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

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Central banks have been considering the introduction of central bank digital currencies (CBDCs). The theoretical literature indicates that this may influence private banks' lending activity and their profitability with implications for financial stability. To provide empirical evidence on this debate, we study the effects of the arrival of a new central-bank issued currency on commercial banks in a historical setup. We use the opening of the Bank of Canada in 1935 as a natural experiment to provide evidence that banks mostly affected by the currency competition experienced lower profitability but did not decrease their lending compared to unaffected peers.

Keywords: Money and Banking, Central Bank Digital Currencies, Central Banks, Bank Profitability, Bank Lending, Bank of Canada, Banknote Monopoly.

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

Currency is to the science of economy what the squaring of the circle is to geometry, or perpetual motion to mechanics. (...) Many changes are now taking place in the currencies of the world, and important inquires have been lately instituted concerning the best mode of constituting the circulating medium. (Jevons, 1896, p. vi-vii)

1   Introduction

Recent debates about the possibility of issuing central bank digital currency (CBDC) resuscitated interest in classical monetary research on the role and forms of money in the economy. Central banks and commercial banks coexist in modern economies and both types of banks issue money. Central banks have the monopoly on the central-bank issued medium of exchange, while commercial banks issue private, inside, money in the form of bank deposits. One of the primary concerns of CBDC issuance is that the business model of commercial banks may be affected by the introduction of a retail CBDC, given that this new form of central bank money can be seen as competition and substitute to bank deposits. In one of the first published papers on that topic, Andolfatto (2021) presents a theoretical model in which he shows that while CBDC may reduce banks' profits, it does not necessarily need to have a negative impact on bank lending. A similar conclusion has been reached by Chiu et al. (2022) and Whited et al. (2022). However, a few other theoretical studies show that the CBDC can affect banks in different ways, see Williamson (2021) and Keister and Sanches (2022). There is a lack of empirical evidence to validate these models, because, as pointed out in Andolfatto (2021), we have no available data to assess the impact of CBDC on commercial banks. First examples of active CBDC projects include quantitative restrictions so that the competition with commercial banking is limited (Soderberg et al., 2022). In situations like this, studying similar events from banking history may provide valuable and insightful factual assessment. In this paper, we draw lessons from a historical experiment in which the central bank introduced a new medium of exchange in competition with the circulating private money. Our findings can shed some light on the impact of new public money (CBDC) issuance on banks' business models and stability.

Advances in payment systems undoubtedly affect monetary equilibria (Tobin, 1986; Marimon et al., 2003), as do new forms of money (Brunnermeier and Niepelt, 2019, Fernández-Villaverde et al., 2021). Theoretical models can assess the impact of a new form of money on commercial banks' profits, lending, funding costs and investments in a laboratory-like setup, under a range of assumptions. But how is the commercial banking sector affected by changes in the provision of outside money in practice? This is a highly relevant question, yet a difficult one to answer partly due to data availability. We follow the recent literature and use detailed historical data to inform current policy debates (see Frost et al., 2020 and Monnet et al., 2021). We contribute to the literature on private vs public money by studying a unique event: the opening of a major central bank in 1935 and the subsequent note issuance monopoly that affected the private note issuing banks in many aspects. To our knowledge, our paper is the first one to empirically examine the impact of the arrival of a new form of central bank money on

commercial banks.[1] In our study, we employ bank-level panel data.

The historical event we study is the establishment of the Bank of Canada. The Canadian central bank gained the cash monopoly fairly late, in 1950, and before that, numerous private banks were printing their own money, making it an important part of their funding. As a result of the establishment of the Bank of Canada, 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 below that cap due to their different funding strategies. In the years 1935-1950, central bank's and chartered banks' notes were used in parallel. The passing of the Bank of Canada Act and its consequences can be interpreted as an exogenous change that affected chartered banks' business models. As such, in the first step of our analysis, we use a difference-in-differences (DiD) 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 the law) and control banks (banks that were not affected by the cap on the maximum note issuance). We find that banks constrained by new issuance limits experienced lower Z-scores[2] and return-on-assets (an economically significant effect, correspondingly 8-24% and 10-25% lower than control banks), suggesting that the note issuance was an important source of revenue for private banks. The effect on lending is not significant.

We corroborate these results by an additional test, to tackle the empirical challenge of data limitation and to provide a robustness check. We apply the synthetic control method (SCM) to study the development of the Canadian banks in comparison to their international peers. The method developed by Abadie and Gardeazabal (2003) and Abadie et al. (2010) has been increasingly used by empirical researchers (Abadie, 2021), and may be particularly useful in historical studies, where data limitations play a relatively larger role (Gilchrist et al., 2023). We gather additional historical data on individual Swedish banks to create a synthetic control group that enables us to triple the size of our original dataset. Using this alternative method to assess the impact of the arrival of central bank money on Canadian banks, we confirm that their lending was not affected by the reform, but profits went down. Even though we work with annual banking data and the availability and frequency of historical data series are far from perfect, two separate empirical exercises allow us to reach consistent conclusions about

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[1]Existing historical papers studying the coexistence of private and public money are descriptive in their nature and rely on aggregate data (Ögren, 2006; Ögren and Engdahl, 2008; Weber, 2015; Fung et al., 2017b; Jonung, 2021).

[2]In the literature, the Z-score is a common indicator for risk measures that measure institutions' financial soundness (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:

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

where we calculate the standard deviation of return on assets (ROA) over the period 1927-1950. The Z-score puts banks' financial buffer (returns and equity) in relation to the volatility of returns and is interpreted as the inverse of the probability of insolvency: If the Z-score is high, larger shocks to profitability are required for a bank to default. Lower Z-score implies that the financial institution has a higher probability of insolvency.

the impact of the new central bank money on commercial banks' profits and lending.

We contribute to the literature on currencies and CBDC by linking a historical event to current debates and considering the similarities and differences between the two situations. Moreover, our paper delivers new insights in the economic history literature and the literature covering the establishment of the Bank of Canada that has been mostly narrative or relying on aggregate data so far (Bordo and Redish, 1987; Watts, 1993; Kianieff, 2004; Powell, 2005). According to our knowledge, we are the first to look at the creation of the Bank of Canada from chartered banks' perspective and the first to use bank-level data to test hypotheses about the impact of CBDC on commercial banks derived from the theoretical literature.

The paper is structured as follows. In section 2, we briefly review the theoretical literature on the impact of CBDCs on financial stability and formulate hypotheses. Section 3 provides an overview of the money circulation in Canada and details about the establishment of the Bank of Canada. Section 4 presents data and in section 5, we show the empirical results. In section 6, we interpret and discuss our findings in the context of lessons for CBDC. Section 7 concludes.

2   Theoretical framework and hypothesis development

This section briefly revises the theoretical literature on the impact of CBDCs on private banks. Andolfatto (2021) studies this issue in an overlapping generations setup with a monopolistic banking sector. How private banks react to the introduction of CBDC, depends on the interest rate set on the new currency in relation to the deposit interest rate offered by the bank to their clients. A high enough CBDC rate incentivizes banks to raise their deposit rate, which attracts more deposits and depositors (both the intensive and the extensive margin are affected). The monopoly bank profit is then reduced, but bank lending remains unaffected or it can even increase. As such, Andolfatto (2021) concludes that the introduction of CBDC does not pose a threat to financial stability. These results are likely to hold in an oligopolistic setting as well.

A similar conclusion has been reached by Chiu et al. (2022). In a New Monetarist framework encompassing a whole range of bank competitiveness, they show that CBDC does not lead to bank disintermediation if banks have market power. CBDC may, however, lower bank profits. Whited et al. (2022) reach the same conclusions using a dynamic banking model. Keister and Sanches (2022) consider a model in the New Monetarist tradition, but assume instead that the banking sector is competitive. In such a setup, the CBDC may lead to bank disintermediation. Considering a competitive banking sector and a New Monetarist model, Williamson (2022) also concludes that bank disintermediation may happen as a result of CBDC. However, in his model, this effect is beneficial as it reduces the capital overaccumulation problem.

It remains inconclusive from the theoretical literature whether the introduction of CBDC may lower bank profitability, contract bank lending and even lead to disintermediation. We conduct our empirical analysis applied to the Canadian economy to provide the first evidence related to the theoretical studies on the impact of CBDC issuance. We argue that the intro-

duction of the Bank of Canada notes, a new medium of exchange, would have a similar effect as the CBDC issuance in competition with the circulating private money. Given the fairly concentrated Canadian banking system, it would be difficult to argue that chartered banks in the 1930s operated in a competitive setup. Thus, theoretical conclusions about the impact of central bank currency in a non-competitive setup are likely to hold, which brings us to two main hypotheses that we want to test.

Hypothesis 1: After the introduction of central bank currency, private banks' profitability decreases.

