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Department of Economics
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Private Bank Money vs Central Bank Money: A Historical Lesson for CBDC Introduction

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Private Bank Money vs Central Bank Money: A Historical Lesson for CBDC Introduction*

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December 16, 2019

Abstract

In this paper, a unique event is studied: the opening of Bank of Canada in 1935, the central bank note issuance monopoly and its impact on the note issuing chartered banks. Between 1935-1950, Canadian chartered banks had to gradually withdraw their notes from circulation. In a difference-in-differences analysis, I show that chartered banks constrained by new issuance limits experienced higher volatility of return-on-equity in the short run and lower Z -scores and return-on-assets in the longer horizon, suggesting that note issuance was an important source of revenue for private banks and allowed them to smooth the profits. The effect on lending is either non-significant or ambiguous. This study of central bank cash implementation can offer lessons for the current debates on a new form of central bank money - central bank digital currencies - and their potential impacts on commercial banks.

Keywords: Banknote Monopoly, Banknote Issuance, Cash, Central Bank Digital Currencies, Double Liability, Canadian banks, Financial Stability, Bank of Canada

JEL-Classification: E42, E5, G21, G28, N22

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1 Introduction

Debates about a new form of central bank money - central bank digital currencies (CBDC) - gained momentum in 2017-2018, when cryptocurrencies reached their peak of popularity. Even without the cryptocurrency boom, in an increasingly electronic world, where the majority of money is inside money - thus generated by commercial banks, and not central banks, central banks stand in front of a challenge to adapt to the new environment. At this stage, it is difficult to comment on the advantages and disadvantages of CBDC, given that it may be implemented in several ways, see Bordo and Levin (2017), Mersch (2017) and Keister and Sanches (2019). However, first studies and comments (see Mersch, 2017; BIS, 2018; Stevens, 2017; Mancini-Griffoli, Peria, Agur, Ari, Kiff, Popescu, and Rochon, 2018; Davoodalhosseini and Rivadeneyra, 2018) note that the business model of commercial banks may be affected by the introduction of CBDC that mostly affects the funding side of the banks (deposits) and their profitability. It is highly probable that some changes in the commercial banking sector may happen due to the implementation of CBDC, but we can only speculate in which direction they would go.¹ In situations like this, studying similar events from banking history may provide some factual assessment (see e.g. Weber, 2015 and Fung et al., 2017).

In this paper, I turn my attention to the period when the competition of central and commercial banks over people's money played itself out at the cash level. In many countries, among others Canada that lies at the center of this study, central banks gained cash monopoly fairly late, and before that, numerous private banks were printing their own money, making it an important part of their funding (Söderberg, 2018). The advent of central banking issuance monopoly was feared by Canadian commercial banks back then as the advent of CBDC is feared by today's commercial banks (see e.g. Shortt, 1905a; Shortt, 1905b; Fung, Hendry, and Weber, 2017; Wojtuszek and Bujnowski, 2018; Swedish Banker's Association, 2019a; Swedish Banker's Association, 2019b). The situations are in many ways analogous, with the difference of the technology level at which they play themselves out. In fact, in existing taxonomies of money (see Bjerg, 2017; Bech and Garratt, 2017; Adrian and Griffoli, 2019), what differentiates cash from CBDC is its electronic form.² Given that CBDC has still not been implemented, it is not clear whether central banks would choose its version that does not pay interest or is

¹A recent study by Keister and Sanches (2019) delivers a theoretical model that studies how different forms of CBDC affect banks' funding costs, investment, and welfare. They conclude that CBDC leads households to shift away from bank deposits and raises bank funding costs, leading to a decrease in bank-funded investment. Andolfatto (2018) investigates the impact of an interest-bearing CBDC on a monopolistic banking sector and concludes that CBDC does not necessarily need to reduce lending by banks; however, it may lower their profits. Similarly, Chiu, Davoodalhosseini, Jiang, and Zhu (2019) conclude that the impact of CBDC on commercial banks' lending depends on the competition in the deposit market and the the interest rate on CBDC. Juks (2018) considers a hypothetical scenario of deposit outflow into CBDC and performs an indicative calculation of how e-krona (the Swedish CBDC) would impact banks.

²Both central bank cash and CBDC are a form a central bank issued money that should be widely accessible and can be viewed as competition to the commercial banks' funding sources (private banknotes in the past and deposit money today), see BIS (2018). As Engert and Fung (2017) note, both can be also subject of seigniorage revenue to the central bank. They both can serve as means of payment, unit of accounts and store of value, fulfilling the main functions of money, see Camera (2017). However, some features of CBDC are different than for cash, e.g. CBDC can be an answer to the zero-lower bound problem, while cash is subject to it. The technological challenges of CBDC are clearly different than those of cash.

interest-bearing. In the first case, CBDC would be more similar to cash, in the latter, it would have additional attributes. This paper delivers insights on how central bank's note monopoly affected commercial banks, focusing on the potential cost side of the implementation of a new form of non-interest bearing central banking money. The non-interest bearing version of CBDC is currently considered as an option by Sveriges Riksbank (Nessén et al., 2018), Bank of Canada (Engert and Fung, 2017), New Zealand (Bascand, 2018), and according to IMF, none of the central banks surveyed "*are seriously considering interest-bearing CBDC*" (Mancini-Griffoli et al., 2018).

Bank of Canada began operations as late as in 1935, and it gained banknote monopoly in 1950. As a result of the establishment of a central bank, the amendment to the Bank Act of 1934 regulating the Canadian chartered banks restricted their note-issuing privileges. The law introduced a cap on the maximum issuance of banknotes in relation to the capital, and potentially affected differently banks that were above or underneath that cap due to their different funding strategies. In years 1935-1950, central bank's and chartered banks' notes were used in parallel by public. The passing of Bank of Canada Act and its consequences can be interpreted as an exogenous change that affected chartered banks business models. As such, I use a difference-in-differences method to estimate differential effects of this event for treated (banks that relied more heavily on note issuance and were affected by the cap imposed by law) and control banks (banks that were not affected by the cap on maximum note issuance).

I show that chartered banks constrained by new issuance limits experienced higher volatility of return-on-equity in the short run and lower Z-scores and return-on-assets in the longer horizon, suggesting that note issuance was an important source of revenue for private banks and allowed them to smooth the profits. The effect on lending is either non-significant or ambiguous. While interpreting these results in the context of CBDC, one needs to bear in mind that the historical estimates pose the upper limit of what would likely happen to commercial banks once CBDC is introduced, as discussed in section 5. First, consumers have currently access to many central bank currency substitutes that were unavailable at the time of introduction of Bank of Canada banknotes, which would make the elasticity of substitution between CBDC and bank deposits lower than between central bank notes and commercial bank notes. Second, in the first half of the twentieth century, the public in Canada was basically forced by law to entirely switch from commercial bank notes to central bank notes. If CBDC were to be introduced, such a shift would be voluntary. Hence, estimates from the past likely present 'the worst case scenario' of effects of introduction of a new form of central bank currency on incumbent private banks.

The paper is structured as follows. Section 2 provides overview of money circulation in Canada and the role of chartered banks in it, along with details on the note monopoly established by the Bank of Canada Act. Section 3 presents data and descriptive statistics and in section 4, I conduct the empirical analysis. In section 5, I interpret and discuss the findings of the paper in the context of lessons for CBDC. Section 6 concludes.

2 Chartered banks' note issuance in Canada

The roots for the modern Canadian banking system evolved gradually starting from the 19th century.³ At first, the banking system evolved separately in four provinces (Upper and Lower Canada, New Brunswick, Nova Scotia) which formed the Dominion of Canada in 1867.⁴ Chartered banks in Canada were mostly established to resolve the problem of the lack of currency on Canadian territories and their right to issue notes distinguished them from other financial intermediaries at that time (Neufeld, 1972)⁵.

Private bank notes circulation preceded the paper currency issued by the government in Canada by around half a century. First provincial (government) notes were authorized in 1866, and two years later, their name was changed to Dominion notes (Fung et al., 2017). Before the establishment of the Bank of Canada, chartered banks' notes that were not legal tender coexisted alongside Dominion notes which were legal tender. Dominion notes were established in 1868 and their issue was partly gold-backed and partly fiduciary. During the gold standard, they were redeemable in gold.⁶ Part of the Dominion notes was used by public, and part was used by banks in interbank transactions (Dominion Bureau of Statistics, 1940, p.893). In fact, the majority of Dominion notes was used as reserves by banks, and hence, despite their relatively high issuance, they did not become the most popular circulating medium of exchange among the public (Fung et al., 2017). Chartered bank notes could be converted into Dominion notes. Despite their fiduciary status, chartered banks' notes were the main circulating medium in Canada. Holding chartered bank notes was relatively safe. First, bank shareholders were subject to double liability.⁷ Second, in 1880, chartered note-holders were given the first lien on banks' assets. Since 1881, no note-holder in Canada suffered a loss (Dominion Bureau of Statistics, 1940, p. 894). The spreading of chartered banks' notes was furthermore facilitated by their interchangeability. Fung, Hendry, and Weber (2017) state that the Bank Act of 1890 made chartered bank notes uniform currency. Before the act, notes from locations other than

³Breckenridge (1910) reports about the existence of Canada Banking Company as early as in 1792, but only few records from that time can be found. Only 25 years later a new project of bank issue has been launched in Montreal, Lower Canada.

⁴As a Dominion, Canada was a semi-independent country eligible for the self-governance, with some exceptions (as changes in the constitution, or signing own treaties). The Statute of Westminster, 1931, extended the Dominion's rights to the independent external affairs. See Encyclopaedia Britannica Online (2015). Only with the Canada Act from 1982, the amendments to the constitutions of Canada no longer have to be approved by the British government.

⁵From 1850 on (due to the Free Banking Act), only chartered banks had right to issue notes. However, the notes were not legal tender in Canada. With the establishment of Dominion, note issuance by chartered banks became increasingly unified under common regulation. From 1871 on, bank notes' minimum denomination were \$4. From 1880 on, the chartered banks could issue notes of \$5 and multiples up to the amount of the paid-up capital (Powell, 2005). Additionally, in the period of the movement of the crops, since 1908, an "excess" circulation of up to 15 percent of the equity was possible, but it was linked to an interest payment of 5 percent on the excess (Fung et al., 2017).

⁶Canada was on gold standard from 1 August 1854 to 4 August 1914 and from 1 July 1926 to January 1929 (Powell, 2005).

⁷Given their unique right to issue notes, chartered banks were subject to double liability that applied only to them and not to other financial institutions (see Debates of the Senate, 1869, p. 84-85, Journals of the Senate of Canada, 1868, p.A1-10). Under the double liability rule, in the case of a bank's failure, the shareholders were held responsible for an additional amount not larger than the par value of their shares (Breckenridge, 1910).

the branch where they were to be redeemed, were traded at discounts. After 1890, notes had to be accepted at par throughout the country. Proposals to abolish private bank notes were brought forward as early as in 1841, but the proposal was not adopted due to opposition from the side of chartered banks. Another proposal was presented in 1869, but again, the public was not willing to accept government monopoly over money (Rich, 1977).⁸

The importance of chartered bank notes for the public is evident in Figure 1, which shows annual averages of note circulation in the hands of the public in years 1927-1950, with distinction into chartered bank notes and Dominion and Bank of Canada notes (after the establishment in 1935, Bank of Canada assumed liability for outstanding Dominion notes that were slowly replaced). In 1927, Dominion and Bank of Canada notes corresponded to merely 15% of notes in circulation, in 1934, the ratio accounted to 20%, and in 1935, the year in which Bank of Canada started its operation and issued first Bank of Canada notes, the ratio increased to 28.5%.⁹ After the establishment of Bank of Canada,¹⁰ chartered bank notes slowly disappeared from the circulation and Bank of Canada notes took over as the medium of exchange.¹¹ However, we can see that the substitution occurred gradually and the public did not rush to use Bank of Canada notes over chartered bank notes.¹²

The Bank of Canada was designed to serve the public interest and to have the sole right of issuing Canadian banknotes. As such, the amendment to the Bank Act of 1934 from 28th June restricted the note-issuing privileges of chartered banks.¹³ From 1935 on, the maximum

⁸Commercial bankers reacted to government proposals with hostility, as *“in their eyes, the note issue still represented the central and most profitable feature in banking.”* (Shortt, 1905a, p. 34). The public was concerned with possibly lacking flexibility of governmentally supplied currency and with the risk of monetizing the debt (Shortt, 1905b).

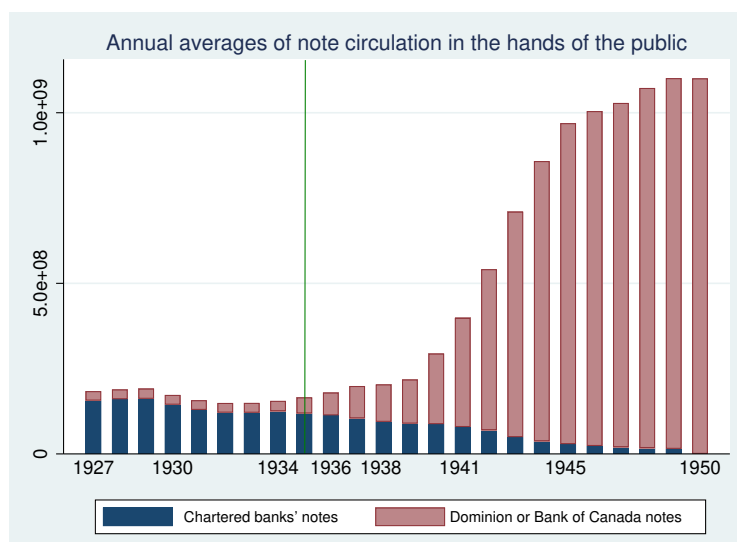
⁹In years 1900-1926, Dominion notes in circulation accounted for ca. one fifth of the chartered banks' notes circulation.

