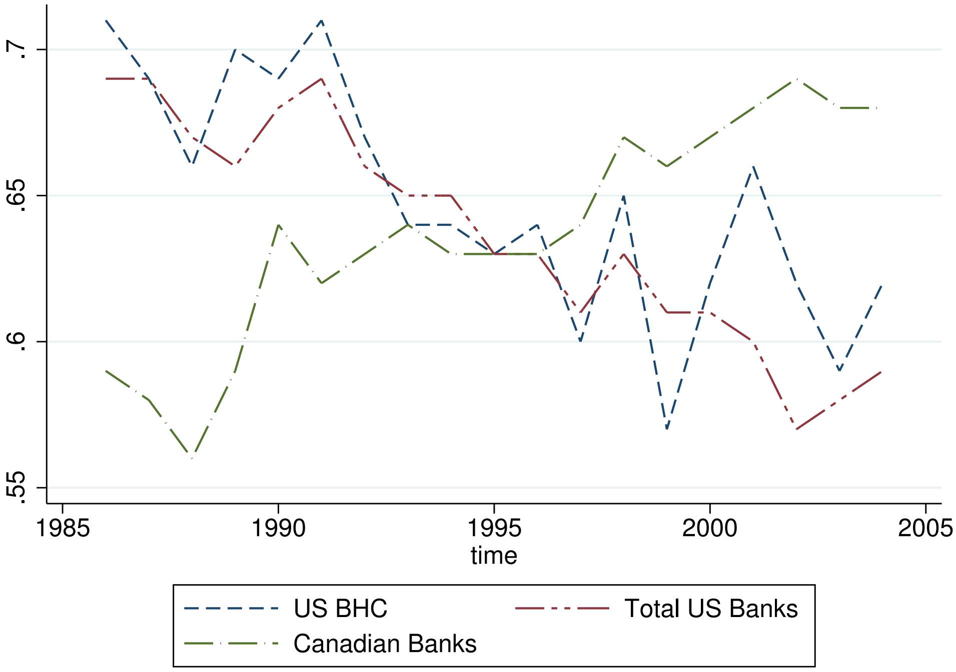

Figure 2. Labour Expense Ratio

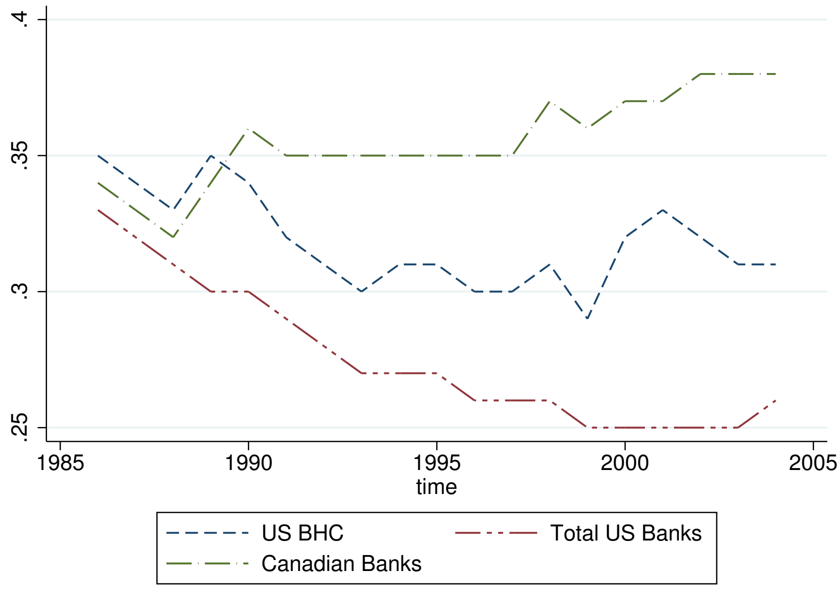

Figure 3. Capital Expense Ratio

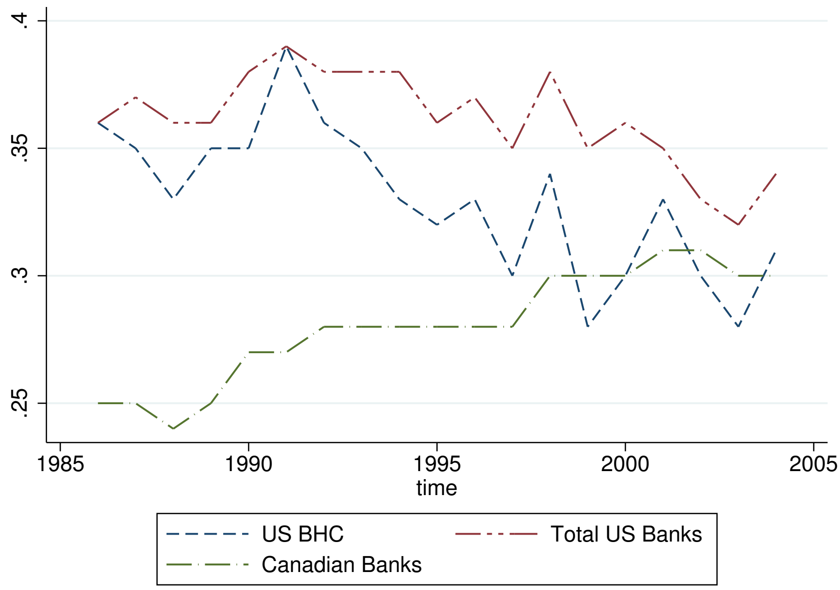

Figure 4. Net Operating Revenue Per Employee