Hypothesis 2: After the introduction of central bank currency, private bank lending is not affected.

A distinct set of papers considers CBDCs impact on financial stability in the context of bank runs or panics. Kim and Kwon (2022) show that CBDC may increase the likelihood of bank panics. Williamson (2021), too, concludes that CBDC encourages banking panics. On the contrary, Keister and Monnet (2022) show that with a CBDC in place, banks perform less maturity transformation, and hence are less likely to be a subject of run. Brunnermeier and Niepelt (2019) derive conditions for the equivalence of public and private money and conclude that CBDCs could reduce the risks of bank runs. Barrdear and Kumhof (2021) discuss policy solutions that could prevent bank runs. The theoretical literature is largely inconclusive about the impact of CBDCs on bank panics/runs, as there are several design choices and policies that could prevent them. When it comes to theoretical literature regarding the probability of bank runs, we abstain from formulating any hypothesis. Also, we know that no bank run occurred in Canada in the considered period. Public deposits were largely unaffected (see Figure B1 in Appendix B).

3 Private and public money in Canada

The Canadian central bank, the Bank of Canada, opened its doors on March 11th 1935. It was designed to serve the public interest and to have the sole right of issuing Canadian banknotes. Before the establishment of the central bank, private money issued by commercial (chartered) banks was the main medium of exchange in Canada.[3]

3.1 Private money circulation

Private bank notes circulation preceded the paper currency issued by the government in Canada by around half a century. 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). From 1850 on (due to the Free Banking Act), only chartered banks had right to issue notes. First provincial (government) notes were authorized in 1866, and two years later, their name was changed to Dominion notes (Fung et al., 2017b). Since 1890, chartered bank notes traded at par throughout

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[3]Appendix A provides more details on the evolution of the banking industry in Canada.
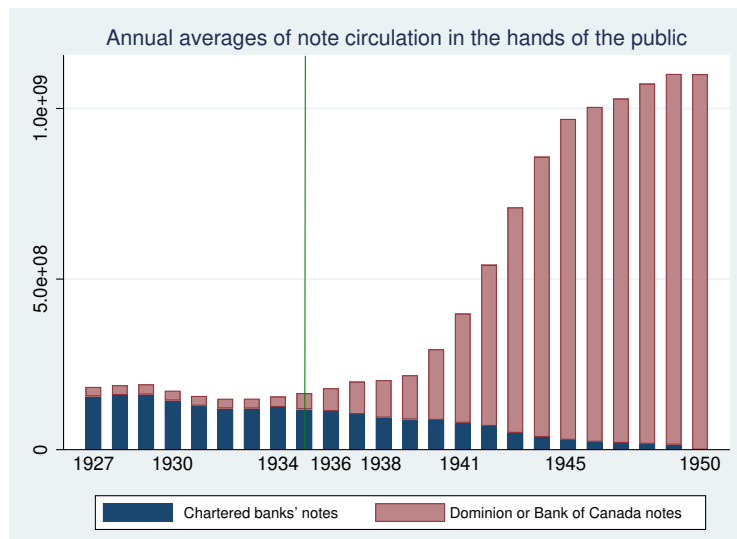
Figure 1: Annual averages of note circulation in the hands of the public in Canada: 1927-1950

the country and each bank accepted other banks' notes. Before the establishment of the Bank of Canada, chartered banks' notes that were not legal tender coexisted alongside Dominion notes which were legal tender.[4] 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., 2017b). Chartered banks' notes were the main circulating medium in Canada, see Figure 1.[5]

3.2 The establishment of the Bank of Canada

For many years, the Canadian banking system was operating efficiently without the existence of a central bank. Even the report recommending the creation of the Bank of Canada admitted it: *"insofar as the ordinary functions of banking are concerned, the Canadian banks give admirable evidence of security, efficiency and convenience."* (Royal Commission, 1933, p.61).[6] First proposals for the Canadian central bank were made in 1913, and then in 1914, 1917, 1918, 1923 and late 1920s, but all of them were unsuccessful (Watts, 1993). There were several political, but also some economic reasons behind the creation of the Bank of Canada in mid 1930s.

Watts (1993) argues that the establishment of the Canadian central bank was due to support by a few influential persons rather than a response to the public demand. Bordo and Redish (1987), too, 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

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[4]Chartered bank notes were required to be converted into Dominion notes or gold on demand.

[5]The figure is based on data from Dominion Bureau of Statistics (1944), p. 881 and Dominion Bureau of Statistics (1953), p. 1101. The plot shows the annual averages of month-end values in each year. In 1927, Dominion and the 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 the Bank of Canada started its operation and issued first Bank of Canada notes, the ratio increased to 28.5%. In years 1900-1926, Dominion notes in circulation accounted for ca. one fifth of the chartered banks' notes circulation.

[6]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."*

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. Moreover, Canada's legal status has to be considered here: As 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). As such, in the 1930s, a more general move towards creating Canadian sovereign institutions took place.

Kianieff (2004) argues that focusing on political considerations paints an incomplete picture of the reasons behind the establishment of the Bank of Canada. On the economic side, the economic crisis in Canada and the worldwide economic slump of the 1930s made the public more distrustful towards pure market institutions. Particularly farmers, that suffered from a decline in crop yields and prices, became advocates of the creation of a central bank (Powell, 2005, p. 47). There were deflationary pressures in the country and critics maintained that it was due to the contractionary policy of chartered banks. Canada was lacking a money market (Kianieff, 2004). With rising external indebtedness of the country, the value of the Canadian dollar became more of importance, and it was believed that one single banking authority would be better suited to control the foreign exchange (Royal Commission, 1933).

When the decennial revision of the Bank Act in 1934 was approaching, Prime Minister R.B. Bennett 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[7] 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.[8] The mission of the Bank of Canada was to *"regulate currency and credit, control the external value of the Canadian dollar, and to mitigate (...) trade fluctuations in Canada* (Elliott, 1935, p. 99). Moreover, it acted as a fiscal agent and financial advisor to the government (Watts, 1993, p. 14-15). Dividends of the Bank of Canada were limited to 4.5% and the surplus profits were to be divided between the rest fund and the government (Elliott, 1935, p.99).[9] As such, even though the Bank of Canada was designed to be an independent institution, its seigniorage indoubtedly alleviated the indebtedness problem of the government.

3.3 Note issuance monopoly of the Bank of Canada

The report recommending the creation of the Bank of Canada studied the setup of central banks in other countries and concluded that several principles need to be followed to ensure that the central bank fulfills its functions. Banknote issuance monopoly, allowing the bank to

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[7]Three out of five commissioners were in favor, and the pro votes were cast among British commissioners, while the Canadian ones opposed the creation of the Canadian central bank (Watts, 1993, p. 10-11).

[8]The Bank of Canada was first opened as a private institution with a wide distribution of shares and directors selected among diversified occupations to ensure its independence from government and minimize the risk to monetize the debt, a fear of which has blocked such developments before (Shortt, 1905b; Elliott, 1935).

[9]Once the rest fund amounted to twice the paid-up capital, all surplus profits were paid to the Dominion.

control the volume of credit and maintain the stability of the currency, was one of them (Royal Commission, 1933, p.65).[10] The note issuance monopoly was a by-product of the creation of the Bank of Canada, but there was no specific desire to compete with or displace the private notes. It was believed that the central bank would be beneficial for chartered banks, as it would provide them with some centralized services, such as re-discounting (available even before through a different institution) or providing aid in time of need and crisis (Royal Commission, 1933). The Bank of Canada could also extend collateralized loans to the chartered banks (Elliott, 1935, p.100).

The Bank of Canada Act was passed on 3rd July 1934. The amendment to the Bank Act of 1934 from 28th June restricted the note-issuing privileges of chartered banks. From 1935 on, the maximum 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. From 1945, the maximum note issuance could not exceed 25 percent of banks' capital, See Figure 3.[11] 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.

3.4 Impact of the Bank of Canada's establishment on chartered banks

After the establishment of the Bank of Canada, chartered bank notes slowly disappeared from the circulation and the Bank of Canada notes took over as the medium of exchange. The substitution occurred gradually, see Figure 1. The public obtained Bank of Canada notes through withdrawals from accounts with chartered banks. Chartered banks paid out their own notes to the public in the first place, and the Bank of Canada notes, if smaller denominations were requested (chartered banks' notes had a minimum denomination of 5 dollars), or if a given bank's issue approached the limit given by law (Bank of Canada, 1936). Figure 2 provides a stylized representation of commercial banks' balance sheets before, during and after the

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[10]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). Commercial 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).