¹⁰The Canadian banking system was operating efficiently without the existence of a central bank, but the economic crisis in Canada and the worldwide economic slump of the 1930s made Prime Minister R.B. Bennett think about establishing a central bank. He set up a royal commission on the 31st July 1933 which was supposed to consider arguments for and against a central bank. After completing the hearings in September 1933, the commission advised creating such an institution and the Bank of Canada Act was passed on 3rd July 1934. The privately-owned bank opened its doors on March 11th 1935 and was nationalized in 1938. Bordo and Redish (1987) argue that the emergence of the Bank of Canada was a response to political rather than economic pressures: International organizations urged countries that did not yet have a central bank to establish one, as this would facilitate international monetary cooperation. In the absence of a Canadian central bank, international balances between Canada and London were settled in New York, where also the value of the Canadian dollar was determined. As Calomiris and Haber (2014), p. 312, note *“As an economic matter, the creation of the Bank of Canada had little effect on the commercial banking system: there simply wasn't much broken that needed fixing.”*

¹¹As visible from Figure 1, Bank of Canada increased the money supply considerably in an attempt to help Canadian economy out of depression (Ryan-Collins, 2015).

¹²Given public and banks' hesitation with regards to previous attempts to abolish private bank notes, one may wonder how come the Bank of Canada note monopoly was accepted in the 1930s, particularly by chartered banks. One explanation could be that chartered banks lost their political power. Another, that in fact, note issuing became less and less important for chartered banks as they could easily finance themselves with deposits. Figure A1 in Appendix A shows the historical evolution of the aggregate note to deposits ratio in years 1867-1950. The ratio shows a declining trend over time, so perhaps there is some truth to the latter hypothesis.

¹³Section 61, subsection 2 of the Bank Act 1934 reads: *“(...) on and after the day on which the Bank of Canada is authorized to commence business, the maximum amount of notes of a bank in circulation at any time shall not exceed the amount of the unimpaired paid-up capital of the bank on the said day on which the Bank of Canada is authorized to commence business, and on the first day of January in each year for a period of five years commencing on the first day of January nineteen hundred and thirty-six the said maximum shall be*



Note: Based on data from Dominion Bureau of Statistics (1944), p. 881 and Dominion Bureau of Statistics (1953), p. 1101. The data refers to annual averages of month-end figures.

Figure 1: Annual averages of note circulation in the hands of the public

note issuance by chartered banks was capped by their paid-up capital, and from 1936 on, the maximum issuance was gradually lowered, first by 5 percentage points, and then by 10 percentage points.¹⁴ From 1945, the maximum note issuance could not exceed 25 percent of banks' capital. Formally the right of commercial banks to issue their own notes was brought to an end by the amendment to the Bank Act in 1944 that specified that all chartered banks should redeem their notes in circulation until January 1st, 1950. Banks' annual reports (see Imperial Bank of Canada, 1936; The Canadian Bank of Commerce, 1937) indicate that there would be severe penalties, were the limit not respected. The Bank Act from 1934 implied another important change in the business of chartered banks: it ordered a gradual abolition of double liability applied to Canadian banks' shareholders. Since double liability in Canada was first and foremost established to protect banks' noteholders, the retraction of the right to issue banknotes by chartered banks was linked to the abolition in the contingent liability level.¹⁵

Given that the law referred to the maximum note issuance in relation to the paid-up capital, it implied a reduction in double liability level common to all chartered banks. When it comes to the impact on banks' note issuance, however, the law could have a differential impact on banks depending on their dependence on note issuance in the first place. This is explored in

reduced by five per centum, and on the first day of January in each year for a period of five years commencing on the first day of January nineteen hundred and forty-one the said maximum shall be reduced by ten per centum and thereafter until Parliament further enacts, the amount of notes of a bank in circulation shall not exceed twenty-five per centum of the amount of the unimpaired paid-up capital of the bank." Even though the law refers to a 'per centum' decrease it is clear from the suggested path and archival documents that actually a change in percentage points was meant.

¹⁴For a long-run aggregate ratio of bank notes to banks' paid-up capital, refer to Figure A2 in Appendix A.

¹⁵Referring to the section 125, subsection 2 of the Bank Act, Dixon, 1935, p. 76-77, writes: "*Along with the restriction of the note-issuing privileges of the banks, there is provided a corresponding reduction in the super-added liability of shareholders. In the event of insolvency this liability of a shareholder, in addition to any amount unpaid upon the shares held, will not bear a greater proportion to the par value of the shares held, than the proportion of the amount of notes which the bank is authorized to issue bears to the paid-up capital of the bank.*"

the rest of the paper, where I compare various measures for the group of banks that issued relatively more notes (treated banks) and the banks that were less reliant on money printing (control banks).

3 Data and descriptive statistics

The main data source is the historical Canada Year Book, which provides balance sheet and accounting data for chartered banks (individual banks' balance sheets are available from 1901 on, before that only the aggregate data is presented). The yearbooks provide details on the main components of assets and liabilities of chartered banks, as well as profits and dividend rate (that was regulated for most of the period).¹⁶ I collect profit and balance sheet data for the ten chartered banks existing in 1935 for the years 1927-1950.¹⁷ One of the banks in the sample, Barclays Bank of Canada, was only established in 1929 and there is no data on the profit ratios for this bank.

In addition, I collect data on market prices of publicly traded shares of Canadian chartered banks on the Toronto Stock Exchange from the archives of the Globe and the Globe and Mail. Whenever possible, I use the Annual Financial Survey to obtain the information on past years high and low price of a given share. Otherwise, I obtain this information from the first January issues of the newspaper. In 1944, a stock-split took place for Canadian chartered banks, which may influence the trade statistics. Moreover, after that time, some data is missing and/or illegible due to bad quality of the newspaper scans. Thus, the results derived using stock prices should be treated with caution.

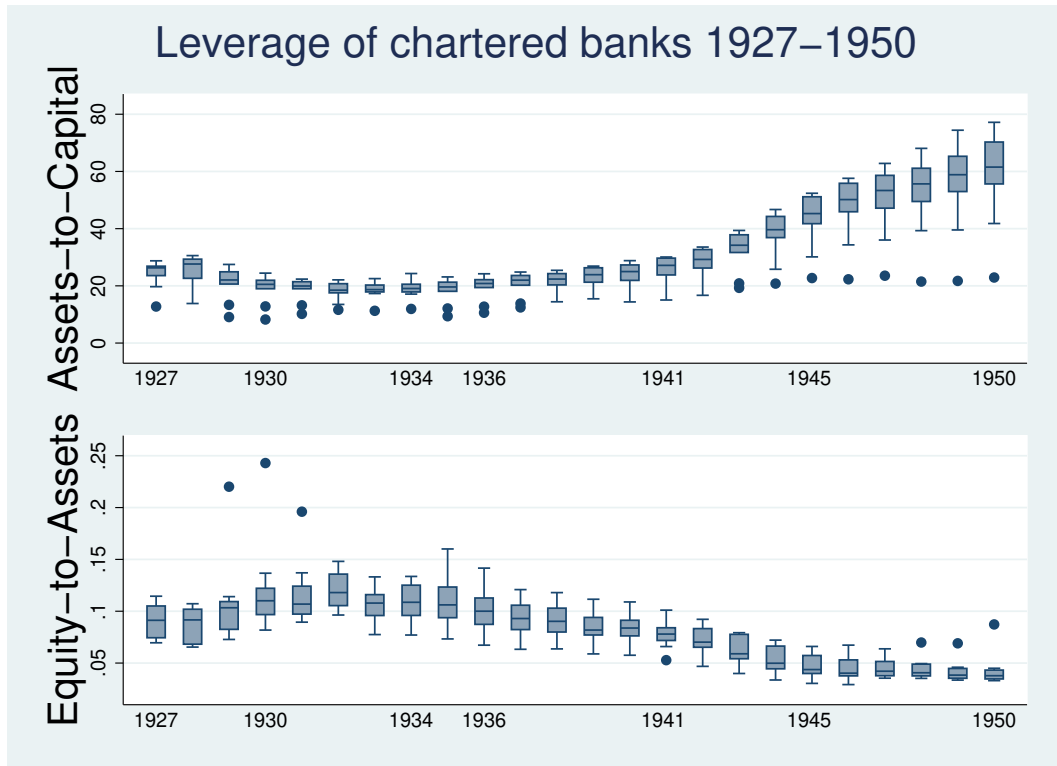
Narrative evidence on banks' reaction to the Bank of Canada note monopoly is further provided by banks' annual reports, retrieved from McGill Digital Archive of Canadian Corporate Reports. Annual reports provide also data for separate lending categories, used in the robustness section 4.4.1.

3.1 Balance sheet and profit measures of Canadian chartered banks

In the considered period, banks' leverage was following an upward trend, which is reflected in Figure 2 plotting assets-to-capital and equity-to-assets for the ten Canadian chartered banks in years 1927-1950 in the form of the box plot. The box plots give an indication of the distribution of considered variable among the ten Canadian banks in a given year, and the horizontal line in the middle of the box indicates the median, on which I focus in the description. Over time, median leverage (defined as assets-to-capital) of Canadian banks increased, and an increase in the dispersion among banks can be observed. The tendency in the equity-to-assets ratio is less

¹⁶Despite their availability, the yearbooks are not a perfect source of data, as over time, the way of presenting balance sheet data changed several times. In the early sample years, the Canada Year Book provided information on individual chartered banks at the end of the year, while for later years, starting from 1934, balance sheets calculated as an average over 12 months are available for a given year and preceding years.

¹⁷I collect data starting from 1927 in order to account for the period before the onset of Great Depression that had a big negative impact on Canadian economy.



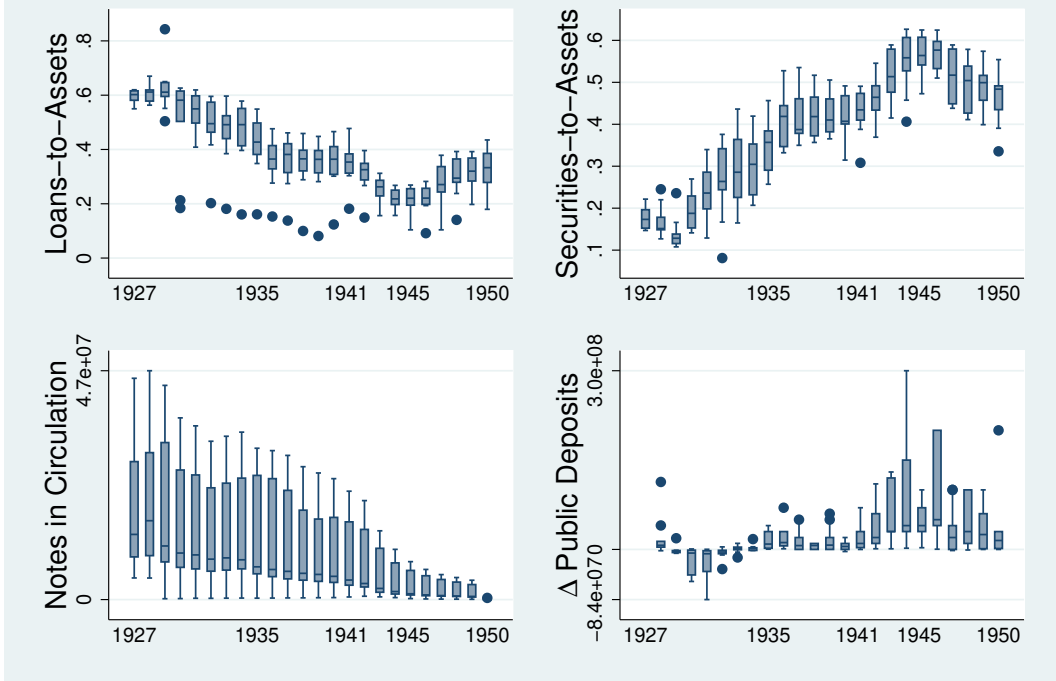
Note: The horizontal line in the middle of the box indicates the median, and the lower and upper borders of the box represent the 25th and 75th percentile. The upper and lower adjacent lines indicate maximum and minimum values that are not outliers (defined as more than 1.5 interquartile ranges away from the 25th or 75th percentile.)

Figure 2: Leverage and contingent liability level for Canadian chartered banks in years 1934-1950

indicative of a strong trend, but also for this measure, the median decreases, indicating higher leverage. Recall that double liability was gradually abolished starting from 1936, so the box plots could indicate that as banks moved from double liability to single liability, their riskiness increased. However, note that, *ceteris paribus*, a reduction of notes in circulation over time leads to a mechanical increase in leverage, even if banks do not expand their balance sheets. Thus, the plots in Figure 2 by no means suggest any causal relation.

Figure 3 provides more insights on the balance sheet composition of Canadian chartered banks in 1927-1950. We see that over time (and thus under lower levels of contingent liability), Canadian banks lowered their loans-to-assets and increased their securities holdings. This is consistent with the narrative of Neufeld (1972) who emphasizes that the securities holdings of Canadian chartered banks in that period consisted predominantly of federal and government securities, mostly due to government financing in the First and Second World War, and given banks' previous bad experiences with corporate securities and railway financing. Neufeld (1972), p. 116 notes: *"the steady decline in the relative importance of bank loans among assets after the 1911-15 period had its counterpart not only in an increase in security holdings but in holdings of increasingly more liquid securities."* Thus, even though Canadian banks increased their leverage in the first half of the twentieth century (partially due to the enforced decrease in notes in circulation plotted in the second row of Figure 3), this should not be interpreted as a

Balance sheet measures of chartered banks 1927–1950



Note: The horizontal line in the middle of the box indicates the median, and the lower and upper borders of the box represent the 25th and 75th percentile. The upper and lower adjacent lines indicate maximum and minimum values that are not outliers (defined as more than 1.5 interquartile ranges away from the 25th or 75th percentile).