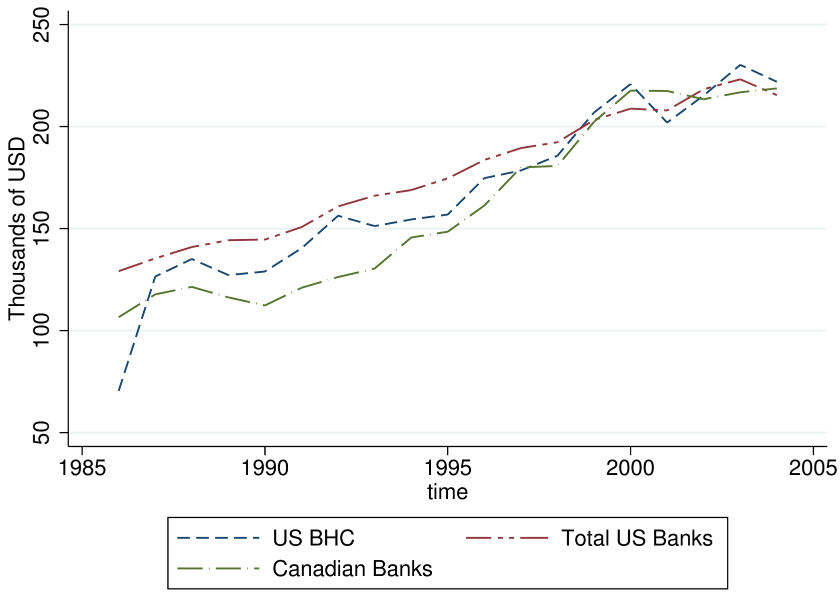

Figure 5. Annual Wage and Benefits Per Employee

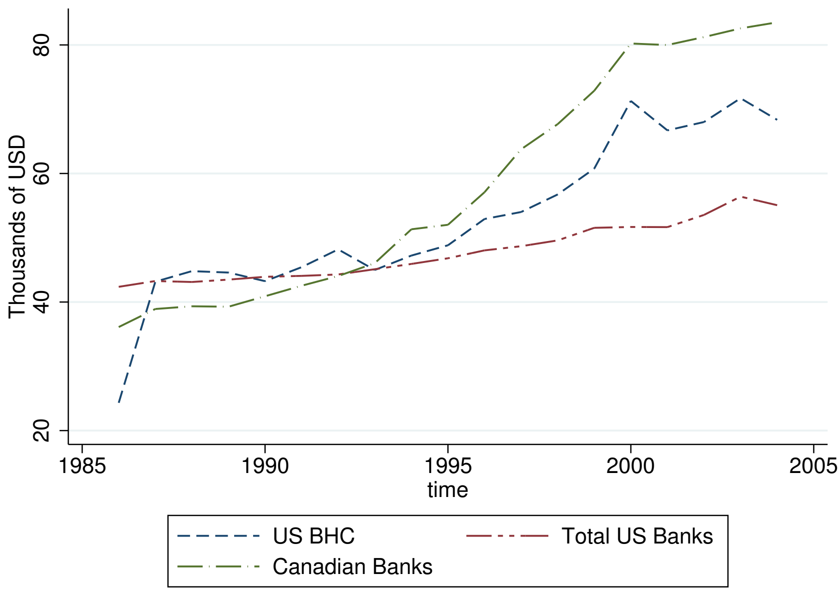

Figure 6. Price Deflators Used in National Accounts for Banking Services