[11]Section 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 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.

reform. The figure assumes unchanged total assets. Private bank notes on the liability side are substituted by deposits. Dominion Notes became the Bank of Canada notes or deposits held at the Bank of Canada after 1935. After the establishment of the Bank of Canada, Canadian chartered banks were required to hold the Bank of Canada notes or deposits at the Bank of Canada corresponding to at least 5 percent of their deposit liabilities in Canada. This reserve requirement, albeit new, was not binding for the banks, as already prior to the establishment of the Bank of Canada, they were holding Dominion notes well exceeding this required percentage. Looking at Figure 2, it becomes clear why Hypothesis 1 could hold. Issuing private notes was a cheap way of financing for commercial banks due to no interest being paid on notes. Other sources of funding than note issuance were more expensive (for example, in the period 1929-1937, savings deposits were subject to an interest rate of 1.5-3%, and even some demand deposits were interest-bearing, see Nixon et al., 1937), and hence, changes on the liability side of banks could affect their profitability.[12] At the same time, banks did not have to reduce lending as long as they could find alternative funding sources.
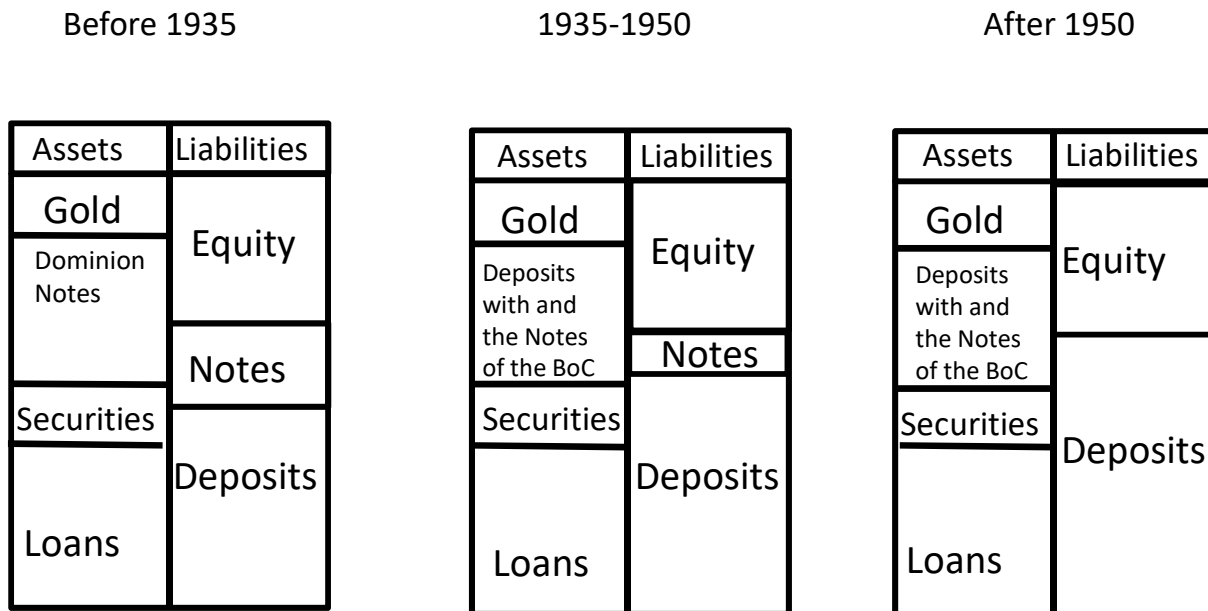

Figure 2: Stylized representation of chartered banks' balance sheets

Note issuance monopoly of the Bank of Canada had an influence on commercial banks' profits through its impact on their seigniorage. The proponents of the Bank of Canada were not oblivious to the impact of note issuance monopoly on chartered banks, but it was concluded that banks could profitably operate even without the seigniorage gains. In a part of the report (Royal Commission, 1933, p. 106), the Canadian Bankers' Association estimated the cost of the loss of money printing privilege to commercial banks. At the time of writing the report, the average net profit from printing notes amounted to 1.60% of note circulation. Taking the

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[12]In the considered period, savings deposits (also called time deposits), constituted the majority of deposits at Canadian chartered banks, see Dominion Bureau of Statistics, 1944, p. 888. and Dominion Bureau of Statistics, 1951, p. 1040. On average, in years 1927-1950, time deposits accounted for 66% of all deposits at Canadian chartered banks.

report's estimate to our data and taking into account average net profits in 1935, the estimated profit loss amounted to 24% of net profits of banks. If we take into account the cost of the replacement of chartered banks' notes with new money, estimated by the Canadian Bankers' Association, the profit loss could reach even 58% (in relation to average 1935 profits). The gradual phasing off of note issuance was supposed to limit the impact of bank note monopoly on the economy (Kianieff, 2004, p. 440).

Chartered banks could potentially compensate for losing the right to issue notes by changing interest rates on deposits. Lowering deposit rates would lower banks' funding costs, perhaps at the expense of losing some clients. That could possibly lead to less lending. On the other hand, raising deposit rates could attract new depositors and allow more lending, along the lines of the model in Andolfatto (2021). 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.

Apart from influencing the chartered banks' note issuance, the Bank Act from 1934 implied also 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.[13] The law implied a reduction in double liability level common to all chartered banks, hence no differentiation between banks can be made. 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. That observation forms basis for the main empirical test in the paper.

3.5 Commercial banks' reaction to the Bank of Canada note monopoly

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.

Almost all banks commented on the changes in bank law and establishment of the Bank of Canada in their reports, indicating which possible consequences the introduction of central bank

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[13]Referring 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.*"

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, we 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, in the empirical part, we test an additional hypothesis that private banks' branching is reduced after the introduction of central bank currency. We will examine whether treated and control banks' percentage change in branch number was different.

4 Data

4.1 Canadian bank-level data

The main data source is the historical Canada Year Book, which provides annual balance sheet and accounting data for chartered banks. The yearbooks provide details on the main components of assets and liabilities of chartered banks, as well as profits and number of branches. We manually collect data for the ten chartered banks existing in 1935 for the years 1927-1950.[14] 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.

4.2 Swedish bank-level data

We use the Swedish bank-level data 1927-1950 to create a synthetic control donor pool for individual Canadian banks. There are several reasons why we choose Sweden for comparison. First of all, Canada and Sweden are similar in many aspects historically. Both countries are small open economies with a relatively consolidated banking sector. In both countries, banks could open branches so the number of banks was fairly limited, but they were diversified geographically. Secondly, Swedish bank-level data is of exceptional quality and allows us to test different hypotheses, including those requiring profit information at bank-level. Lastly, while both countries were affected by the Great Depression, as most advanced economies, their

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[14]We 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. A short description of aggregate trends in the Canadian banking industry in the considered period is provided in Appendix B.

banking sector remained fairly intact. Moreover, Sweden was not subject to a currency reform in the considered period, which is an important requirement for the synthetic control method.

We gather balance sheet and profit information on Swedish banks in each December 1927-1950 from a periodical publication called "Uppgifter om bankerna" published yearly by the Royal Bank Inspection. We have information on every Swedish bank that operated in that time period.[15] This triples the number of banks available for the estimation compared to the case when we only use Canadian banks.

5 Empirical results

5.1 Bank-specific changes in note issuance

The law from 1934 introduced a cap on chartered banks' note issuance in relation to the capital, so the banks could be affected to different degrees. If a bank never fully executed its right to issue banknotes, it would not be affected by the change in regulation. On the opposite, if 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 would affect banks' behavior. Figure 3 plots the individual change in banknote issuance for 10 Canadian chartered banks over the period 1933-1950.[16] The ticks on the y-axis between 1 and 0 indicate different values of the cap imposed by the law. The cap on the notes to capital ratio is 1 in 1935, which means that banks that had an average ratio above 1 had to adjust their business models. In order to take into account expectation, in our benchmark specification, we focus on the ratio in 1933. As we see from Figure 3 presenting the notes to capital ratio for all ten banks, in 1933, three banks were constrained by the ratio of notes to capital equal 1: Banque Canadienne Nationale,

Imperial Bank of Canada,

Bank of Toronto. These banks can thus be considered as banks *treated* by the regulation. We discuss the sensitivity of our results to this assumption at the end of section 5.2.

The summary statistics for nine Canadian banks[17] used in the empirical analysis is provided in Table 1. In our DiD, we focus on four outcome variables. In order to test hypothesis 1, we zoom into two variables related to the profitability of banks: the Z-score (1) and ROA (2). To adress Hypothesis 2, we also run our tests for the growth rate in lending (3). Lastly, following the narrative found in bank statements, we take into account the growth rate in branching (4). Regressions (3) and (4) allow us to assess the impact of the reform on banks' provision of credit and services to the community, related to bank intermediation.[18]

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[15]We need to restrict our initial sample of 31 Swedish banks to banks for which we have information during the whole considered period, so we end up with 19 Swedish banks as the donor pool for the synthetic control.