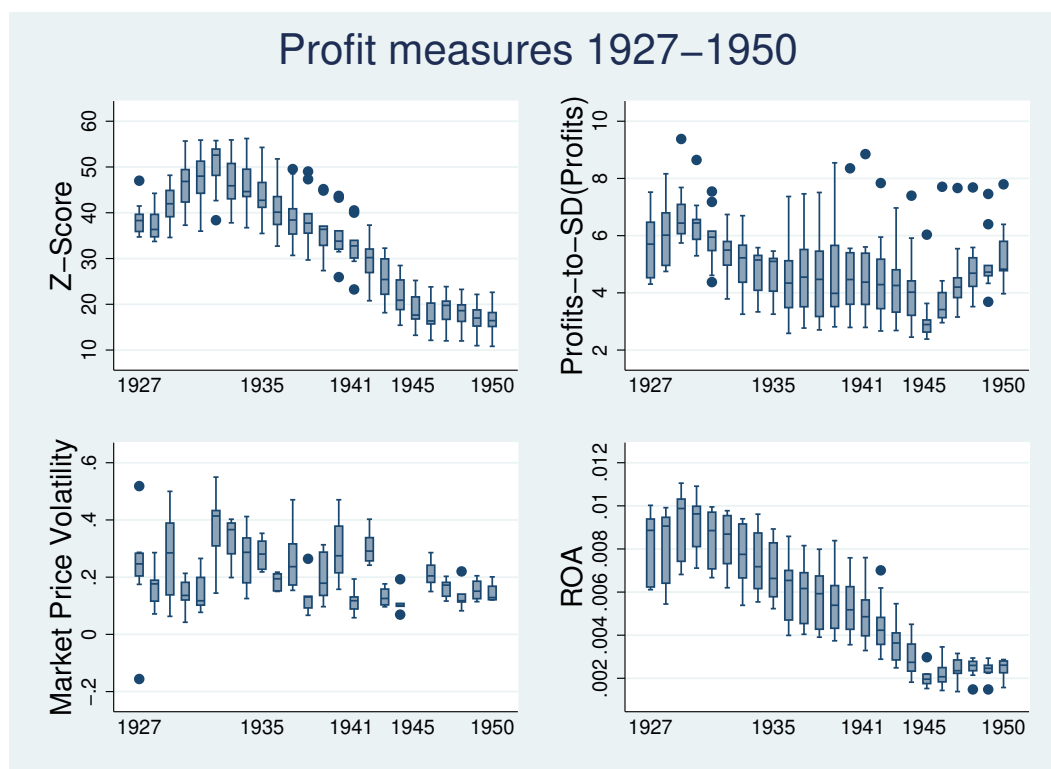
Figure 3: Balance sheet measures for Canadian chartered banks in years 1927-1950

sign of increased risk-taking (perhaps due to the shift towards a more lenient liability regime of banks' shareholders). The change in public deposits (calculated as first difference) does not seem to exhibit a clear pattern over time. Chartered banks could potentially compensate for losing the right to issue notes by raising interest rates on deposits. However, the examination of interest rates in Canada in the considered period does not deliver many insights. While the interest rates on loans of Canadian banks were subject to a 6 (from 1944) or 7% ceiling in period 1934-50, there was no ceiling on interest rate demanded on deposits. However, the interest rates paid on deposits paid into chartered banks followed closely interest on government securities. Ascah (1999), p.47, writes about the government pressure exerted on banks and other financial intermediaries accepting deposits to follow the recommended interest rates' trajectory.

Figure 4 presents the measures calculated using the profit and stock price information of banks. In the literature, volatility of returns and the Z-score are common indicators for risk measures (Laeven and Levine, 2009; Köhler, 2012). The Z-score is defined as the ratio of the return on assets plus the equity to assets ratio divided by the standard deviation of the return on assets over the considered time period. The formula for the Z-score is the following:

$$Z - Score_{i,t} = \frac{ROA_{i,t} + E/A_{i,t}}{SD(ROA_i)}, \quad (1)$$

where I calculate the standard deviation of return on assets (ROA) over the period 1927-1950.



Note: The horizontal line in the middle of the box indicates the median, and the lower and upper borders of the box represent the 25th and 75th percentile. The upper and lower adjacent lines indicate maximum and minimum values that are not outliers (defined as more than 1.5 interquartile ranges away from the 25th or 75th percentile).

Figure 4: Profit measures and stock market volatility for Canadian chartered banks in years 1927-1950

Z-score is interpreted as the inverse of the probability of insolvency, and it indicates a lower bound for number of standard deviations returns have to drop below expected in order to exhaust the bank's equity. It is often used as an alternative to the distance to default measure when the market data is unavailable (Laeven and Levine, 2009). The Z-score of the banks follows a declining trend over time, in line with the pattern exhibited by ROA and the equity-to-assets ratio presented in Figure 2. Profits to their standard deviation (calculated over the period 1927-1950) and market price volatility (defined as the difference between the highest and lowest stock price in a given year, divided by the average price in the same year) do not follow a strong trend.

3.2 Bank-specific changes in note issuance

The law from 1934 introduced a cap on chartered banks' note issuance. From 1935 on, when Bank of Canada opened its doors, banks' notes to paid-up capital ratio could not exceed 1, and the limit (corresponding to the super-added liability) was to be lowered with time by first 5 percentage points and then 10 percentage points until in 1950 the banks right to issue notes came ultimately to an end, see Table 1.

The law introduced a cap on the maximum issuance of banknotes in relation to the capital, so it might be that if a bank never fully executed its right to issue banknotes and issued only

| Year | Limit on the $\frac{\text{Notes}}{\text{Capital}}$ ratio | Liability level |
|------|--|-----------------|
| 1935 | 1 | 2 |
| 1936 | 0.95 | 1.95 |
| 1937 | 0.9 | 1.9 |
| 1938 | 0.85 | 1.85 |
| 1939 | 0.8 | 1.8 |
| 1940 | 0.75 | 1.75 |
| 1941 | 0.65 | 1.65 |
| 1942 | 0.55 | 1.55 |
| 1943 | 0.45 | 1.45 |
| 1944 | 0.35 | 1.35 |
| 1945 | 0.25 | 1.25 |
| 1946 | 0.25 | 1.25 |
| 1947 | 0.25 | 1.25 |
| 1948 | 0.25 | 1.25 |
| 1949 | 0.25 | 1.25 |
| 1950 | 0 | 1 |

Table 1: Liability levels and limits on note issuance 1935-1950

very few of them, it would not be affected by the change in regulation at all in a given year. On the opposite, if before the establishment of the Bank of Canada a bank was relying heavily on financing through issuing notes, a law restricting the maximum note issuance to a certain fraction of capital would be binding and could affect banks' behavior. Narrative evidence suggests that banks were afraid of possible consequences of the limit on banknote issuance. Private correspondence (Barclays Bank Archives, 1934) between the Barclays Bank in Canada officials indicates that the upcoming change in regulation was a reason why bank increased its paid-up capital in 1935 - in order to be able to issue more notes in the transition period. Interestingly, Barclays Bank of Canada was never among the banks that were relying heavily on note issuance, so eventually, the law was not binding for it. Given the fact that in the transition period 1936-1950, the maximum limit was reduced from the day of 1st January, the banks de facto had to adapt to the change in the year before. Figure 5 plots the individual change in banknote issuance for 10 Canadian chartered banks over the period 1933-1950. The ticks on the y-axis between 1 and 0 indicate different values of the ratio imposed by the law over time. I plot this ratio starting from 1933. The plot starts after Great Depression, given that this period is unlikely to be representative for the discussed ratio. For a long-run aggregate ratio of bank notes to banks' paid-up capital, refer to Figure A2 in Appendix A.

As discussed earlier, in the wake of the change in regulation, the ratio of notes to capital in 1935 could not exceed 1, which means that banks that had an average note to capital ratio of above 1 in 1934 had to adjust their business model after the Bank Act was amended, while the ones with this ratio below 1 could continue business as usual. In order to take into account expectation of banknote monopoly by banks, I focus at the ratio in 1933 (in 1934 banks were fully aware of the law proposals that have been made). As we see from the Figure 5 presenting the notes to capital ratio for all ten banks, in 1933, three banks were constrained

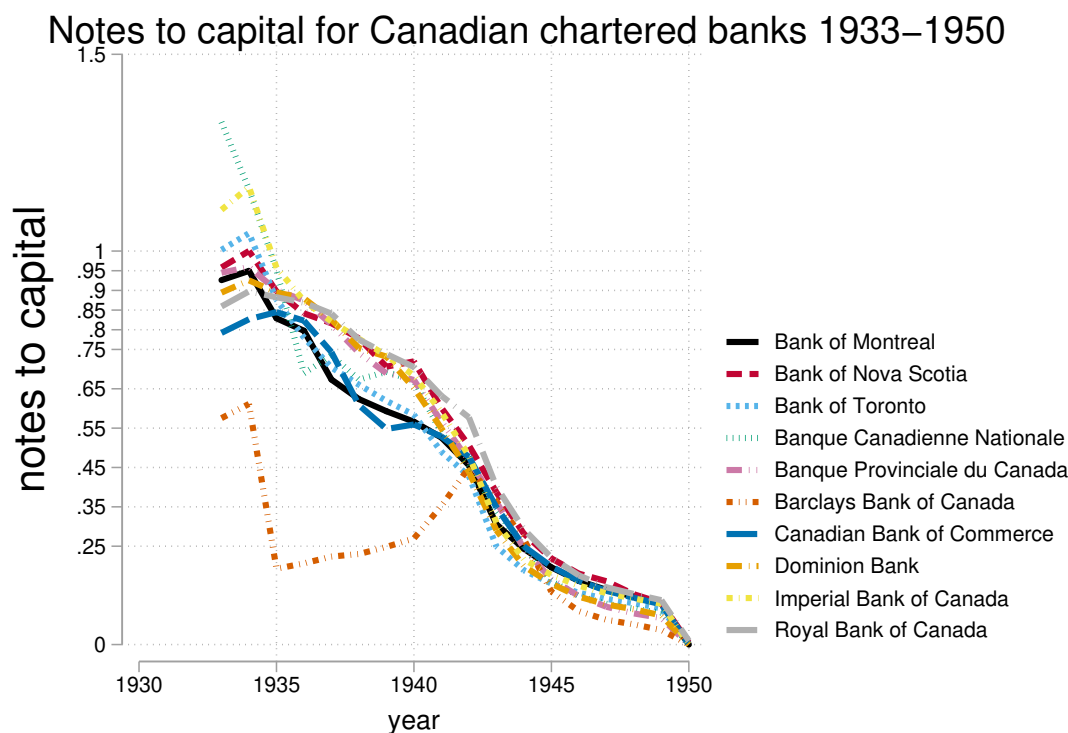


Figure 5: The ratio of notes to capital for Canadian chartered banks in years 1933-1950

by the ratio of notes to capital equal 1: Banque Canadienne Nationale,¹⁸ Imperial Bank of Canada,¹⁹ Bank of Toronto, while in 1934 for four banks the change in regulation imposed a binding constraint: Banque Canadienne Nationale, Imperial Bank of Canada, Bank of Toronto and the Bank of Nova Scotia. Depending on the definition of the treatment year, these banks can thus be considered as banks *treated* by the regulation. My benchmark specification defines the treatment in 1933 in order to make sure that the change in law was unexpected for banks. I also test the robustness of results for the definition of treatment made in 1934, which moves Bank of Nova Scotia to the treated group.

Before running the diff-in-diff regression, I report the summary statistics of the treated and control groups and show the trends in chosen variables. Table 2 reports the summary statistics for control and treated banks for the period before the change in the law, i.e. for years 1927-1934, along with the normalized differences, defined as in Imbens and Wooldridge (2009). We see that the treated and control banks are fairly similar when it comes to their leverage ratios, standard deviation of returns and flows of public deposits. However, treated banks, having a higher share of notes to the paid-up capital (even though in absolute numbers they issued less notes due to their smaller size), were on average smaller than the control banks (as defined by total assets) and had higher returns on assets and profits in relation to their standard deviation,

¹⁸Banque Canadienne Nationale, having the highest ratio of notes to capital, was formed after the merge of Banque d'Hochelega and Banque Nationale in 1924. The latter bank was known for having high note circulation and low capitalisation, and its capital became further impaired in the pre-merge years (Noiseux, 2002). Hence, Banque Canadienne Nationale's high note to capital ratio may have been a legacy of that merge.

¹⁹The Imperial Bank of Canada took over Weyburn Security Bank in 1931. Imperial Bank of Canada (1931), p. 27, mentions that the Weyburn Security Banks had few deposits, which may have contributed to the heightened note to capital ratio of the Imperial Bank of Canada.