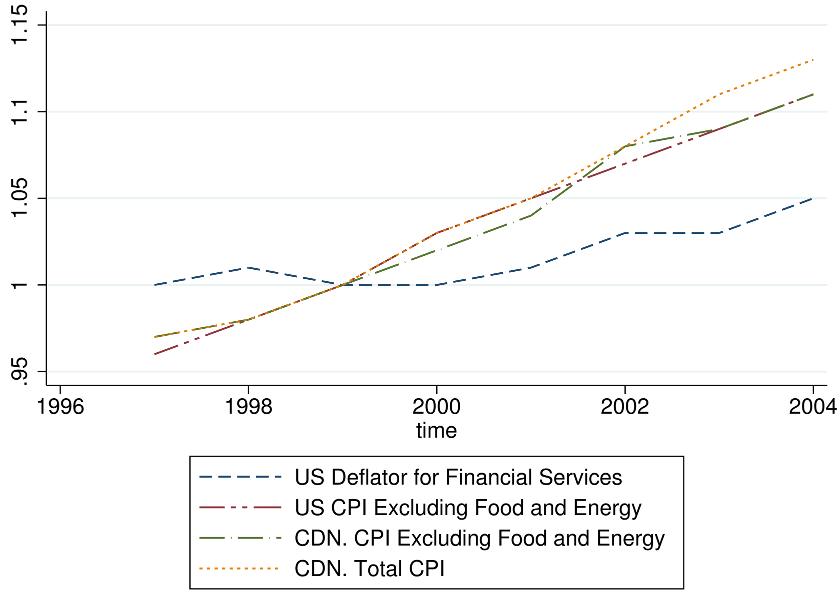

Figure 7. Total Assets Per Employee

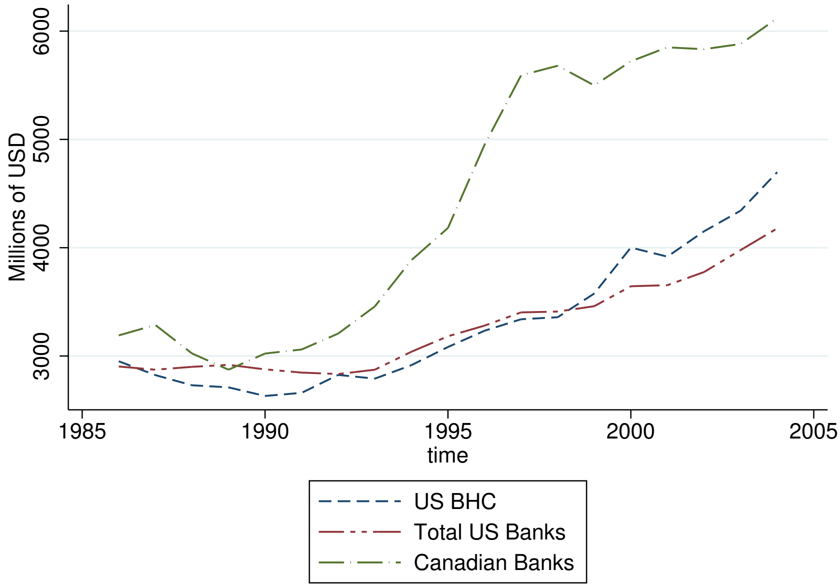

Figure 8. Total On- and Off-Balance-Sheet Assets Per Employee

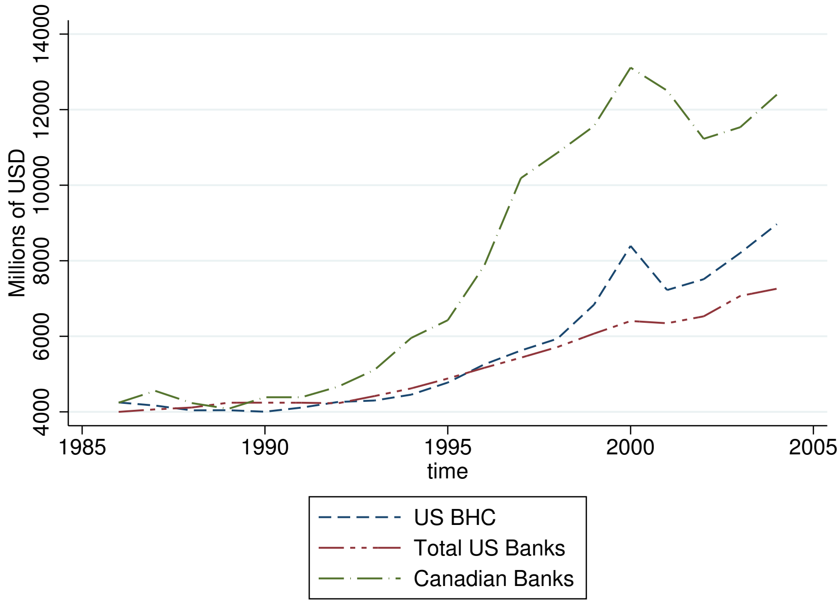