[16]The plot starts after Great Depression, given that the period of a financial and economic crisis is unlikely to be representative for the discussed ratio.

[17]We exclude Barclays Bank of Canada from the empirical analysis. It was established quite late, in 1929 and had very few branches, It did not report its profits and losses, and hence, cannot be used in regressions. Moreover, the pattern of the notes to capital ratio was quite distinct from other banks, as in Figure 3.

[18]The results for disaggregated categories of lending are either non-significant or ambiguous and do not change the narrative in the current paper.
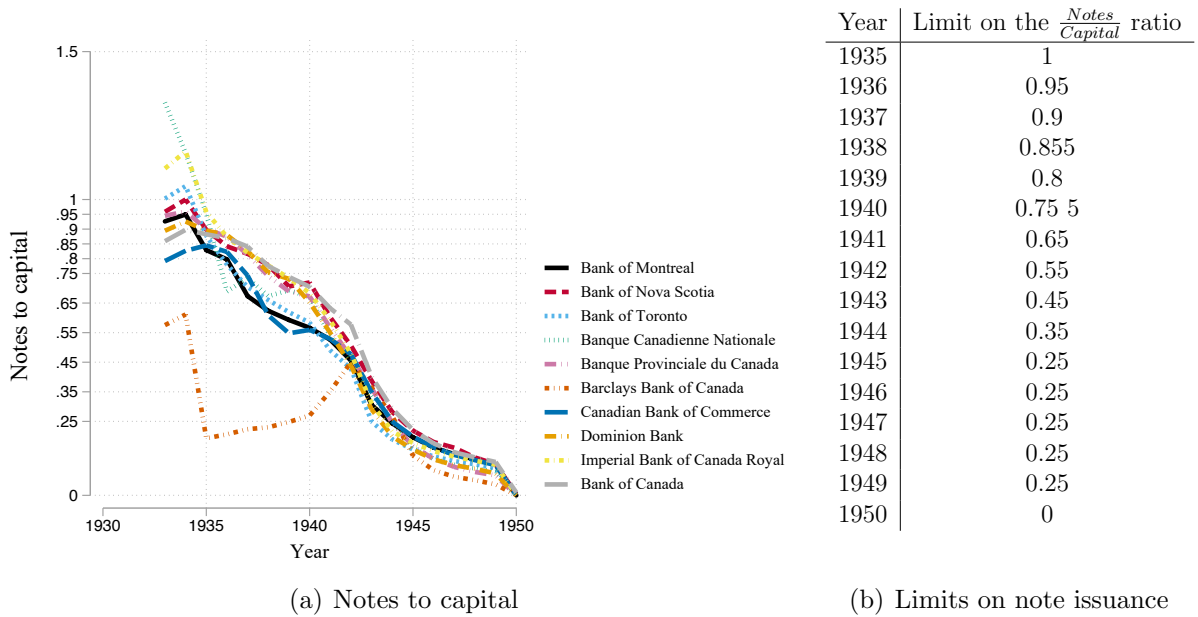
Year	Limit on the $\frac{Notes}{Capital}$ ratio
1935	1
1936	0.95
1937	0.9
1938	0.855
1939	0.8
1940	0.75 5
1941	0.65
1942	0.55
1943	0.45
1944	0.35
1945	0.25
1946	0.25
1947	0.25
1948	0.25
1949	0.25
1950	0

(a) Notes to capital   (b) Limits on note issuance

Figure 3: The notes to capital ratio and issuance limits of Canadian banks (1933-1950).

In Table 1, we present the means and T-statistics for the four outcome variables along with some additional variables of interest for the control and treated groups. As indicated by the T-statistics, the treated and control groups were comparable in 1933. The only significant difference between the two groups was the notes-to-capital ratio, which was higher for the treated group. Given the period of Great Depression preceding the establishment of the Bank of Canada, we want to make sure that our specification and results are not driven by the recession. Thus, in Table 1, we also compare the banks in 1928, before the onset of the Great Depression. We see that the means of different variables for both groups had the same relationship in 1928 as in 1933 and that the treated banks had an already higher notes-to-capital ratio than the control banks in 1928. This simple test allows us to conclude that the treated banks were not more heavily tied to bank note issue in 1933 because they were harder hit by the Depression. Importantly, neither in 1928, nor in 1933 were our outcome variables statistically different between the two groups. Lastly, in Table 1, we present the summary statistics for year 1941, in the middle of World War II. There is no evidence of differences between banks arising due to the war.

The trends governing the development of variables of interest were similar across the treated and control banks, see Figure C1 in Appendix C. No obvious big changes are visible at the first glance in the period after 1935, but we test this statement formally in the next section.

5.2 Bank-level difference-in-differences analysis

In the following, we conduct a difference-in-differences regression around the year 1935 to test whether the amendment to the Bank Act affected differently Canadian banks for whom the limit on note issuance was binding. The baseline difference-in-differences model takes the

Table 1: Summary statistics for control and treated banks, 1928, 1933 and 1941

	Mean in 1928			Mean in 1933			Mean in 1941		
	Control	Treated	T-stat	Control	Treated	T-stat	Control	Treated	T-stat
Z-score	37.85	36.34	0.59	46.96	44.83	0.47	33.95	30.03	1.05
ROA ($1*10^3$)	7.72	8.53	-0.62	7.26	8.74	-1.36	4.84	5.56	-0.62
Lending Growth Rate	.14	.06	0.8	-.05	-.03	-0.43	0.05	0.06	-0.16
Branch Growth Rate	.09	.04	0.52	-.03	-.03	-0.1	-0.004	0.004	-1.1
Number of Branches	527	319	1.04	429	206	1.35	371	197	1.32
Loans-to-Assets	.6	.61	-0.27	.48	.53	-1.05	0.36	0.37	-0.18
Total Assets (m)	505	144	1.56	406	123	1.57	571	185	1.48
Capital Ratio	.04	.04	-0.15	.06	.05	0.3	0.04	0.04	0.67
Notes-to-Capital	1.34	2.09	-1.82	.9	1.14	-3.42**	0.57	0.54	0.89

Notes. The detailed definitions of variables are given in Appendix D. ROA stands for Return on Assets. m stands for million. Growth rate of variable x is defined as $\frac{x_t - x_{t-1}}{x_{t-1}}$.

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Table 2: Impact of the limits on note issuance on Canadian banks

	(1) Z-score	(2) ROA	(3) Growth Rate of Lending	(4) Growth Rate of Branches
	Dummy treatment			
$Post_{1935} * Treated_{i,1933}$	-3.534*	-0.000906**	0.0702	0.0290
	(1.835)	(0.000436)	(0.0652)	(0.0353)
adj. R^2	0.659	0.674	0.050	0.077
	Continuous time-invariant treatment			
$Post_{1935} * Treat(N2K_{i,1933} - \widetilde{N2K_{1933}})$	-10.74*	-0.00206*	0.248	0.193
	(6.095)	(0.00124)	(0.195)	(0.148)
adj. R^2	0.659	0.671	0.051	0.104
N	207	207	207	207
Controls	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y
Time FE	N	N	N	N

Notes. The Table presents the estimation of regressions 2 (dummy treatment) and 3 (continuous time-invariant treatment). Z-score is defined by equation 1 in the text. ROA stands for Return on Assets. Growth rate of variable x is defined as $\Delta x_t / x_{t-1}$. In all columns, we control for bank-specific change in total assets and change in national production (common to all banks). Robust standard errors are reported in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

following form:

$$y_{i,t} = \alpha_i + \beta_1 Post_{1935} * Treated_{i,1933} + \beta_2 x_{i,t} + \beta_3 z_t + \beta_4 Post_{1935} + \epsilon_{i,t}, \quad (2)$$

where $y_{i,t}$ denotes the profit measures and variables linked to bank intermediation for bank i in time t, α_i is the bank fixed effect, $x_{i,t}$ controls for the change in a given bank's total assets. Because of the sample size, we can't have time fixed effects in the regression, but we include z_t to control for change in national production common to all the banks. $\epsilon_{i,t}$ 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 (note that the $Treated$ dummy is collinear with the bank fixed effects, hence, it is omitted from the regression). 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.

In addition to the dummy definition of treated banks, as in regression 2, one can explore the difference in distances to the regulated limits that specific banks had. It is clear from Figure 3 that each of Canadian banks had a different distance to the maximum limit imposed by law. We can measure that distance in 1933 and create a continuous time-invariant treatment measure $Treat(N2K_{i,1933} - \widetilde{N2K_{1933}})$ as in regression 3. The bigger the distance from the imposed limit, the more was a bank constrained by the regulation. The regression is

$$y_{i,t} = \alpha_i + \beta_1 Post_{1935} * Treat(N2K_{i,1933} - \widetilde{N2K_{1933}}) + \beta_2 x_{i,t} + \beta_3 z_t + \beta_4 Post_{1935} + \epsilon_{i,t}, \quad (3)$$

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. All other terms are defined as before and β_1, the coefficient on the interaction term is the coefficient of interest.