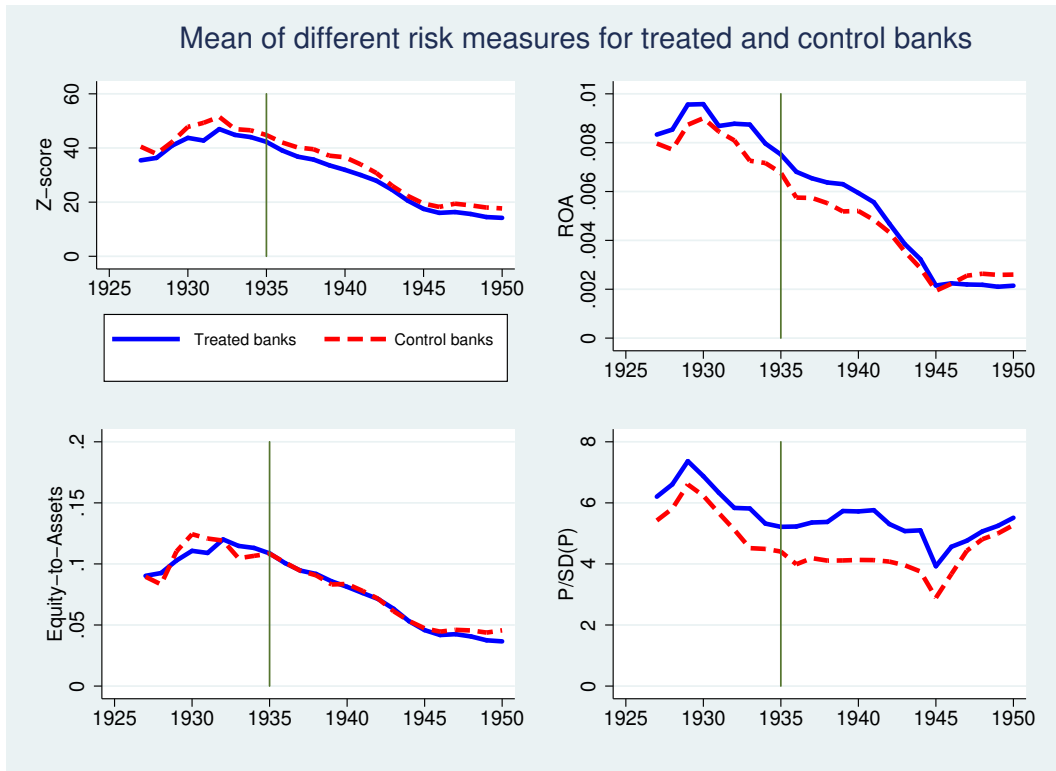


Figure 6: Mean of risk and profit measures of treated and control banks in years 1927-1950

which may suggest that high note issuance in relation to their size helped them stabilize their returns and obtain higher profit margins. Even though there were some absolute differences between the treated and control banks before 1935, figures 6 and 7 presenting the mean of chosen risk and profit measures and balance sheet characteristics of treated and control banks show that the trends governing the development of these variables were mostly similar across the banks. No obvious big changes are visible at the first glance in the period after 1935, but I test this statement formally in the next section.

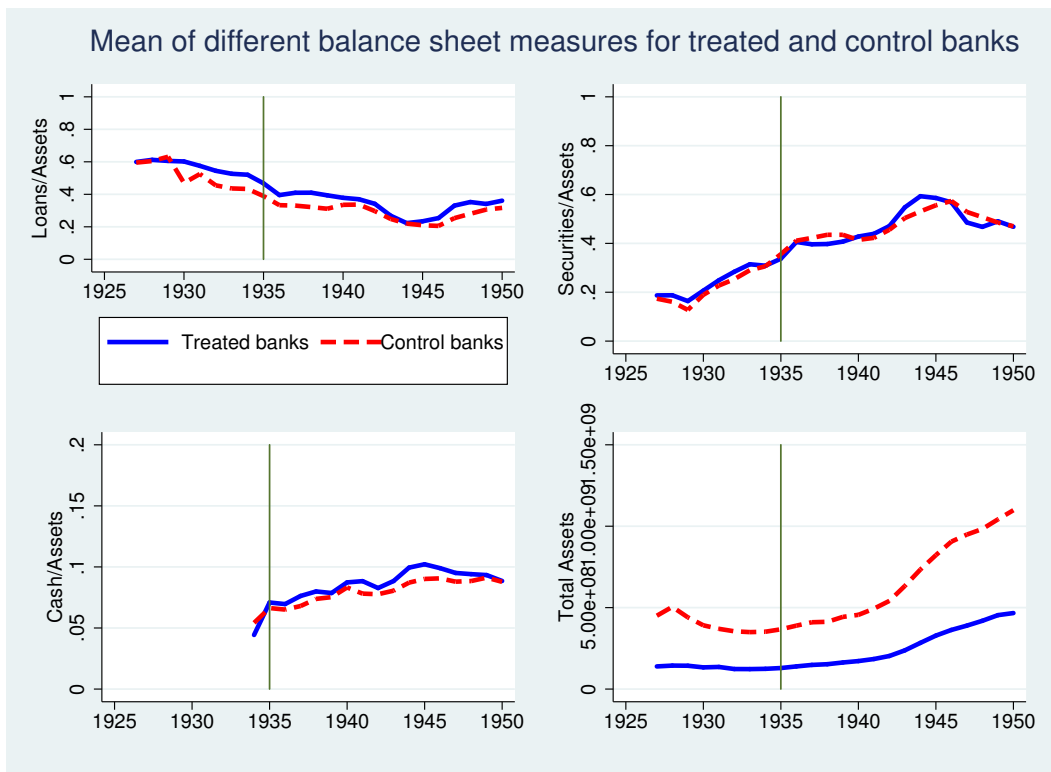
4 Empirical strategy and results

In the following, I conduct a difference-in-differences regression around the year 1935 to test whether the amendment to the Bank Act affected differently banks for whom the limit on note issuance was binding. The limit on banknote issuance imposed a binding constraint for the treated banks (as defined in section 3.2) that had to adjust their business in response to the change in regulation. Given that the banks in the control group were not predominantly reliant on note financing in the first place, the new law affected them much less and did not force them to immediately change their balance sheet, as it was the case for the treated group. In the absence of capital requirements, the limit on banknote issuance could have led to higher leverage of treated banks (if they wanted to keep the size of their balance sheet constant) or a relative reduction in their assets at a constant leverage. If banks relied much on note financing, it would be also not surprising to see an increase in the volatility of their profits or returns if they used notes to smooth exogenous shocks.

| Variable | Control banks | | | | | Treated banks | | | | | Norm. diff. |
|---------------------------|---------------|-------|-------|-------|-------|---------------|-------|-------|-------|-------|-------------|
| | min | p50 | max | sd | mean | min | p50 | max | sd | mean | |
| Z-score | 34,54 | 43,91 | 56,23 | 6,74 | 45,34 | 33,73 | 41,82 | 52,6 | 6,13 | 41,87 | -0,38* |
| ROA ($1 * 10^3$) | 5,39 | 8,08 | 10,31 | 1,55 | 8,05 | 6,11 | 9,28 | 11,05 | 1,57 | 8,77 | 0,33* |
| Equity-to-Assets | 0,07 | 0,1 | 0,24 | 0,03 | 0,11 | 0,07 | 0,11 | 0,14 | 0,02 | 0,11 | -0,04 |
| Assets-to-Capital | 8,23 | 20,72 | 30,57 | 5,73 | 20,39 | 17,87 | 19,92 | 27,64 | 2,76 | 20,69 | 0,05 |
| Profits/SD(Profits) | 3,25 | 5,52 | 7,68 | 1,14 | 5,48 | 4,96 | 5,92 | 9,38 | 1,17 | 6,29 | 0,5* |
| Net profits (m) | 0,41 | 3,09 | 7,15 | 2,07 | 3,21 | 0,82 | 1,17 | 1,56 | 0,21 | 1,16 | -0,98* |
| 3Y SD(ROA) ($1 * 10^3$) | 0,04 | 0,53 | 1,62 | 0,3 | 0,57 | 0,11 | 0,49 | 1,33 | 0,35 | 0,56 | -0,03 |
| 5Y SD(ROA) ($1 * 10^3$) | 0,24 | 0,81 | 1,34 | 0,31 | 0,78 | 0,35 | 0,66 | 1,43 | 0,36 | 0,76 | -0,04 |
| 3Y SD(ROE) ($1 * 10^3$) | 0,68 | 4,98 | 12,64 | 3,27 | 5,78 | 1,01 | 4,92 | 9,89 | 2,75 | 5,24 | -0,13 |
| 5Y SD(ROE) ($1 * 10^3$) | 1,41 | 7,77 | 17,16 | 3,65 | 8,2 | 3,56 | 7,66 | 12,68 | 2,8 | 7,82 | -0,08 |
| Market Volatility | -0,16 | 0,25 | 0,55 | 0,14 | 0,26 | 0,04 | 0,19 | 0,52 | 0,13 | 0,21 | -0,23 |
| Δ Public Deposits | -84,2 | -1,41 | 113 | 27,3 | -3,75 | -9,35 | -2,45 | 5,54 | 4,47 | -1,87 | 0,07 |
| Loans-to-Assets | 0,16 | 0,55 | 0,84 | 0,13 | 0,52 | 0,46 | 0,59 | 0,65 | 0,05 | 0,57 | 0,4* |
| Securities-to-Assets | 0,08 | 0,2 | 0,44 | 0,09 | 0,22 | 0,12 | 0,23 | 0,36 | 0,07 | 0,24 | 0,17 |
| Cash-to-Assets | 0,01 | 0,06 | 0,1 | 0,03 | 0,05 | 0,03 | 0,05 | 0,05 | 0,01 | 0,04 | -0,27* |
| Total Assets | 4,12 | 270 | 962 | 331 | 399 | 109 | 133 | 155 | 12,4 | 133 | -0,8* |
| Notes | 34,54 | 34,54 | 34,54 | 34,54 | 34,54 | 34,54 | 34,54 | 34,54 | 34,54 | 34,54 | -0,63* |
| Notes-to-Capital | 0,35 | 0,96 | 1,62 | 0,29 | 1,01 | 0,97 | 1,3 | 3,28 | 0,51 | 1,42 | 0,7* |

* denotes that the normalized difference is larger than one quarter, which according to Imbens and Wooldridge (2009) may make the regression sensitive to the specification.

Table 2: Summary statistics for control and treated banks before the treatment



Notes: The cash ratio is only plotted from 1934 due to changes in data reporting and a lack of clear counterpart before that date.

Figure 7: Mean of balance sheet measures of treated and control banks in years 1927-1950

The difference-in-differences model takes the following form:

$$y_{i,t} = \mu_t + \alpha_i + \beta_1 Post_{1935} * Treated_{i,1933} + \beta_2 x_{i,t} + \epsilon_{i,t}, \quad (2)$$

where $y_{i,t}$ denotes the profit and balance sheet measures for bank i in time t , μ_t is the year fixed effect, α_i is the bank fixed effect, $x_{i,t}$ are additional control variables and $\epsilon_{i,t}$ is the error term. $Post_{1935}$ refers to the period after 1935 and $Treated_{i,1933}$ takes the value of 1 for banks whose notes to capital ratio in 1933 exceeded 1. The coefficient β_1 on the interaction term is the coefficient of interest and indicates whether the effect of treatment was different for banks that were more affected by the change in regulation.

4.1 Short-term effects

Given that the path of changes in maximum notes to capital limits was announced publicly in 1934, in my baseline regression, I concentrate on years 1933-1936, which, given the small number of banks and annual data, leaves me with only few observations. Table 3 reports the results for the treatment defined in year 1933, with the difference in assets and in national production as additional regressors in the lower panel of the table. The upper panel of the Table includes time fixed effects which are absent from the second specification due to collinearity with the change in production. We can see that after the regulation, the treated banks become relatively more leveraged (defined as equity to assets ratio). Moreover, the 3- and 5-year standard deviation of their returns on equity ROE increases, suggesting that notes might have

played an important role in profit generation and smoothing for these banks. The volatility of market prices is relatively lower for treated banks. Lastly, their loans to assets exhibit a relative decline, which could suggest that they restrict lending once they need to restrict their note issuance.²⁰

Table 4 presents regression results for a continuous definition of treatment. Thus, I do not work with dummies for the definition of treated and control banks any more. Instead, I measure the distance that each bank had from the maximum note to capital limit imposed by the regulation, either separately for each year the regression is conducted (as specified in equation 3), or only for 1933 (see equation 4). The bigger the distance from the imposed limit, the more was a bank constrained by the regulation.

$$y_{i,t} = \mu_t + \alpha_i + \beta_1 Post_{1935} * Treat(N2K_{it} - \widetilde{N2K}_t) + \beta_2 x_{i,t} + \epsilon_{i,t}, \quad (3)$$

where $\widetilde{N2K}_{it}$ is a distance measure of bank-specific notes-to-capital (N2K) in year t to the target $\widetilde{N2K}_t$ for year t imposed by the regulation.

$$y_{i,t} = \mu_t + \alpha_i + \beta_1 Post_{1935} * Treat(N2K_{i,1933} - \widetilde{N2K}_{1933}) + \beta_2 x_{i,t} + \epsilon_{i,t}, \quad (4)$$

where $N2K_{i,1933}$ is the bank-specific note-to-capital measure in year 1933 and $\widetilde{N2K}_{1933}$ is the target ratio for year 1933.

The results shown in Table 4 mostly confirm the conclusions from the standard difference-in-differences regression. When treatment is defined as a continuous variable, we see that banks for which regulation was more binding, became relatively more leveraged, had higher volatility of returns on assets and returns on equity, and lower loans to assets. Interestingly, the continuous treatment suggests that the treated banks also relatively reduced their share of securities to assets.