Figure 9. Time-Varying Cost-Efficiency of Canadian Banks 1983–2004

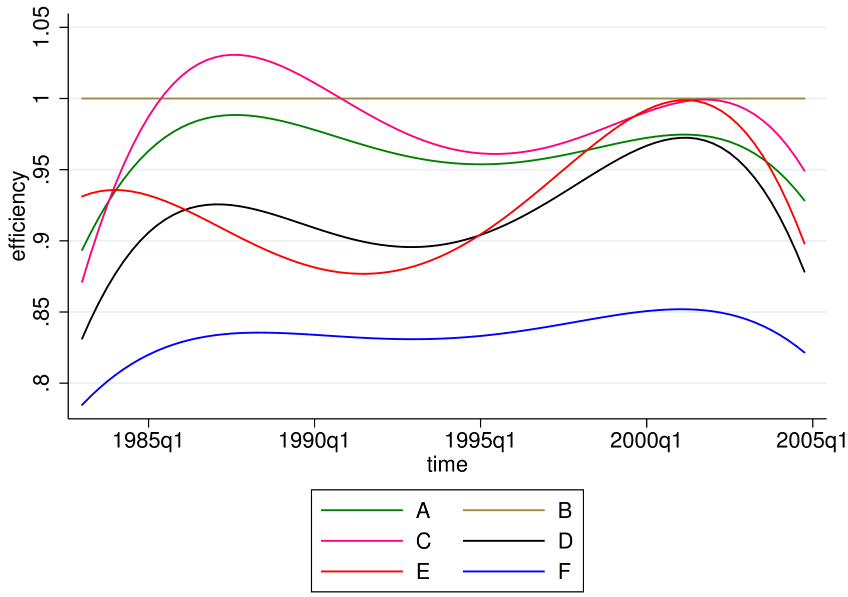

Figure 10. Time-Varying Cost-Efficiency of U.S. BHCs 1986–2004

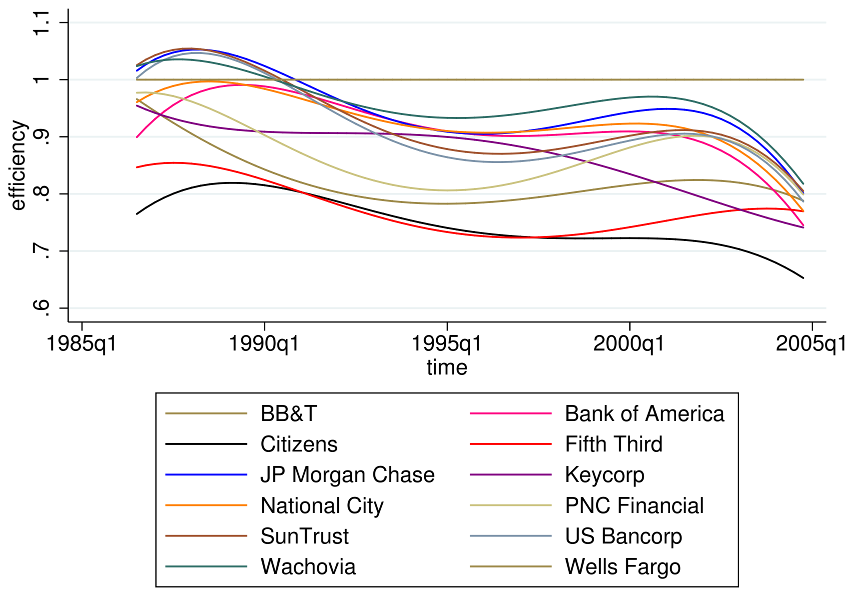