Table 2 presents the results from regressions as specified in 2 and 3 for five chosen out-

come variables.[19] The DiD results suggest that Canadian banks that were bound by the note issuance limit or were closer to this limit, experienced relatively lower returns. In particular, their Z-scores and ROAs were correspondingly 8-24% and 10-25% lower than those of control banks. This indicates that notes might have played an important role in profit generation and smoothing for treated banks.[20] These findings support Hypothesis 1 that banks' profitability is reduced after the introduction of the Bank of Canada notes. We do not find a significant effect on lending and branching of treated vs control banks. We can't reject Hypothesis 2 that bank lending is not affected by the competition from newly introduced public money.

Note that our benchmark specification relies on banks' distance to the imposed limit in 1933. If we use years 1931, 1932, 1934 instead, at least one of the profit measures (Z-score, ROA) is significant under the dummy treatment, while the results for growth rate of lending and growth rate of branches are insignificant. Before 1931, banks tended to exceed the 1:1 ratio of notes to capital, so the dummy treatment does not make sense. When we look at the continuous time-invariant treatment defined in years 1929-1930, the Z-score result remains significant. Thus, our main results are not sensitive to using year 1933 for the definition of treatment. What if we shorten the time horizon instead? If we look at the data until 1945 only, in the regression with the dummy treatment, we find significant result for the Z-score and non-significant results for other variables. Note that shortening the time horizon naturally affects the significance of the results, given the small sample size. Moreover, when we look at the effects year-by-year, it is evident that for ROA, the effect manifests itself only in the medium- to long-run. This may be linked to the fact it was the amendment to the Bank Act in 1944 that explicitly specified that banks need to stop using their notes by 1950. The Bank Act from 1934 only specified the initial path of reduction in the note-co-capital ratio and a limit of 25%. The decision to go down from 25% to 0 was announced in 1944.

The address the issue of a relatively low number of commercial banks in Canada studied in the DiD regression, we provide an additional test providing further supportive evidence. New econometrics methods, like the Synthetic Control Method, allow us to compare the developments of the Canadian banking industry to its international peers that did not undergo a similar transition.

5.3   Synthetic control analysis

In this section, we follow the synthetic control method and explore the historical banking statistics from period 1920–1950. We create synthetic control units using micro data on banks in Sweden. We apply the methodology developed by Abadie and Gardeazabal (2003), Abadie et al. (2011) and Galiani and Quistorff (2017) to create the synthetic control group and conduct empirical analysis. Given our results from the previous section and the focus of the literature,

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[19]In earlier versions of this paper (e.g. Grodecka-Messi, 2021), we tested a broader set of variables used as potential outcome variables, including disaggregated lending. The results were in line with those presented in the current paper.

[20]While we do find a significant effect on ROA, similar regressions for ROE do not result in a significant coefficient. That non-significant result for ROE is corroborated in our synthetic control analysis.

we test whether our DiD results regarding profit ratios and lending still hold when using alternative international datasets. While in the previous section, we differentiated among the Canadian banks depending on their level of the bindingness of the note issuance cap, in the synthetic control part, we consider all Canadian banks as "treated". We are thus comparing the development of the Canadian banks to their international peers that were not subject to a currency reform in the same period.[21]

The synthetic control method (SCM) proposes to use a weighted combination of units in the potential control group (the donor pool) as the synthetic control, which is constructed to fit the characteristics of the treated unit before being affected by the policy change. One key assumption here is that the synthetic control unit represents a good counterfactual for the treated unit after the policy intervention. The synthetic control method does not rely on the parallel trend assumption as in the DiD estimation, because the synthetic control is constructed to follow similar time trend as the treated unit in the pre-treatment period. In addition, the SCM allows the effect of unobservable confounding factors to vary with time, see Billmeier and Nannicini (2013).

The simple formulation of SCM is that we observe a panel of $c + 1$ units over time. One of them experienced an important event in time T_0. We are interested in studying the treatment effect for this unit, for the years $t > T_0$ after the event, defined as $\tau_t = Y_t(1) - Y_t(0)$. The task is quite challenging because we cannot directly observe the counterfactual scenario, instead we only observe the realizations $Y_t(1)$ after the treatment. It is also impossible to argue for random assignment of the treatment. However, we can construct a synthetic control that behaves in a similar way as Canada before the event and use the observed pattern as an educated guess on the value of $Y_t(0)$ if there is no policy change.

We define the weighting vector $W = (w_1, \cdots, w_J)$ with $w_j \in [0, 1]$ for c units in the potential control pool of $C_t = (c_{1t}, \cdots, c_{Jt})$. We construct the synthetic unit $\tilde{Y}_t = \sum_{j=1}^{J} w_j \dot{c}_{jt}$, where $\sum_{j=1}^{c} w_j = 1$. Under conditions presented in Abadie et al. (2010), we can use the usual DiD regressions to estimate the effect of treatment $\tau_{T_0+1}, \cdots, \tau_T$. We can also apply the SCM to multiple units, which means that we will have a vector of synthetic control units $\tilde{Y}_{it}$. Following the literature, we choose the weighting vector w to form a best linear combination of predictors X_i so that the root mean squared prediction error (RMSPE) of the predictor variables is minimized. In this paper, we include the all lagged outcome variables as the predictor variables in the standard synthetic control setting. As shown in Kaul et al. (2022), it is not necessary to include additional control variables to determine the optimal weights when all lagged outcome variables are used.

Abadie (2021) provided a comprehensive discussion on the construction of synthetic controls and the assumptions that shall be taken into consideration. It is highlighted that the units in the donor pool have to be chosen carefully as a good control for the treated unit. The selection

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[21]Note that given the abolition of double liability that happened at the same time in Canada, in our synthetic control analysis, we could be picking up the effect of different risk-taking of Canadian banks due to the changed liability structure. However, moving from double to single liability would likely have the opposite effect on the profit ratios and lending of Canadian banks than the currency reform.

| (a) Total assets | (b) Total loans | (c) Equity to assets ratio |
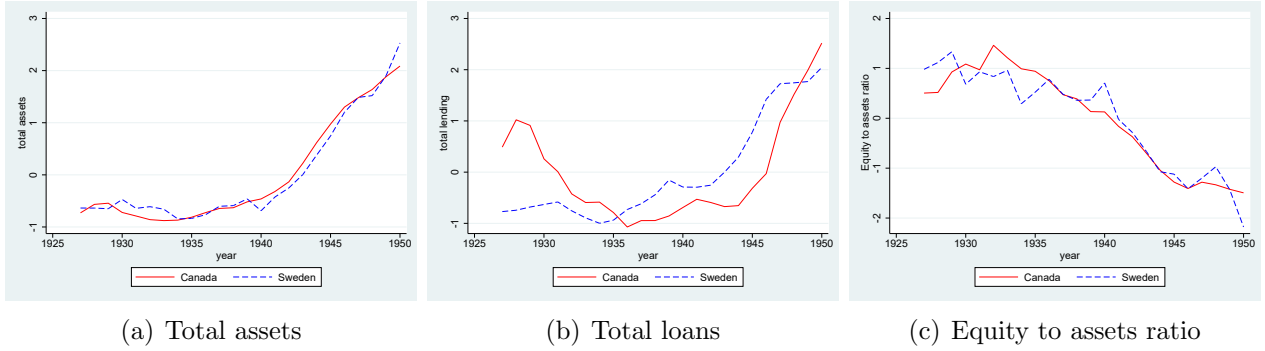
Figure 4: Time series plot of standardised total assets, total loans, and equity to assets ratio from the Canadian banks and the Swedish banks in our sample: 1927–1950.

is based on the characteristics of units in the donor pool, which means that the Swedish banks' characteristics shall be similar to the affected Canadian banks.

Swedish banks are ideal candidates for constructing synthetic control units for Canadian banks. There are significant commonalities between the two banking systems. Figure 4 shows that the total deposit, the total loans, and the equity to assets ratio in the Canadian and Swedish banking sectors in our sample share similar trend over time.[22] In addition, Sweden has a well maintained historical banking database that can be matched to the Canadian banks in our study. This exercise allows us to triple the sample size and have a broaden donor pool to enable better construction of synthetic control units.

We apply the multiple treated units synthetic control method to the Canadian and Swedish bank-level data to take into account multiple treated units in Canada. We follow Cavallo et al. (2013) and Galiani and Quistorff (2017) to conduct the SCM analysis. It allows more than one unit to be treated and at possibly different times. We can run individual SCM on each treated bank, and the treatment effect is computed as the average over all treated units' estimates. We can also run placebo tests to conduct inference on the estimated average treatment effects.