4.2 Long-term effects

Next, I present the results taking into account a longer time span around the change in regulation, i.e. I run the diff-in-diff regression as specified in equation 2 for years 1927-1950. This has the drawback of including the years in the regression, in which the policy change was announced and well known for all the banks. On the other hand, it is unlikely that banks whose business model relied extensively on banknote issuance managed to adapt to the change in the first two years after the enacting of the amendment to the Bank Act, and a longer time span enables to look at the effects of central bank cash monopoly in a longer horizon. I present the results of this exercise in Table 5. In the upper panel of Table 5, merely securities to assets show a significant difference for treated and control banks, suggesting that treated banks invested relatively less in securities after the change in regulation. Once I control for the change in

²⁰Table A1 in Appendix B presents regression results analogous to those from Table 3, but with the treated and control groups defined in year 1934. We see that the results are mostly insignificant, reflecting the fact that in 1934 banks were already informed about the policy change, and thus the change in law cannot be treated as an exogenous shock any more.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|--|---------------------------|--------------------------|--------------------------|-------------------------------|-------------------------|--------------------------|------------------------|---------------------------|----------------------------|-----------------------------|
| | Z-score | ROA | $\frac{Equity}{Assets}$ | $\frac{Profits}{SD(Profits)}$ | 3Y SD(ROA) | 3Y SD(ROE) | 5Y SD(ROE) | Market Volatility | $\frac{Loans}{Assets}$ | $\frac{Securities}{Assets}$ |
| <i>Post</i> ₁₉₃₅ * <i>Treated</i> _{t,1933} | -0.401 (0.469) | -0.000238 (0.000595) | -0.00841* (0.00412) | -0.0416 (0.478) | 0.000390 (0.000277) | 0.00364*** (0.00116) | 0.00237** (0.00109) | -0.0716** (0.0263) | -0.0184* (0.0107) | -0.0254* (0.0125) |
| <i>N</i> | 36 | 36 | 40 | 36 | 36 | 36 | 36 | 30 | 40 | 40 |
| adj. <i>R</i> ² | 0.990 | 0.824 | 0.818 | 0.766 | 0.253 | 0.731 | 0.575 | 0.744 | 0.969 | 0.916 |
| Bank FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Time FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| <i>Post</i> ₁₉₃₅ * <i>Treated</i> _{t,1933} | -1.098 (0.986) | -0.000310 (0.000654) | -0.0121* (0.00609) | -0.0714 (0.498) | 0.000463 (0.000317) | 0.00418*** (0.00142) | 0.00266* (0.00143) | -0.106** (0.0426) | -0.0357* (0.0205) | -0.0171 (0.0239) |
| Δ Assets | -4.21e-08** (1.95e-08) | -4.37e-12 (1.08e-11) | -2.80e-10* (1.60e-10) | -1.79e-09 (5.95e-09) | 4.35e-12 (5.20e-12) | 3.24e-11 (2.95e-11) | 1.77e-11 (3.24e-11) | -1.54e-09* (7.55e-10) | -1.32e-09*** (3.75e-10) | 6.31e-10 (5.49e-10) |
| Δ National_Production | -2.25e-09* (1.11e-09) | -1.32e-12* (7.31e-13) | 3.75e-12 (1.27e-11) | -6.23e-10 (5.25e-10) | -4.31e-13 (5.79e-13) | -5.08e-12* (2.72e-12) | 1.99e-12 (3.04e-12) | -1.96e-10** (6.86e-11) | -1.98e-11 (2.39e-11) | 4.78e-11 (3.73e-11) |
| <i>N</i> | 36 | 36 | 40 | 36 | 36 | 36 | 36 | 30 | 40 | 40 |
| adj. <i>R</i> ² | 0.960 | 0.771 | 0.820 | 0.757 | 0.260 | 0.743 | 0.581 | 0.631 | 0.938 | 0.838 |
| Bank FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Time FE | N | N | N | N | N | N | N | N | N | N |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Difference-in-difference results for years 1933-1936 and the treatment groups defined in 1933

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|--|--------------------------|--------------------------|---------------------------|-------------------------------|--------------------------|-------------------------|------------------------|---------------------------|----------------------------|-----------------------------|
| | Z-score | ROA | $\frac{Equity}{Assets}$ | $\frac{Profits}{SD(Profits)}$ | 3Y SD(ROA) | 3Y SD(ROE) | 5Y SD(ROE) | Market Volatility | $\frac{Loans}{Assets}$ | $\frac{Securities}{Assets}$ |
| $Post_{1935} * Treat(N2K_{it} - \widehat{N2K}_t)$ | 5.298** (2.272) | -0.00129 (0.00365) | -0.0647*** (0.0147) | -0.164 (2.686) | 0.00273* (0.00143) | 0.0140* (0.00800) | 0.0158** (0.00633) | -0.342 (0.347) | -0.102** (0.0434) | -0.139** (0.0595) |
| N | 36 | 36 | 40 | 36 | 36 | 36 | 36 | 30 | 40 | 40 |
| adj. R ² | 0.990 | 0.816 | 0.955 | 0.758 | 0.254 | 0.649 | 0.537 | 0.683 | 0.977 | 0.937 |
| Bank FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Time FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| $Post_{1935} * Treat(N2K_{it} - \widehat{N2K}_t)$ | 7.541 (8.030) | -0.0000360 (0.00532) | -0.0647*** (0.0186) | -0.0387 (3.340) | 0.00348** (0.00138) | 0.0152* (0.00823) | 0.0170** (0.00636) | -0.500 (0.516) | -0.102*** (0.0344) | -0.138*** (0.0441) |
| Δ Assets | -3.12e-08 (2.38e-08) | -4.46e-12 (1.16e-11) | -9.31e-11 (6.04e-11) | -3.22e-09 (6.61e-09) | 6.06e-12 (5.42e-12) | 1.87e-11 (3.23e-11) | 1.49e-11 (3.10e-11) | -8.48e-10 (8.57e-10) | -1.15e-09** (4.14e-10) | 1.03e-09** (4.78e-10) |
| Δ National_Production | -2.43e-09* (1.23e-09) | -1.35e-12* (7.54e-13) | -8.93e-13 (6.54e-12) | -6.13e-10 (5.27e-10) | -3.85e-13 (5.65e-13) | -4.43e-12 (3.18e-12) | 2.39e-12 (3.08e-12) | -2.16e-10** (8.33e-11) | -2.73e-11 (2.36e-11) | 3.85e-11 (3.07e-11) |
| N | 36 | 36 | 40 | 36 | 36 | 36 | 36 | 30 | 40 | 40 |
| adj. R ² | 0.959 | 0.762 | 0.926 | 0.751 | 0.277 | 0.652 | 0.541 | 0.536 | 0.937 | 0.870 |
| Bank FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Time FE | N | N | N | N | N | N | N | N | N | N |
| $Post_{1935} * Treat(N2K_{i,1933} - \widehat{N2K}_{1933})$ | 1.346 (0.943) | -0.000912 (0.000980) | -0.0450** (0.0214) | -0.787 (0.809) | 0.00142*** (0.000432) | 0.00660** (0.00315) | 0.00356 (0.00286) | -0.120 (0.144) | -0.0798** (0.0379) | -0.111** (0.0501) |
| N | 36 | 36 | 40 | 36 | 36 | 36 | 36 | 30 | 40 | 40 |
| adj. R ² | 0.990 | 0.825 | 0.870 | 0.771 | 0.277 | 0.665 | 0.522 | 0.696 | 0.974 | 0.932 |
| Bank FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Time FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| $Post_{1935} * Treat(N2K_{i,1933} - \widehat{N2K}_{1933})$ | -0.564 (3.420) | -0.00120 (0.00179) | -0.0481** (0.0212) | -1.018 (1.052) | 0.00172*** (0.000591) | 0.00762* (0.00369) | 0.00390 (0.00354) | -0.261 (0.283) | -0.0945** (0.0344) | -0.103* (0.0538) |
| Δ Assets | -3.42e-08 (2.12e-08) | -5.17e-12 (1.14e-11) | -2.50e-10** (1.11e-10) | -4.14e-09 (6.59e-09) | 5.36e-12 (5.15e-12) | 1.83e-11 (2.97e-11) | 5.93e-12 (3.14e-11) | -1.12e-09 (8.80e-10) | -1.18e-09*** (3.55e-10) | 6.38e-10 (4.74e-10) |
| Δ National_Production | -2.43e-09* (1.19e-09) | -1.30e-12* (7.24e-13) | 3.14e-12 (1.03e-11) | -5.70e-10 (5.07e-10) | -4.53e-13 (5.68e-13) | -4.76e-12 (3.04e-12) | 2.26e-12 (3.19e-12) | -2.06e-10** (8.16e-11) | -2.26e-11 (2.26e-11) | 4.77e-11 (3.30e-11) |
| N | 36 | 36 | 40 | 36 | 36 | 36 | 36 | 30 | 40 | 40 |
| adj. R ² | 0.958 | 0.772 | 0.868 | 0.763 | 0.291 | 0.669 | 0.523 | 0.560 | 0.939 | 0.855 |
| Bank FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Time FE | N | N | N | N | N | N | N | N | N | N |

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Difference-in-difference results for years 1933-1936 and continuous treatment

banks' assets and national production in the lower panel of the table, regression suggests that treated banks exhibited a relatively lower Z-score, lower returns on assets and lower share of lending in their portfolio after the change in regulation. This is consistent with results from Table 3 that indicate that banknote issuance was an important source of revenue and of revenue smoothing for the banks. Once I change the definition of treated banks from 1933 to 1934, the longer-run horizon regressions indicate relative decrease in Z-score and ROA for treated banks (see Table A2) in Appendix B.

4.3 Robustness: excluding Barclays Bank of Canada

With only ten chartered banks in the sample and an annual dataset, the decision to exclude one of the banks from the empirical tests may seem a folly. However, Barclays Bank of Canada was different from the remaining nine chartered banks in the sample. It has been established quite late, in 1929 and over the considered period it had only one to four branches, in contrast to an extensive branch structure of other banks. It did not report its profits and losses in Canada, and hence, was excluded from those regressions in the previous sections that required data on returns. Moreover, as seen from Figure 5, the pattern of the decline of notes to capital for Barclays Bank of Canada was quite distinct from the development of this ratio of other banks. In this subsection, I thus repeat my main regressions from section 4.1 excluding Barclays Bank of Canada from those regressions in which it was present. Table 6 presents the results from this robustness check, indicating that the significant changes in the leverage, ratio of loans to assets and securities to assets found in the previous sections are not robust to the exclusion of Barclays Bank of Canada from the sample. Hence, it cannot be concluded from the presented regressions that the change in regulation led to a differential readjustment of assets portfolio or leverage among treated and control banks. It is worth highlighting, though, that regulation had impact on profitability ratios of banks, and this result is unaffected by the presence of Barclays Bank of Canada in the dataset, since there is no data on returns of this bank.

4.4 Exploring the channels: lending and branching response

I explore two additional channels through which the banknote monopoly of Bank of Canada could have affected incumbent chartered banks.

4.4.1 Disaggregated lending response

The first channel relates to different categories of loans. While, as discussed in section 4.3, the share of aggregated lending to assets did not develop differently for treated and control banks, perhaps we could see a significant difference while looking at more detailed loan data. In order to test this hypothesis, in addition to the balance sheet data provided by Canada Year Books, I collected data on separate lending categories by banks from their annual reports. The reports are available for all chartered banks excluding Barclays Bank of Canada, however, their coverage over time differs for particular banks, which restricts the sample even further.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|----------------------------------|-------------------------------|----------------------------|----------------------------|-------------------------------|--------------------------|----------------------------|----------------------------|--------------------------|----------------------------|-----------------------------|
| | Z-score | ROA | $\frac{Equity}{Assets}$ | $\frac{Profits}{SD(Profits)}$ | 3Y SD(ROA) | 3Y SD(ROE) | 5Y SD(ROE) | Market Volatility | $\frac{Loans}{Assets}$ | $\frac{Securities}{Assets}$ |
| $Post_{1935} * Treated_{i,1933}$ | 0.443 (0.694) | -0.000375 (0.000277) | 0.000339 (0.000373) | 0.190 (0.207) | 0.000113 (0.0000941) | 0.000923 (0.000963) | 0.00110 (0.00102) | 0.0148 (0.0283) | -0.00912 (0.0182) | -0.0237** (0.0120) |
| <i>N</i> | 216 | 216 | 238 | 216 | 198 | 198 | 180 | 155 | 238 | 238 |
| adj. <i>R</i> ² | 0.970 | 0.907 | 0.856 | 0.825 | 0.384 | 0.289 | 0.312 | 0.441 | 0.843 | 0.911 |
| Bank FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Time FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| $Post_{1935} * Treated_{i,1933}$ | -3.534* (1.835) | -0.000906** (0.000436) | -0.00628 (0.00574) | 0.111 (0.292) | 0.000107 (0.000110) | 0.00109 (0.00103) | 0.00122 (0.00111) | 0.0114 (0.0442) | -0.0480** (0.0234) | -0.00227 (0.0243) |
| Δ Assets | -0.000000102*** (1.33e-08) | -1.31e-11*** (1.93e-12) | -1.62e-10*** (3.13e-11) | -2.04e-09 (1.35e-09) | -1.72e-13 (4.30e-13) | 4.69e-12 (6.22e-12) | 2.75e-12 (7.09e-12) | -3.76e-10* (1.98e-10) | -7.35e-10*** (1.54e-10) | 6.29e-10*** (1.34e-10) |
| Δ National_Production | -4.38e-09*** (1.06e-09) | -5.97e-13*** (2.33e-13) | -1.17e-11*** (2.81e-12) | 2.78e-10*** (1.06e-10) | -9.02e-14* (4.66e-14) | -2.09e-12*** (5.84e-13) | -1.70e-12*** (5.91e-13) | 2.76e-11 (1.72e-11) | 9.57e-12 (7.53e-12) | -4.89e-13 (8.36e-12) |
| <i>N</i> | 207 | 207 | 228 | 207 | 198 | 198 | 180 | 147 | 228 | 228 |
| adj. <i>R</i> ² | 0.659 | 0.674 | 0.577 | 0.709 | 0.040 | 0.065 | 0.101 | 0.173 | 0.777 | 0.739 |
| Bank FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Time FE | N | N | N | N | N | N | N | N | N | N |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Difference-in-difference results for years 1927-1950 and the treatment groups defined in 1933

