# Do Central Clearing Parties Reduce Risk on Repo Markets?

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Drawing on a historical example, I study the introduction of a central clearing party (CCP) in a tri-party repo market. I focus on the French repo market between 1880 and 1913. I build a new and large original database including hand-collected repo rates, macroeconomic variables and security-specific factors. I perform a structural breaks test and I apply a difference-in-differences estimator to a panel data model to study the impact of an 1898 reform introducing a CCP on the market. I find that this regulatory change strongly reduced counterparty risk. Monitoring measures introduced to deal with moral hazard issues were crucial in shaping investors behavior.

JEL codes: E43 G12 G23 N23

Keywords: Clearing House, Repo Market, Paris Stock Exchange

[1] I thank for valuable comments and insights my advisor, Pierre-Cyrille Hautcoeur, as well as Patrice Baubeau, Sibylle Lehmann-Hasemeyer, Eric Hilt, Kris Mitchener, Eric Monnet, Xavier Ragot, Jean-Laurent Rosenthal, Pierre Sicsic, Eugene White, and all participants to seminars in PSE and NYUAD. I am particularly grateful to Angelo Riva.

## 1. Introduction

During the financial crisis of 2007-2009, the U.S. tri-party repo market, a large funding market used by banks to raise short-term loans, played an important role in elevating and propagating risk[2]. At the same time in Europe, the central clearing party (CCP)-based euro interbank repo market displayed remarkable resilience[3]. This difference in behavior suggests that developing a CCP could help deal with repo market fragilities[4]. Nonetheless, because of a lack of empirical evidence, no study analyzes the introduction of a CCP in a repo market.

In my paper, I use a historical case to address this question. I focus on the French historical repo market between 1880 and 1913[5]. In 1895, an international crisis hit the financial market. In the aftermath of the crisis, a reform was passed and a CCP was introduced. I build a new and large original database including hand-collected repo rates, macroeconomic variables, and security-specific factors, to study the pricing mechanisms at work before and after the shock. Using a difference-in-differences estimator applied to a panel data regression, I find that the regulatory change strongly reduced risk on the market. Monitoring measures introduced to deal with moral hazard issues were crucial in this respect. After the reform, no major crisis hit the Paris market until WW1. France even became a "safe haven" for capital during the 1907 international crisis[6].

A repurchase agreement, or repo, is the sale of an asset coupled with the agreement to repurchase the same security at a specific future date at a fixed price. Said differently, it is a collateralized loan during whose validity the lender enjoys full ownership rights over the underlying security. The repo market is large. The total value of repo contracts outstanding in June 2017 was 6.5 trillion euros ($ 7.55 trillion) in Europe[7], and 4 trillion dollars in the US[8]. Put together, these figures amount to one third of the sum of US and EU GDPs.

Repo markets clear on both a price and a quantity dimension. The first one is summarized by an interest rate, the second one by the initial margin, or haircut, associated with the loan. Repo markets are organized in three different segments: OTC bilateral, tri-party repos, and CCP-cleared. On the bilateral market, the settlement of the repo is handled by the trading parties. In tri-party repos,

[2] On the role played by the tri-party repo market in relation to the failures and near-failures of Countrywide Securities, Lehman Brothers, and Bear Sterns, see Copeland, Duffie, Martin, and McLaughlin (2012), Krishnamurthy, Nagel, and Orlov (2012), Adrian, Begalle, Copeland, and Martin (2013), Copeland, Martin, and Walker (2014), as well as Begalle, Martin, McAndrews, and McLaughlin (2016) among others.
[3] See Mancini, Ranaldo, and Wrampelmeyer (2015), and Ebner, Fecht, and Schulz (2016).
[4] See Martin (2015), Baklanova, Dalton, and Tompaidis (2017), and Duffie (2017) for recent reform proposals.
[5] Flandreau and Sicsic (2003) provide a seminal contribution about this market.
[6] Flandreau (1997). See also Bank de France archives (BFA), 1069199121/9, La Crise américaine de 1907.
[7] ICMA Repo survey, October 2017.
[8] SIFMA US Quarterly Highlights, October 2017.

settlement and collateral management settings are outsourced by the parties to a third-party agent, which does not bear the counterparty risk[9]. In markets cleared by a CCP, the latter assumes counterparty risk by inserting itself between the parties and becoming seller to all buyers and buyer to all sellers. As a consequence, it sets rates and haircuts on the market.

Theory posits that in a CCP-based market, lenders do not have strict incentives to run on borrowers, due to the elimination of direct counterparty exposures (Martin, Skeie, and von Thadden, 2014). Moreover, CCPs increase trading efficiency by allowing for anonymous dealings and multi-lateral settling among participating institutions (Boissel, Derrien, Ors, and Thesmar, 2017). Finally, CCPs liquidate collateral and distribute losses in case of default of one of its members. This feature mitigates the risk of disorderly liquidation of collateral (Oehmke, 2014). As a consequence, CCPs may help increase financial stability.

Despite these advantages, there was little interest for a CCP in the US repo market until recently. The introduction of new regulation, and in particular of the Supplementary Leverage Ratio (SLR), has opened the way for a debate over introducing a repo CCP (Martin, 2015). The SLR introduced limits on leverage in banks' balance sheets. The use of a CCP, by netting long and short positions of banks, would reduce the required amount of balance sheet space. Such a measure would therefore allow banks to conduct the same amount of intermediation with a smaller balance sheet (Duffie, 2017).