Our bank-level dataset encompasses a short pre-treatment period, but the upside is that we can extend the post-treatment period until 1950 for all three variables of interest. We match Canadian and Swedish banks based on all pre-treatment observations of the outcome variable. We abstain from using additional controls as predictors, given the findings of Kaul et al. (2022) about the irrelevance of other covariates in such a setting. We present the results for the Z-score, ROA and growth in lending in Figure 5. For each of the outcomes, we show the comparison between the development of Canada and synthetic control unit.

We can see from the upper panels in Figure 5 that banks in Canada are matched to their synthetic counterpart well before the event year 1935. The pre-treatment overlap for ROA is better than for the Z-score. The treatment effects are shown as negative for both ROA and Z-score, because the realized values are much lower than corresponding synthetic control

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[22]The total loans in Canada appear to be more volatile than Sweden before 1930, but the two countries are quite similar in the time period we focus on: 1930–1950. We also obtain aggregate banking statistics, including total deposit and loans data, in Canada and Sweden with a longer time series span from Jordà et al. (2021). The plots of key variables confirm again that the Swedish banks can serve as a good donor pool for Canadian banks.

(a) Effect on Z-score   (b) Effect on ROA   (c) Effect on lending growth

(d) Z-score: placebo test   (e) ROA: placebo test   (f) Lending: placebo test
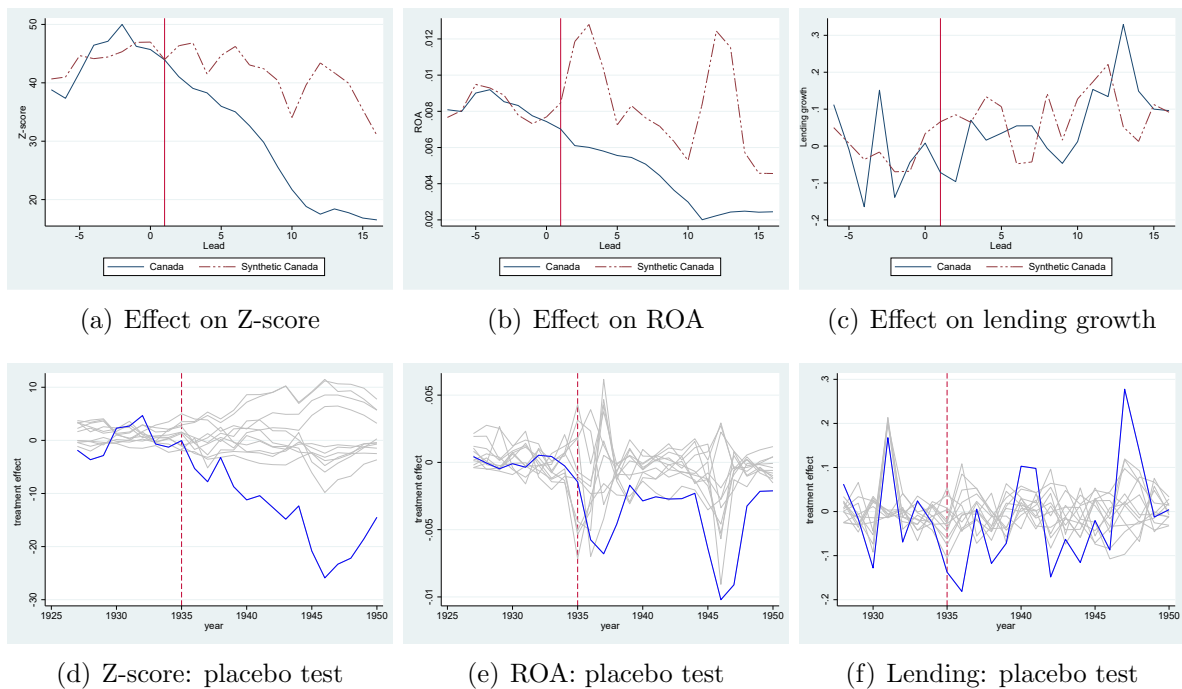
Figure 5: The average treatment effect from the currency reform on the Canadian banking sector: synthetic control method with Swedish bank data

units. Both plots indicate that after the establishment of the Bank of Canada and following limits on private banknote issuance, the Canadian banking industry had lower profits than its synthetic counterpart. The probability that our results related to profit happen by chance is quite low, which lends support to our DiD findings. The placebo tests, too, indicate that after the currency reform the profitability of the Canadian banking industry declined. When it comes to the growth rates of lending, we cannot see any significant difference between Canada and its synthetic counterpart. One caveat is that it appears difficult to match the pre-treatment trend in lending using synthetic control units. It is difficult to draw a strong conclusion on the effect.

Our findings support the hypothesis 1 and 2 derived from theoretical works. The cross-sectional placebo test for the multiple treated unit synthetic control method confirms our findings. In the lower panels in Figure 5, it appears that the identified treatment effects are strong and significant compared with the simulated cross-sectional placebo tests. It suggests that the treatment effect we find is unlikely to be driven by randomness. There are systematic differences between the Z-scores and ROAs of Canadian banks and synthetic control units after the currency reform but not before.[23]

6   Discussion of results and lessons for CBDC

There are many conceptual similarities between what happened in Canada around 1935 and what could happen in a country where a CBDC is introduced. The advent of central banking

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[23]In every simulation of the placebo test, we randomly assign 9 banks as the treated banks from the pool of 28 banks from Canada and Sweden. Then we run the same synthetic matching specification to construct the synthetic control banks as weighted average of other banks in the potential control donor pool.

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, 2017b; Wojtuszko 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 (see BIS, 2018; Engert and Fung, 2017; Camera, 2017). While in the earlier periods, central bank notes were mostly competing with privately issued cash, as in the case of Canada, today the CBDCs can potentially compete with bank deposits, which are the modern form of privately issued money. Despite the historical nature of our empirical analysis and differences between the studied reform and contemporaneous discussions, we believe that our paper provides new and interesting insights about the effects of introducing a new type of currency into the economy on commercial banks.

It is interesting to note that the note monopoly of the Bank of Canada was a result of mostly political rather than economic motivations and the resulting changes in the chartered banks' sector were a by-product of new regulations rather than an aim in itself. The Bank of Canada's establishment and the Bank of Canada notes were to a large extent issued as a response to changing international payments landscape. It was believed that the Bank of Canada note monopoly is necessary for the bank to fulfill its tasks. As a latecomer in the central bank world, the Bank of Canada was following its predecessors and learning from their design. Similarly, with the advent of FinTech and private currency alternatives, it is believed today that CBDCs are necessary for the central banks to fulfill their functions. While many of the motives behind the emergence of interest in the CBDC are economic-linked (see Auer et al., 2021),[24] questions related to the sovereignty of money or financial inclusion also come up in the discussions. With the emergence of first CBDCs, more central banks will adopt CBDCs to keep up with their international peers. These considerations very much resemble the discussion around the creation of the Bank of Canada in the 1930s.

Canada offers a good laboratory for inferring the effects of CBDC on commercial banks. First, in Canada, private bank notes only gradually went out of the circulation, following the introduction of central bank money.[25] 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. Second, the historical experience suggests that commercial banks would probably face relative declines in their profit ratios, once a new form of central bank currency arrives. The documented significant declines observed in historical data are

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[24]Economic motives behind CBDC include providing efficient payments, possibility of addressing the zero lower bound problem, larger seigniorage income to state, see Bindseil, 2020.

[25]Chartered banks presumably preferred to hand out their own notes to customers whenever possible, but there is no evidence that the public rushed to use the BoC notes since the transition was announced by authorities and all notes traded at par throughout the country. Thus, from the point of view of a customer, whether he was using one or the other type of notes should have been irrelevant. Trust in the private financial system could have been an issue here, but Canada was known for its stable system and since 1881, no note holder in Canada suffered a loss (Dominion Bureau of Statistics, 1940, p. 894).

however likely 'exaggerated' if we think of what could happen to commercial banks today, as we explain in the next paragraphs.

While evaluating the Canadian historical experience, it is worth to think about currency substitutes that were available in the past and that are available to the public today. 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 the Bank of Canada notes completely. Central bank currency supply increased from 0% to 100%. 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, such as payment and credit cards. The CBDC will be rather their complement than a substitute as the Bank of Canada cash was in 1930-50s. As a result, the estimated effect of central bank currency introduction on commercial banks presented in this paper may be an upper limit. In addition, 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. This conclusion is reinforced by the observation that if a CBDC were cash-like, i.e. non-interest bearing, there would be unlikely a big outflow from interest-bearing deposits.[26] Potential negative impact of CBDC on financial stability is therefore lower than the historical experience from Canada could suggest.