| Baseline Specification: Dummy treatment | | | | | | |
|---|--------------------------------|-------------------------------|------------------------------------|--------------------------------|-------------------------------|------------------------------------|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | <u>Equity</u> <u>Assets</u> | <u>Loans</u> <u>Assets</u> | <u>Securities</u> <u>Assets</u> | <u>Equity</u> <u>Assets</u> | <u>Loans</u> <u>Assets</u> | <u>Securities</u> <u>Assets</u> |
| $Post_{1935} * Treated_{i,1933}$ | -0.00230 (0.00156) | -0.00856 (0.00871) | -0.0161 (0.00981) | -0.00283 (0.00275) | -0.0268 (0.0221) | 0.00385 (0.0227) |
| Δ Assets | | | | -3.23e-11 (4.00e-11) | -1.10e-09** (4.11e-10) | 1.20e-09** (4.63e-10) |
| Δ National_Production | | | | -6.42e-12** (3.10e-12) | -2.01e-11 (2.38e-11) | 2.08e-11 (2.91e-11) |
| N | 36 | 36 | 36 | 36 | 36 | 36 |
| adj. R^2 | 0.989 | 0.967 | 0.955 | 0.968 | 0.860 | 0.857 |
| Continuous Treatment $Treat(N2K_{it} - \widetilde{N2K}_t)$ | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | <u>Equity</u> <u>Assets</u> | <u>Loans</u> <u>Assets</u> | <u>Securities</u> <u>Assets</u> | <u>Equity</u> <u>Assets</u> | <u>Loans</u> <u>Assets</u> | <u>Securities</u> <u>Assets</u> |
| $Post_{1935} * Treat(N2K_{it} - \widetilde{N2K}_t)$ | 0.00189 (0.00934) | 0.0555 (0.0857) | -0.0658 (0.0750) | 0.0136 (0.0205) | 0.0860 (0.148) | -0.0839 (0.158) |
| Δ Assets | | | | -2.78e-12 (5.06e-11) | -9.92e-10** (4.49e-10) | 1.15e-09** (4.89e-10) |
| Δ National_Production | | | | -6.95e-12* (3.38e-12) | -2.33e-11 (2.51e-11) | 2.12e-11 (2.97e-11) |
| N | 36 | 36 | 36 | 36 | 36 | 36 |
| adj. R^2 | 0.987 | 0.965 | 0.955 | 0.965 | 0.856 | 0.852 |
| Continuous Treatment $Treat(N2K_{i,1933} - \widetilde{N2K}_{1933})$ | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | <u>Equity</u> <u>Assets</u> | <u>Loans</u> <u>Assets</u> | <u>Securities</u> <u>Assets</u> | <u>Equity</u> <u>Assets</u> | <u>Loans</u> <u>Assets</u> | <u>Securities</u> <u>Assets</u> |
| $Post_{1935} * Treat(N2K_{i,1933} - \widetilde{N2K}_{1933})$ | 0.00136 (0.00294) | -0.00693 (0.0274) | -0.0635** (0.0273) | 0.00112 (0.00712) | -0.0661 (0.0636) | 0.00209 (0.0659) |
| Δ Assets | | | | -4.37e-12 (4.48e-11) | -1.06e-09** (4.29e-10) | 1.17e-09** (4.71e-10) |
| Δ National_Production | | | | -7.05e-12** (3.26e-12) | -2.10e-11 (2.43e-11) | 2.14e-11 (2.86e-11) |
| N | 36 | 36 | 36 | 36 | 36 | 36 |
| adj. R^2 | 0.987 | 0.966 | 0.957 | 0.966 | 0.856 | 0.857 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

All specifications include bank fixed effects.

The specification without additional controls includes also time fixed effects.

Table 6: Difference-in-difference results for years 1933-1936, excluding Barclays Bank of Canada

Nonetheless, the detailed lending data gives an insight into different lending strategies of banks. Figure A3 in Appendix A provides graphs showing the development of the ratios of different loan types to assets for treated and control banks. The distinguishable loan types are: call loans (loans against security of shares or bonds), current loans (loans to companies and industries), non-current loans (long-term loans), provincial loans (loans to provincial governments), municipal loans (loans to cities, towns, municipalities and school districts), letters of credit (trade loans) and mortgages. Call and current loans were the main lending categories of Canadian banks. The remaining loan types constituted a small share of banks' lending. The coverage of provincial and municipal loans does not allow for a D-i-D analysis. Table 7 provides regression results for the remaining loan ratios in the short run and Table 8 in the long run. Most of the results in the short run are non-significant. The significance increases for the long-run regressions, however, the results are ambiguous. Some of the regressions indicate that treated banks increased their ratio of call loans to assets, non-current loans to assets and letters of credit to assets relatively more than the control banks, while they decreased their ratio of current loans to assets relatively more. Given that current loans constitute the largest fraction of loans in banks' portfolio (see the y-axis scale on Figure A3 in Appendix A), the opposite sign on the coefficient for this loan type in one of the regressions can probably explain the non-significance of the aggregate loan-to-assets ratio (once we exclude Barclays Bank of Canada). The positive coefficient on call loans could also be a result of increased risk-taking by treated banks, wanting to increase the riskiness of their portfolio in order to safeguard their waning profits. However, given the caps on interest rates, this is unlikely to be the case.

There might be another reason for why the response of lending is ambiguous. The reading of banks' annual reports may give an indication of this, even though it is important to keep in mind that the reports were mainly addressed to shareholders, and hence, the banks could have presented themselves in a favorable light in the reports. The reduction or increase in lending may not only be a sign of changing supply, but also demand. Several bank reports mention that their increased engagement in securities purchases is mostly due to lower demand for loans, e.g. Bank of Montreal (1937), p. 12 reads: *"we would prefer to have a larger proportion of our funds out in loans for productive and business purposes. But it is beyond the power of a commercial bank to increase at will its total of safe loans; the initiative lies with the borrowers."* Bank of Montreal (1938), p. 12 mentions that companies increasingly choose bond financing over bank financing: *"Corporation borrowers have continued to favour a policy of borrowing in part by means of short-term obligations bearing a lower rate of interest than that which would apply to long-range loans."* Companies reduced also their demand for credit due to war-related orders that were on average settled faster than other types of orders, as Royal Bank of Canada (1942), p. 6 mentions *"Fresh borrowers do appear, but many companies which were regular bank borrowers do not find it necessary to lean upon the bank for the assistance, largely because the character of their business has changed. They are now engaged principally in producing war material for the Government and consequently collect the amounts due them more promptly."* These extracts from banks' reports obviously give no indication on the difference between

treated and control banks, but they point to the fact that observed changes in different loan categories may have been a response to lower demand from the side of customers rather than deliberate reduction of loan supply due to the loss of note printing rights.

4.4.2 Branching response

The second channel relates to the branching response of banks and is motivated by the narrative found in annual banks' reports. Almost all banks commented on the changes in bank law and establishment of Bank of Canada in their reports, indicating which possible consequences the introduction of central bank note monopoly may have. Bank reports usually mentioned two possible reactions: introduction of new charges for customers and closing of bank branches (see e.g. The Bank of Toronto, 1933, The Bank of Toronto, 1934, The Dominion Bank, 1932, Bank of Montreal, 1932, The Canadian Bank of Commerce, 1932). The second reaction was linked to the fact that some of the loss-operating branches were kept opened in remote locations only thanks to the note issuing privilege that raised the profits of banks. Bank of Montreal (1932), p.10, writes: *"If the circulation privilege were taken away from the banks, as has been mooted, I do not see how they could justify continuing many of their smaller branches, of which even now a large number are operated at a loss (...)"*, The Canadian Bank of Commerce (1932), p. 19: *"If (...) the note-issuing privilege were withdrawn the country's banking service would undoubtedly be curtailed through the closing of small branches rendered unprofitable by the expense of carrying currency other than their own."* Given these statements in banks' annual reports, I test whether treated and control banks' percentage change in branch number was different. Despite full data coverage, I exclude Barclays Bank of Canada from these regressions, because it oscillated between having from one to four branches in the considered time period, resulting in extreme percentage changes. Table 9 presents the results from this regression. There is no significant difference, neither in the short nor in the long run, in the changes of branches of treated and control banks.

5 Discussion of results and lessons for CBDC

The period after the establishment of Bank of Canada was characterized by increased leverage of Canadian chartered banks, the relative decline of lending in their portfolio, lower ROA and Z-scores, but fairly stable profits in relation to their standard deviation, as well as market price volatility. Chartered banks note circulation went down only slowly, following broadly the trend imposed by the 1934 regulation. It does not seem that the public rushed to substitute 'risky' chartered banks notes with the 'safe' notes issued by the new central bank. Some commercial banks were more affected by the change in law than the others, since note issuance constituted a larger share of their funding. Taking into account the differential response of banks for whom the new regulation was binding and the control banks, I show that note issuance was indeed an important source of seignorage for banks. First of all, when we compare treated and control banks before the treatment, treated banks have higher ROAs and profits in

| | (1) $\frac{Call}{Assets}$ | (2) $\frac{Current}{Assets}$ | (3) $\frac{Non-Current}{Assets}$ | (4) $\frac{LoC}{Assets}$ | (5) $\frac{Mortgages}{Assets}$ |
|---|------------------------------|---------------------------------|-------------------------------------|-----------------------------|-----------------------------------|
| Baseline Specification: Dummy treatment | | | | | |
| $Post_{1935} * Treated_{i,1933}$ | 0.200 (0.827) | 0.469 (2.658) | -0.0370 (0.0437) | -0.123 (0.278) | 0.0332 (0.0332) |
| N | 24 | 24 | 24 | 24 | 22 |
| adj. R^2 | 0.738 | 0.882 | 0.838 | 0.811 | 0.929 |
| $Post_{1935} * Treated_{i,1933}$ | -1.071 (1.328) | -0.821 (4.871) | -0.00314 (0.0371) | -0.201 (0.394) | -0.0160 (0.0399) |
| Δ Assets | -8.46e-08* (3.97e-08) | -8.58e-08 (9.26e-08) | 2.25e-09 (2.91e-09) | -5.22e-09 (1.23e-08) | -2.59e-09 (1.56e-09) |
| Δ National_Production | 3.48e-09* (1.89e-09) | -6.66e-09 (5.16e-09) | 8.40e-13 (7.33e-11) | -2.76e-10 (5.86e-10) | -2.75e-12 (5.36e-11) |
| N | 24 | 24 | 24 | 24 | 22 |
| adj. R^2 | 0.690 | 0.698 | 0.830 | 0.811 | 0.933 |
| Continuous Treatment $Treat(N2K_{it} - \widetilde{N2K}_t)$ | | | | | |
| $Post_{1935} * Treat(N2K_{it} - \widetilde{N2K}_t)$ | 25.42** (10.00) | 31.89 (28.81) | 0.0810 (0.428) | 0.234 (3.174) | 0.117 (0.353) |
| N | 24 | 24 | 24 | 24 | 22 |
| adj. R^2 | 0.804 | 0.894 | 0.853 | 0.814 | 0.930 |
| $Post_{1935} * Treat(N2K_{it} - \widetilde{N2K}_t)$ | 18.23 (18.87) | 31.82 (69.53) | 0.459 (0.625) | -1.357 (3.706) | -0.259 (0.422) |
| Δ Assets | -4.00e-08 (3.95e-08) | -1.32e-08 (0.000000101) | 2.19e-09 (2.88e-09) | -9.69e-09 (1.13e-08) | -2.42e-09 (1.63e-09) |
| Δ National_Production | 2.87e-09 (1.83e-09) | -7.12e-09 (5.25e-09) | -3.39e-11 (7.13e-11) | -4.74e-10 (5.04e-10) | 3.14e-12 (6.36e-11) |
| N | 24 | 24 | 24 | 24 | 22 |
| adj. R^2 | 0.683 | 0.684 | 0.844 | 0.820 | 0.931 |
| Continuous Treatment $Treat(N2K_{i,1933} - \widetilde{N2K}_{1933})$ | | | | | |
| $Post_{1935} * Treat(N2K_{i,1933} - \widetilde{N2K}_{1933})$ | 6.633 (4.416) | 15.89* (8.161) | -0.376 (0.308) | -1.722 (1.094) | 0.244 (0.200) |
| N | 24 | 24 | 24 | 24 | 22 |
| adj. R^2 | 0.765 | 0.898 | 0.859 | 0.826 | 0.936 |
| $Post_{1935} * Treat(N2K_{i,1933} - \widetilde{N2K}_{1933})$ | 1.489 (7.203) | 14.18 (18.84) | -0.266 (0.294) | -2.716 (1.701) | 0.0887 (0.263) |
| Δ Assets | -6.20e-08 (4.01e-08) | -2.06e-08 (9.16e-08) | 1.32e-09 (2.75e-09) | -1.20e-08 (1.07e-08) | -1.90e-09 (1.34e-09) |
| Δ National_Production | 3.14e-09 (1.99e-09) | -7.64e-09 (4.78e-09) | 1.48e-11 (7.98e-11) | -1.75e-10 (5.44e-10) | -1.74e-11 (5.57e-11) |
| N | 24 | 24 | 24 | 24 | 22 |
| adj. R^2 | 0.677 | 0.706 | 0.839 | 0.836 | 0.934 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

LoC stands for letters of credit. All specifications include bank fixed effects.