Figure 11. Cross-Sectional Average of Total Costs - Canadian Banks

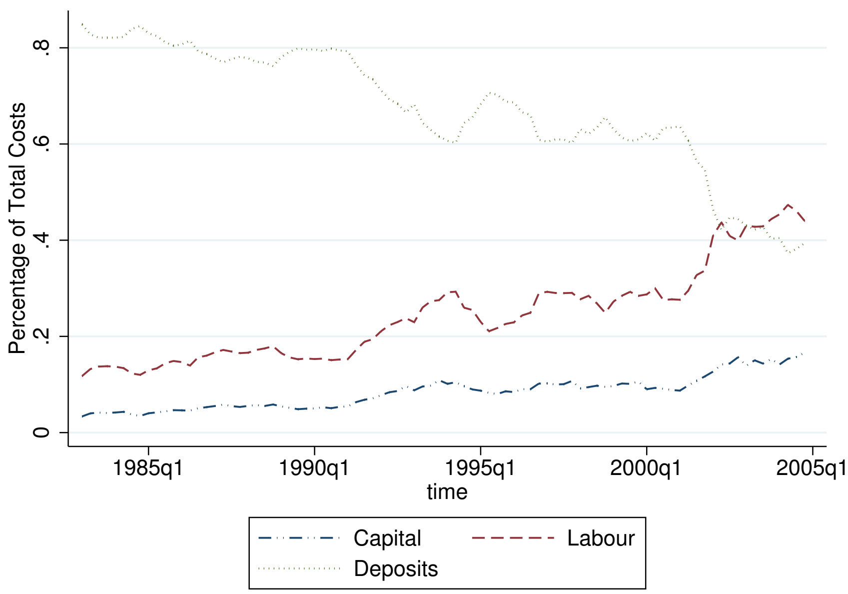

Figure 12. Cross-Sectional Average of Total Costs - U.S. BHCs

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