Moreover, it is worth to highlight that in our paper, we focus on the impact of the CBDC on commercial banks. As a means of payment used in transactions, CBDCs would undoubtedly affect also other market operators, in particular payment platforms and companies offering payment solutions, such as credit cards that generate high fees (Fung et al., 2017a).[27] Through the impact of CBDC on transactions technology, CBDC could also affect banks' profits by lowering their revenue from transaction fees and cross-selling of payment products.[28] On the other hand, CBDCs would likely (and hopefully) lower the social cost of currency by implementing a more efficient transactions technology. By allowing the shift towards more cashless society, it could lower banks' costs, since cash handling is costly. The last observation calls for parallels with the Canadian experience. Before the establishment of the Bank of Canada, Canadian chartered banks had to handle notes of ten different Canadian banks, plus Dominion notes. In the interim period, the Bank of Canada notes circulated along with private ones, which

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[26]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). Recent report by Soderberg et al. (2022) discusses ongoing and advanced CBDC projects and none of them plans on implementing the interest-bearing form of CBDC.

[27]Two recent papers (Li, 2023; Huynh et al., 2020) using Canadian data estimate the demand for CBDC among other payment instruments and show how its potential varies with particular characteristics of the CBDC. The papers focus on the demand and consumer side and do not comment on the effects for private banks.

[28]Non-interest income of banks is a large share of banks' operating income (DeYoung and Rice, 2004, Haubrich and Young, 2019) and the estimates of bank revenues related to payment activities for the U.S. banks conclude that such revenue accounts to 16-21 percent of banks' operating revenue (Rice and Stanton, 2003; DeYoung and Rice, 2004).

potentially temporarily increased the burden of banks related to cash-handling. However, in the long run, having only one remaining type of paper currency definitely lowered social and even banks' costs linked to the design and printing of banknotes, their transport, handling of different types of cash etc. Our analysis and data do not allow us to quantify the impact of the new form of central bank currency on the transactions technology and profits linked to it, but it is certainly an aspect of CBDC that should be investigated further.

Last but not least, it has to be considered that the currently discussed CBDC design choices often take into account a two-tier structure, in which the private sector, including commercial banks, play an active role by providing services to consumers and acting as an intermediary between the public and the central bank. This could provide additional income to private banks, mitigating the negative impact of CBDCs on bank revenue. It could even strengthen the position of commercial banks in the payments market that has been endangered in the era of FinTech (Deloitte, 2015; Cocheo, 2023; Ginovsky, 2022). These considerations show the need for further studies with the use of detailed revenue data and theoretical models that study the aspects of payment efficiency.

7 Conclusion

Central bank history offers many episodes that can be useful in guiding modern policy challenges. In this paper, we study the establishment of the 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.

The law, the Bank of Canada Act, imposed a gradual decline in the commercial banks' notes in circulation, which was binding only for some Canadian banks that were more reliant on note issuance in the first place. Given the exogenous nature of the event, we conduct a DiD analysis on the impact of central bank cash arrival on commercial banks, focusing on their profitability and lending. We show that banks for whom the imposed issuance limits were binding, experienced relatively lower returns, but we don't find any significant effect on bank lending. It suggests that banks' shareholders rather than broader public payed the bill for the transition to central bank note monopoly. Our DiD results are further corroborated by the synthetic control analysis where we compare the development of Canadian banks to their international peers.

To our knowledge, this study is the first empirical assessment of the effects of arrival of new form of central bank currency on commercial banks. The current findings indicate that the impact of CBDC on commercial banks would be probably gradual. 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. There are certainty dissimilarities between the paper-based central bank money and the CBDC introduction. In particular, CBDC can be seen as a substitute to bank deposits,

which have an electronic form. Offering a factual assessment of the effects of the arrival of central bank money, our paper can nonetheless be a useful complement of theoretical studies and simulations aiming at assessing the potential impact of CBDC on commercial banks.

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Appendix

A Historical Narrative

The roots for the modern Canadian banking system evolved gradually starting from the 19th century.[29] 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.

From 1850 on (due to the Free Banking Act), only chartered banks had right to issue notes.

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., 2017b). 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.[30] 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). Chartered bank notes could be converted into Dominion notes.

The chartered bank 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., 2017b). Figure A1 shows a long-run trend of notes to capital in Canada. The vertical line is set in 1935, when the Bank of Canada was opened.

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[29]Breckenridge (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.

[30]Canada was on gold standard from 1 August 1854 to 4 August 1914 and from 1 July 1926 to January 1929 (Powell, 2005).
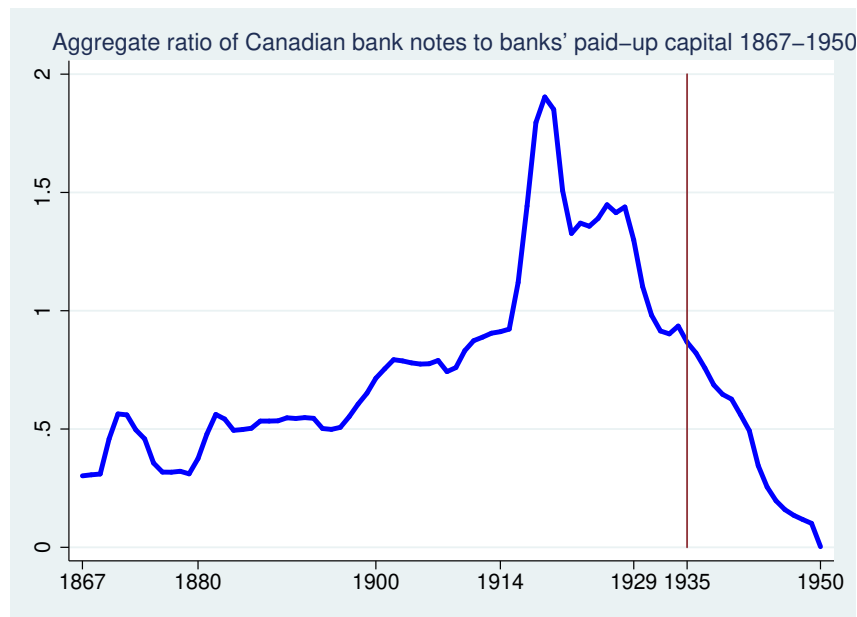
Aggregate ratio of Canadian bank notes to banks' paid–up capital 1867–1950

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

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.[31] 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 (2017b) state that the Bank Act of 1890 made chartered bank notes a uniform currency. Before the act, notes from locations other than the branch where they were to be redeemed, were traded at discounts. After 1890, notes had to be accepted at par throughout the country. Moreover, the Bank Act of 1890 created the Bank Circulation Redemption Fund (BCRF) that essentially required the banks to contribute to a banknote insurance fund. 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).[32]

The importance of chartered bank notes for the public is evident in Figure 1. Given 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

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[31]Given 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).

[32]The public was concerned with possibly lacking flexibility of governmentally supplied currency and with the risk of monetizing the debt (Shortt, 1905b).

could easily finance themselves with deposits. Figure A2 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. Watts (1993), p. 29, confirms this interpretation noting that chartered banks' opposition to the BoC note monopoly was unexpectedly subdued, probably to their changed earnings structure.
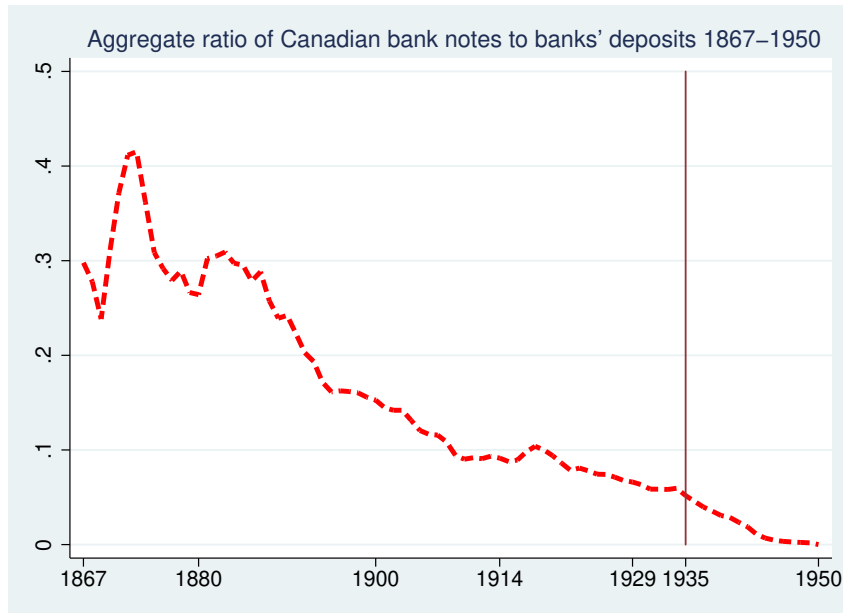
Note: Based on data from Dominion Bureau of Statistics (1935), p. 968, Dominion Bureau of Statistics (1951), p. 1040, Dominion Bureau of Statistics (1953), p. 1106.