The specification without additional controls includes also time fixed effects.

Table 7: Difference-in-difference results for years 1933-1936 and separate loan categories

| | (1) $\frac{Call}{Assets}$ | (2) $\frac{Current}{Assets}$ | (3) $\frac{Non-Current}{Assets}$ | (4) $\frac{LoC}{Assets}$ | (5) $\frac{Mortgages}{Assets}$ |
|---|------------------------------|---------------------------------|-------------------------------------|-----------------------------|-----------------------------------|
| Baseline Specification: Dummy treatment | | | | | |
| $Post_{1935} * Treated_{i,1933}$ | 3.819*** (0.796) | 1.599 (4.035) | 0.0806*** (0.0237) | -0.207 (0.352) | -0.00856 (0.0323) |
| N | 166 | 166 | 162 | 165 | 152 |
| adj. R^2 | 0.839 | 0.619 | 0.830 | 0.387 | 0.691 |
| $Post_{1935} * Treated_{i,1933}$ | 3.189** (1.291) | -5.010** (2.261) | 0.0311 (0.0445) | -0.0660 (0.324) | -0.0102 (0.0298) |
| Δ Assets | -1.05e-09 (6.61e-09) | -5.84e-08*** (1.15e-08) | -1.50e-09*** (2.75e-10) | 5.03e-09 (4.49e-09) | -5.71e-10*** (1.12e-10) |
| Δ National.Production | -8.37e-10*** (2.76e-10) | 2.76e-09*** (6.06e-10) | -4.65e-11*** (1.40e-11) | 3.31e-10*** (1.12e-10) | -1.72e-11 (1.14e-11) |
| N | 161 | 161 | 157 | 160 | 147 |
| adj. R^2 | 0.598 | 0.750 | 0.538 | 0.359 | 0.676 |
| Continuous Treatment $Treat(N2K_{it} - \widetilde{N2K}_t)$ | | | | | |
| $Post_{1935} * Treat(N2K_{it} - \widetilde{N2K}_t)$ | 23.19*** (4.560) | 31.50 (25.27) | -0.0925 (0.244) | 3.273 (3.091) | -0.0741 (0.193) |
| N | 166 | 166 | 162 | 165 | 152 |
| adj. R^2 | 0.845 | 0.625 | 0.827 | 0.384 | 0.693 |
| $Post_{1935} * Treat(N2K_{it} - \widetilde{N2K}_t)$ | -6.538 (5.043) | 1.898 (9.852) | -0.0682 (0.222) | 1.206 (1.892) | -0.121 (0.163) |
| Δ Assets | -1.26e-08** (6.33e-09) | -6.71e-08*** (8.84e-09) | -1.33e-09*** (2.82e-10) | 3.91e-09 (4.89e-09) | -5.18e-10*** (1.16e-10) |
| Δ National.Production | -1.17e-09*** (2.77e-10) | 2.34e-09*** (6.33e-10) | -4.01e-11*** (1.40e-11) | 2.96e-10*** (1.13e-10) | -1.61e-11 (1.16e-11) |
| N | 161 | 161 | 157 | 160 | 147 |
| adj. R^2 | 0.653 | 0.762 | 0.556 | 0.361 | 0.675 |
| Continuous Treatment $Treat(N2K_{i,1933} - \widetilde{N2K}_{1933})$ | | | | | |
| $Post_{1935} * Treat(N2K_{i,1933} - \widetilde{N2K}_{1933})$ | 21.70*** (3.651) | 15.13 (15.39) | 0.360*** (0.128) | 1.541 (1.198) | -0.0160 (0.191) |
| N | 166 | 166 | 162 | 165 | 152 |
| adj. R^2 | 0.855 | 0.621 | 0.828 | 0.388 | 0.691 |
| $Post_{1935} * Treat(N2K_{i,1933} - \widetilde{N2K}_{1933})$ | 24.00*** (6.532) | -5.347 (10.80) | 0.0855 (0.249) | 2.868* (1.712) | 0.0558 (0.186) |
| Δ Assets | 1.76e-11 (5.24e-09) | -5.49e-08*** (1.10e-08) | -1.52e-09*** (2.77e-10) | 5.55e-09 (4.61e-09) | -5.52e-10*** (1.08e-10) |
| Δ National.Production | -8.12e-10*** (2.63e-10) | 2.77e-09*** (6.09e-10) | -4.64e-11*** (1.40e-11) | 3.35e-10*** (1.12e-10) | -1.70e-11 (1.14e-11) |
| N | 161 | 161 | 157 | 160 | 147 |
| adj. R^2 | 0.637 | 0.739 | 0.537 | 0.364 | 0.676 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

LoC stands for letters of credit. All specifications include bank fixed effects.

The specification without additional controls includes also time fixed effects.

Table 8: Difference-in-difference results for years 1927-1950 and separate loan categories

| | (1) | (2) | (3) | (4) | (5) | (6) |
|--|-------------------|--------------------------|-------------------|--------------------------|-------------------|--------------------------|
| | % Δ | % Δ | % Δ | % Δ | % Δ | % Δ |
| Short run: 1933-1936 | | | | | | |
| $Post_{1935} * Treated_{i,1933}$ | -0.629 (2.024) | 0.0481 (2.041) | | | | |
| $Post_{1935} * Treat(N2K_{it} - \widetilde{N2K}_t)$ | | | -21.00 (13.69) | -21.88 (16.77) | | |
| $Post_{1935} * Treat(N2K_{i,1933} - \widetilde{N2K}_{1933})$ | | | | | -7.948 (6.281) | -6.796 (8.077) |
| Δ Assets | | 4.09e-08* (2.31e-08) | | 1.92e-08 (2.63e-08) | | 2.06e-08 (2.73e-08) |
| Δ National_Production | | -1.21e-09 (2.53e-09) | | -1.09e-09 (2.52e-09) | | -7.53e-10 (2.33e-09) |
| N | 36 | 36 | 36 | 36 | 36 | 36 |
| adj. R^2 | 0.089 | 0.048 | 0.148 | 0.097 | 0.169 | 0.100 |
| Long run: 1927-1950 | | | | | | |
| $Post_{1935} * Treated_{i,1933}$ | 1.545 (2.854) | 2.898 (3.528) | | | | |
| $Post_{1935} * Treat(N2K_{it} - \widetilde{N2K}_t)$ | | | 7.586 (7.683) | -10.47 (6.879) | | |
| $Post_{1935} * Treat(N2K_{i,1933} - \widetilde{N2K}_{1933})$ | | | | | 14.24 (11.37) | 19.30 (14.77) |
| Δ Assets | | 3.69e-08* (2.04e-08) | | 3.19e-08* (1.90e-08) | | 4.05e-08** (1.99e-08) |
| Δ National_Production | | 2.05e-09** (8.27e-10) | | 1.93e-09** (8.37e-10) | | 2.04e-09** (8.09e-10) |
| N | 207 | 207 | 207 | 207 | 207 | 207 |
| adj. R^2 | 0.293 | 0.077 | 0.296 | 0.076 | 0.312 | 0.104 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Regressions in columns (1), (3), (5) include bank and time fixed effects.

Regressions in columns (2), (4), (6) include bank fixed effects.

In all regressions, percentage change in the number of branches is the dependent variable.

Table 9: Branching response to the change in regulation

relation to their standard deviation. After the change in regulation, in the short-run, treated banks experience relatively higher volatility of ROE, while in the long-run, their Z-scores and ROA go down relatively more than for the control banks.

Canada offers a good laboratory for testing the effects of arrival of a new form of central bank money on commercial banks due to the change in law that constitutes exogenous treatment for note issuing banks. However, the caveat of the presented analysis is the relatively low number of commercial banks in Canada for which the difference-in-differences tests may be computed. Having this in mind, we can nonetheless learn something from this historical episode. First of all, in Canada, as in U.S. the arrival of central bank currency did not mean an immediate death of private currencies. As Weber (2015), p. 24, concludes studying the period of coexistence of Federal Reserve and national banks' notes: *"Introducing a central bank-issued e-money will not necessarily drive out any privately-issued e-moneys that are already in existence. National bank notes did not go out of circulation until more than 20 years after the Federal Reserve Act, and it is likely that they would have continued to circulate if their continued circulation had not been made legally impossible."* Looking at Figures 1 and 5 for Canada, we see that also in Canada private bank notes only gradually went out of the circulation, following the path induced by the regulation. This suggests that public has a tendency to use well-known medium of exchange and it is unlikely that it would dramatically shift funds from commercial banks to central bank if a CBDC were established. Such a shift would probably occur gradually, as it did in the past. From this perspective, it good news for commercial banks that may fear the loss of deposit funding linked to the arrival of CBDCs. They would probably have time to adapt to the new situation.

Second, the historical experience suggests that commercial banks would probably face relative declines in their profits or increased funding costs that would reduce their profitability and their ability to smooth the returns, once a new form of central bank currency arrives. While in the Canadian case, there was a significant difference in how treated and control banks' profits and volatility thereof evolved after the exogenous change in law that restricted their seigniorage rights, one has to note that the economic significance of these differences was relatively small (as compared to the means of considered variables). Thus, a slight decline in profitability and higher volatility of profits was observed in Canada for treated banks, but given the size of the effect, it was nothing that would put a banks' existence in danger. This result, too, suggests that even though funding costs of banks would probably increase once they face central bank competition in form of CBDC, it is unlikely that they would suffer severe losses.

Third, while evaluating the Canadian experience of central bank cash implementation in the context of CBDC, it is worth to think about currency substitutes that were available in the past and that are available to the public today. As Figure 1 shows, commercial bank notes had a very strong position among the public in Canada and the change in law forced the public to shift from commercial bank notes to Bank of Canada notes completely. This happened in a period when today's common cash substitutes, such as payment and credit cards, mobile phone payments etc. were not available. Central bank currency supply increased from 0% to 100%.

It may suggest that the estimated effect of central bank currency introduction on commercial banks presented in this paper may be an upper limit. Currently, central bank cash is already available and CBDC would further increase the supply of central bank currency, but not at the scale that happened in the past. Moreover, nowadays, consumers have an option to use an array of payment instruments, and CBDC will be rather their complement than a substitute as Bank of Canada cash was in 1930-50s. Khiaonarong and Humphrey (2019) discuss the potential demand for CBDCs in the context of cash usage in several countries. They state that the public demand for CBDC will likely be weak in countries, where cash no longer is the king, such as Sweden or Norway. In other countries, such as for example, Germany, Italy, Spain (see Esselink and Hernández, 2017 and Solutions, 2018 for estimates on cash usage in different countries), where cash usage is still relatively high, the introduction of CBDC could potentially have larger consequences for commercial banks. As such, the effect of CBDC introduction on private banks will differ from country to country and be mostly visible in mostly cash-based societies.

Fourth, the estimates presented in this paper are likely to represent the upper limit due to the fact that in the first half of the twentieth century, the public in Canada was basically forced by law to entirely switch from commercial bank notes to central bank notes. If CBDC were to be introduced, the possible shift from commercial bank deposits to CBDC would be voluntary. Hence, estimates from the past likely present 'the worst case scenario' of effects of introduction of a new form of central bank currency on incumbent private banks. Potential negative impact of CBDC on financial stability is therefore lower than the historical experience from Canada could suggest.

6 Conclusion

Central bank history offers many episodes that can be useful in guiding modern policy challenges. In this paper, I study the period of establishment of Bank of Canada and the arrival of central bank notes' monopoly that posed a competition for one of Canadian chartered banks funding sources: cash issuance. In 1935 in Canada, central bank cash was a novelty, similarly to the central bank digital currencies discussed today. Commercial banks feared the loss of seigniorage revenues, but the law imposed a gradual decline in their notes in circulation.

Given that new laws were binding only for some of the Canadian banks that were more reliant on note issuance in the first place, and the exogenous nature of the change in law in 1934 in Canada, I conduct a difference-in-differences analysis on the impact of central bank cash arrival on commercial banks, focusing on their risk measures and returns. I show that banks for whom the imposed issuance limits were binding, experienced relatively lower returns and higher volatility thereof.

To my knowledge, this study is the first empirical assessment of the effects of arrival of new form of central bank currency on commercial banks. Weber (2015) and Fung et al. (2017) discuss similarities between historical experiences in U.S. and Canada and CBDC, but on a narrative basis. The current study confirms their conjunction that the impact of CBDC on

commercial banks would be probably gradual, as the public tends to continue using the existing forms of money even if a safe central bank currency arrives. While I show that the profitability of Canadian banks decreased due to the arrival of central bank competition, the economic importance of this effect was relatively small. The effect of an introduction of CBDC on commercial banks is likely to be lower today compared with past central bank cash introduction experiences, when central bank currency was first established and had fewer substitutes.

As with many historical studies, the present one suffers from problems with data availability and relatively small sample of considered banks, which should be taken into account while analyzing the results. Offering a factual assessment of the effects of the arrival of central bank money, it can nonetheless be a useful complement of theoretical studies and simulations aiming at assessing the potential impact of CBDC on commercial banks (Juks, 2018; Andolfatto, 2018; Chiu et al., 2019; Keister and Sanches, 2019).

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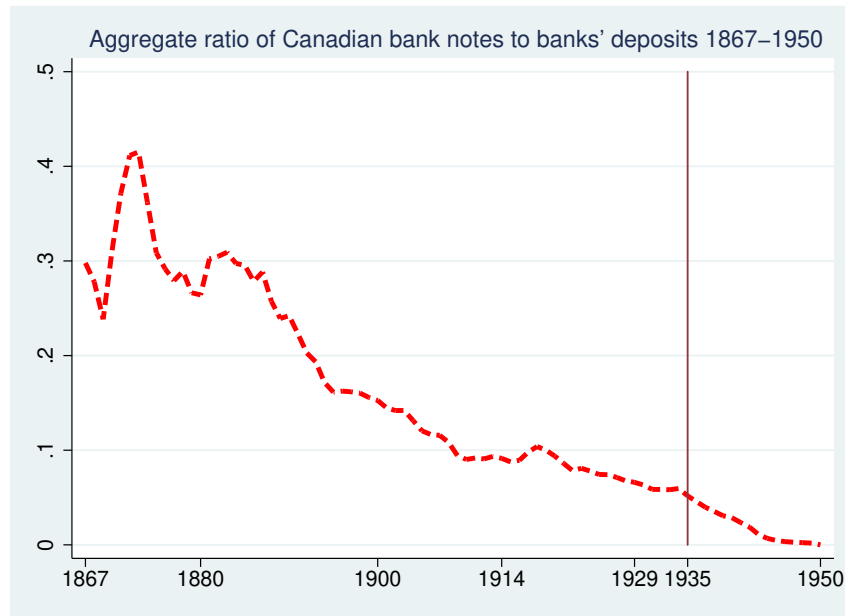
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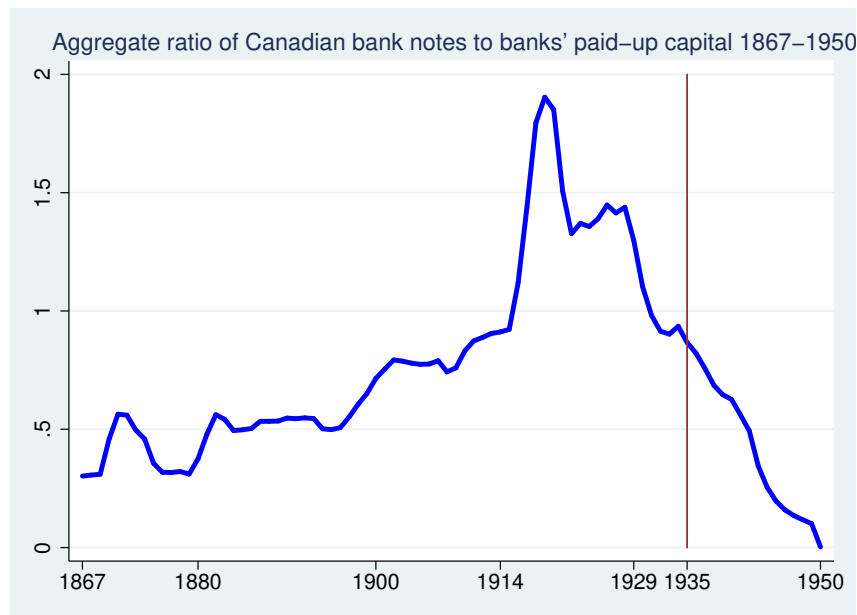
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A Appendix A: Additional Graphs



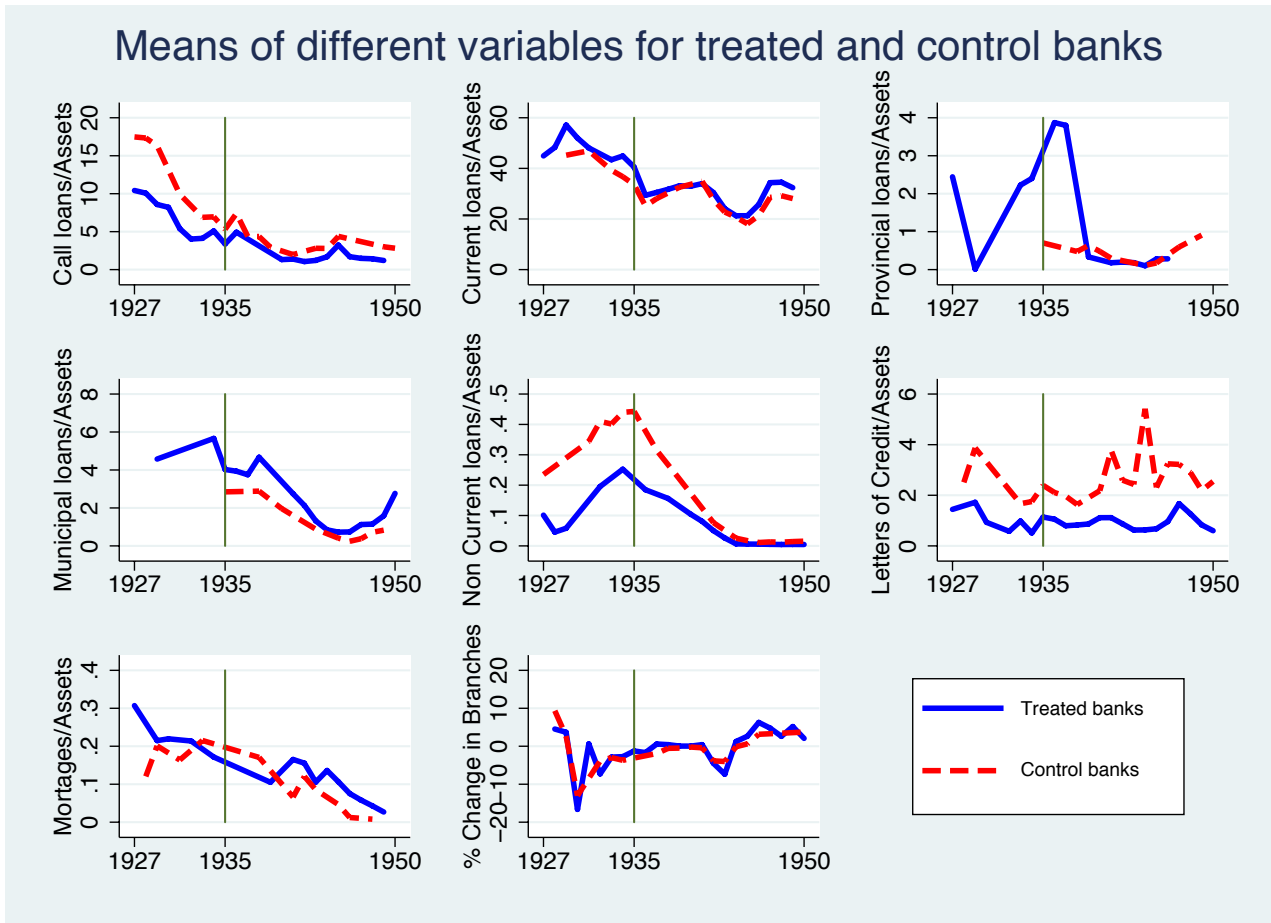
Note: Based on data from Dominion Bureau of Statistics (1935), p. 968, Dominion Bureau of Statistics (1951), p. 1040, Dominion Bureau of Statistics (1953), p. 1106.

Figure A1: Aggregate bank notes to deposits in Canada, 1867-1950



Note: Based on data from Dominion Bureau of Statistics (1935), p. 968, Dominion Bureau of Statistics (1951), p. 1040, Dominion Bureau of Statistics (1953), p. 1106.

Figure A2: Aggregate bank notes to capital in Canada, 1867-1950



Note: Based on annual reports of banks and Canada Year Books (for branches). Barclays Bank of Canada is not included in the branch graph due to its low number of branches that would result in very high percentage changes.

Figure A3: Additional ratios, treated vs control banks, 1927-1950

B Appendix B: Regressions with treatment defined in 1934

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|----------------------------------|--------------------------|--------------------------|--------------------------|-------------------------------|--------------------------|-------------------------|-------------------------|---------------------------|----------------------------|-----------------------------|
| | Z-score | ROA | $\frac{Equity}{Assets}$ | $\frac{Profits}{SD(Profits)}$ | 3Y SD(ROA) | 3Y SD(ROE) | 5Y SD(ROE) | Market Volatility | $\frac{Loans}{Assets}$ | $\frac{Securities}{Assets}$ |
| $Post_{1935} * Treated_{t,1934}$ | -0.0143 (0.445) | -0.0000892 (0.000483) | -0.00867* (0.00459) | 0.0284 (0.374) | -0.0000792 (0.000274) | 0.000360 (0.00150) | -0.000508 (0.00135) | -0.00213 (0.0379) | -0.0117 (0.0118) | -0.0183 (0.0140) |
| N | 36 | 36 | 40 | 36 | 36 | 36 | 36 | 30 | 40 | 40 |
| adj. R^2 | 0.989 | 0.822 | 0.821 | 0.766 | 0.183 | 0.635 | 0.510 | 0.690 | 0.968 | 0.913 |
| Bank FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Time FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| $Post_{1935} * Treated_{t,1934}$ | -0.815 (0.940) | -0.0000522 (0.000573) | -0.0133* (0.00678) | 0.00747 (0.407) | -0.0000930 (0.000306) | 0.000363 (0.00156) | -0.000780 (0.00123) | -0.0244 (0.0643) | -0.0315 (0.0193) | -0.00843 (0.0239) |
| Δ Assets | -4.17e-08* (2.08e-08) | -2.26e-12 (1.16e-11) | -3.12e-10* (1.73e-10) | -1.09e-09 (6.29e-09) | -7.15e-13 (5.18e-12) | 1.74e-13 (2.58e-11) | -1.42e-11 (2.30e-11) | -8.41e-10 (1.04e-09) | -1.35e-09*** (3.87e-10) | 6.73e-10 (5.81e-10) |
| Δ National_Production | -2.26e-09* (1.16e-09) | -1.37e-12* (7.39e-13) | 4.40e-12 (1.26e-11) | -6.39e-10 (5.28e-10) | -3.16e-13 (5.91e-13) | -4.35e-12 (3.12e-12) | 2.71e-12 (3.03e-12) | -2.13e-10** (8.49e-11) | -1.92e-11 (2.45e-11) | 4.70e-11 (3.83e-11) |
| N | 36 | 36 | 40 | 36 | 36 | 36 | 36 | 30 | 40 | 40 |
| adj. R^2 | 0.959 | 0.768 | 0.828 | 0.757 | 0.175 | 0.634 | 0.514 | 0.543 | 0.937 | 0.836 |
| Bank FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Time FE | N | N | N | N | N | N | N | N | N | N |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A1: Difference-in-difference results for years 1933-1936 and the treatment groups defined in 1934

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|----------------------------------|-------------------------------|----------------------------|----------------------------|-------------------------------|--------------------------|----------------------------|----------------------------|--------------------------|----------------------------|-----------------------------|
| | Z-score | ROA | $\frac{Equity}{Assets}$ | $\frac{Profits}{SD(Profits)}$ | 3Y SD(ROA) | 3Y SD(ROE) | 5Y SD(ROE) | Market Volatility | $\frac{Loans}{Assets}$ | $\frac{Securities}{Assets}$ |
| $Post_{1935} * Treated_{i,1934}$ | -0.0923 (0.683) | -0.000440* (0.000243) | -0.0000950 (0.00408) | 0.116 (0.174) | 0.0000282 (0.0000921) | -0.000429 (0.000935) | -0.000263 (0.00101) | 0.0243 (0.0283) | 0.00988 (0.0190) | -0.0473*** (0.0116) |
| N | 216 | 216 | 238 | 216 | 198 | 198 | 180 | 155 | 238 | 238 |
| adj. R^2 | 0.969 | 0.908 | 0.856 | 0.825 | 0.379 | 0.287 | 0.308 | 0.443 | 0.843 | 0.916 |
| Bank FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Time FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| $Post_{1935} * Treated_{i,1934}$ | -4.400** (1.814) | -0.000997*** (0.000405) | -0.00702 (0.00596) | 0.0314 (0.269) | 0.0000183 (0.000106) | -0.000305 (0.00101) | -0.000222 (0.00115) | 0.0292 (0.0395) | -0.0328 (0.0243) | -0.0241 (0.0235) |
| Δ Assets | -0.000000104*** (1.34e-08) | -1.34e-11*** (1.95e-12) | -1.64e-10*** (3.16e-11) | -2.11e-09 (1.36e-09) | -2.57e-13 (4.52e-13) | 3.24e-12 (6.35e-12) | 8.57e-13 (7.18e-12) | -3.48e-10* (2.03e-10) | -7.28e-10*** (1.57e-10) | 6.07e-10*** (1.32e-10) |
| Δ National_Production | -4.38e-09*** (1.06e-09) | -5.97e-13*** (2.32e-13) | -1.17e-11*** (2.80e-12) | 2.78e-10*** (1.06e-10) | -9.02e-14* (4.65e-14) | -2.08e-12*** (5.84e-13) | -1.70e-12*** (5.89e-13) | 2.71e-11 (1.71e-11) | 9.57e-12 (7.59e-12) | -5.41e-13 (8.32e-12) |
| N | 207 | 207 | 228 | 207 | 198 | 198 | 180 | 147 | 228 | 228 |
| adj. R^2 | 0.662 | 0.676 | 0.578 | 0.709 | 0.036 | 0.062 | 0.097 | 0.177 | 0.774 | 0.741 |
| Bank FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Time FE | N | N | N | N | N | N | N | N | N | N |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A2: Difference-in-difference results for years 1927-1950 and the treatment groups defined in 1934