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

B Aggregate trends among Canadian chartered banks

In this section, we briefly comment on general trends visible in the Canadian banking industry in period 1927-1950 which we visualize in Figure B1. The box plots give an indication of the distribution of considered variable among the ten Canadian banks (including Barclays Bank of Canada) in a given year, and the horizontal line in the middle of the box indicates the median, on which we focus in the description. In that time, bank leverage defined as assets to capital was following an upward trend. Over time, 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. A similar trend in the reshuffling of the banks' asset portfolio due to war has been also observed among other advanced economies, as Jordà et al. (2021) report.

The change in public deposits (calculated as first difference) does not seem to exhibit a clear pattern over time.

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) does not follow a strong trend.

When it comes to ratios calculated using the profit measures of banks, both return on assets (ROA) and the Z-score follow a declining trend.

Growth rates of lending and branches do not indicate an explicit trend.
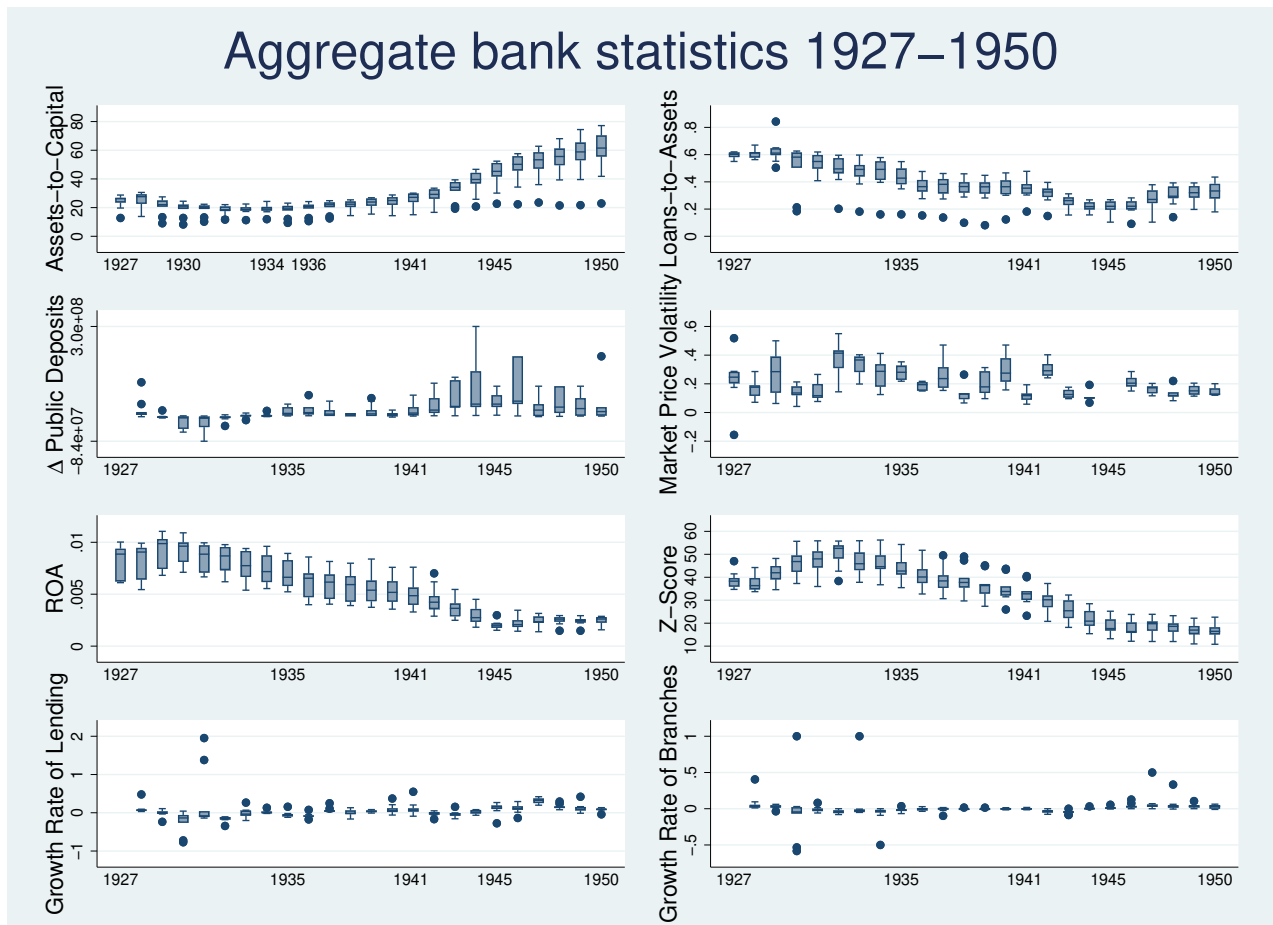
Note: Capital refers to the paid-up capital. Equity comprises all liabilities to shareholders, including the paid-up capital and the rest or reserve fund. The horizontal line in the middle of the box indicates the median, and the lower and upper borders of the box represent the 25th and 75th percentile. 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 B1: Aggregate trends among Canadian chartered banks in years 1927-1950

C   Additional Graphs
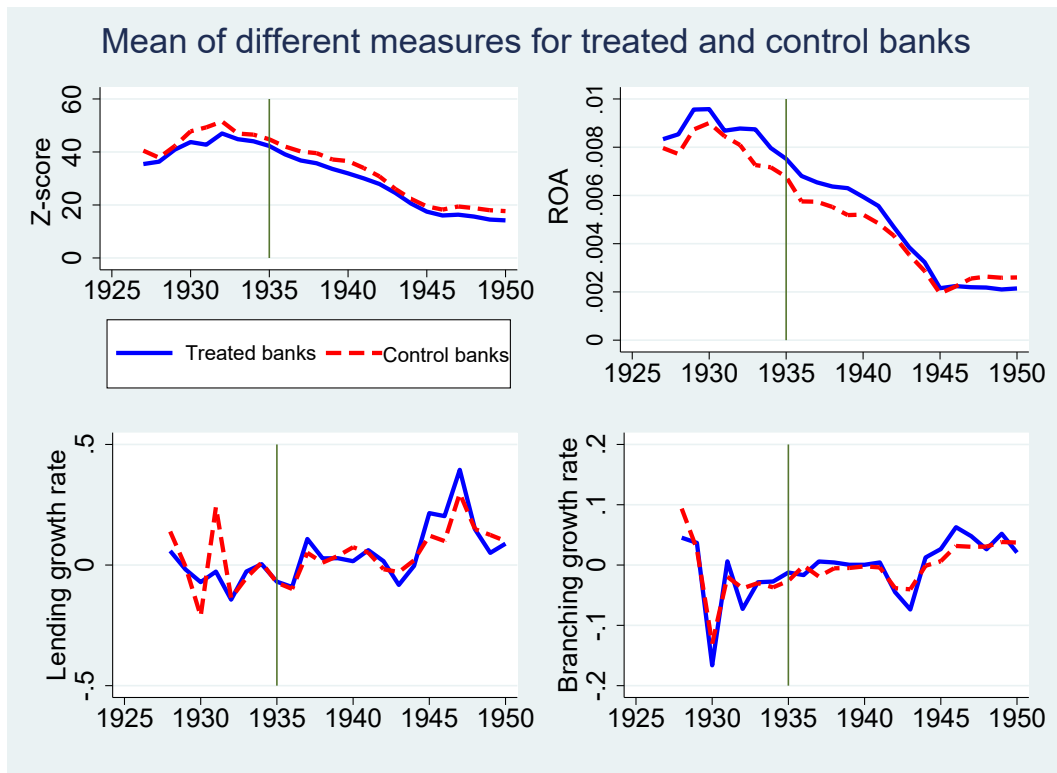
Figure C1: Mean of chosen variables for treated and control banks in years 1927-1950

D Details on variables

- Z-score:
$$\text{Z-Score}_{i,t} = \frac{ROA_{i,t} + E/A_{i,t}}{SD(ROA_i)},$$

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

- ROA: Net Profits/Total Assets

- Assets-to-Capital: Total Assets/Paid-up Capital

- Net profits: Net profits

- Market Volatility: the difference between the highest and lowest stock price in a given year, divided by the average price in the same year

- Δ Public Deposits: $PublicDepositLiabilities_t - PublicDepositLiabilities_{t-1}$

- Loans-to-Assets: Total Loans/Total Assets

- Total Assets: Total Assets

- Notes: Notes in Circulation

- Notes-to-Capital: Notes in Circulation/Paid-up Capital

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