Despite academics and practitioners are currently debating about introducing a CCP in the US repo market, no existing empirical study analyzes the potential consequences of this measure. In this paper, I fill this gap by focusing on a historical case. This approach allows me to analyze both the context in which the reform took place and the medium-run effects of the regulatory change. I study the introduction of a CCP in the French "*marché des reports*". The reform took place in 1898, following an international crisis originated by speculation on gold mining stocks. At that time, this market for sale and repurchase agreements negotiated each month one fourth of the French GDP[10].

To study the French historical repo market, I construct a new original database from archival sources. The database includes all repo rates published at the end of the month on Paris stock exchange official lists, from 1880 to 1913. I chose this period for its institutional homogeneity, and because it represented the heyday of the Paris financial market. The start date of my analysis was decided based on data availability. Total number of repo rates is 58,786 over the whole period. The average number is 144 rates per month. Moreover, the DB contains new hand-collected corporate governance data, such as dates of payment of interests and dividends, dates of general assemblies,

[9] See Krishnamurthy, Nagel, and Orlov (2012), Adrian, Begalle, Copeland, and Martin (2013) among others.
[10] Charousset (1898) and Allix (1901) for estimates on volumes exchanged on the repo market. Lévy-Leboyer and Bourguignon (2008) for estimates on GDP.

and dates of issue of new capital, for a portfolio of 49 securities. Finally, I use previously unexploited data about returns and volatility for these 49 securities.

Repo market microstructure did not allow the use of haircuts. Consequently, counterparty risk was managed by applying different rates to different collateral securities. Higher rates meant higher risk. For each end of the month, I calculate the dispersion of repo rates among underlying assets and use it as a measure of risk on the market. I show that dispersion increased in periods of tight monetary conditions, as rates on safer collateral did not change while rates on riskier collateral increased.

I perform a structural breaks analysis to single out the exact moment in which rates dispersion was reduced. I find a reduction in risk perception in the moment of the introduction of a monitoring mechanism in January 1901. The introduction of the CCP itself had not been enough for investors to consider the market as safe. On the contrary, this anti-moral-hazard policy had a strong effect on decreasing interest rates. Investors were able to trust brokers more than before, as they were monitored by their peers. This reduced the incentive for lenders to ask for higher protection under the form of higher interest rates.

I then use a panel data regression to identify the determinants of repo rates. The large dimension of my data set and its high quality allow me to single out several dispersion determinants. In particular, I find that upwards dispersion is mainly explained by counterparty risk, measured through volatility of asset returns. Moreover, I explain the singular presence of a high number of negative interest rates in the market by focusing on market corporate governance practices. Negative rates reflect a premium paid by investors to participate to capital issues by private companies.

In order to study the impact of the reform on the repo market, I apply a difference-in-differences estimator to the panel data model. I find that the regulatory change strongly reduced the average interest rate for those assets that were previously considered risky. All the market could be now considered as a safe one. The reform was effective in lowering risk on the whole financial market. As a consequence, no major crisis hit the Paris market between 1899 and the beginning of WW1.

I finally document a side effect of the reform. By forcing deposit banks to pay commission fees and a financial transaction tax on every negotiation undertaken on listed securities, the new set of laws provided financial institutions with an incentive to develop a rival market. Using original archival data, I find that volumes invested on the repo market decreased in favor of advances on securities granted by deposit banks to their clients. Volumes negotiated in the market for these competing instruments went gradually beyond the amount of repo funding in the years preceding WW1.

## 2. Historical Background

In the French repo market, money lenders were mainly banks, industrial firms and retailers investing their liquid assets, and individual investors[11]. Money borrowers were bullish forward traders willing to roll over their open positions, and needed liquidity to do so. Loans took the form of a sale of an asset coupled with the agreement to repurchase the same asset on a specific future date, 15 or 30 days later. In this section I present the microstructure of the market and its 1898 reorganization.

### 2.1 Market Microstructure

All operations in the Bourse were mediated by pure brokers. The latter were called *agents de change*. They collected sale and purchase orders in behalf of their clients, and performed multilateral netting among them. Brokers were responsible for payment to their clients and fellow brokers. As a consequence, they were exposed to bankruptcy if their clients defaulted (Hautcoeur and Riva, 2012).

*Agent*'s responsibility involved their personal wealth, as well as their seat's. Every seat had its own capital, shared by the broker with his associates. Number of brokers was fixed by the government[12]. They were organized in a guild-like organization called *Compagnie des Agents de Change* (CAC). They were not allowed to undertake financial trade for their own sake, and made profits through commission fees.

Alongside the Bourse, stood an OTC market, called the *Coulisse* (the curb market), providing immediacy and opacity for professional investors. Most *Coulisse* transactions were made on bilateral basis. Its members often acted as dealers, acting under dual capacity. The Bourse enjoyed a monopoly over stock market transactions. Nonetheless, the existence of the OTC market, illegal by the law, was tolerated and even protected by the government. The *Coulisse* in fact provided the market with the liquidity necessary for its operations, and in particular for government bonds issues.

The Paris market was primarily a forward market. Forward trading on the stock exchange was highly developed at the time. It represented three times the French GDP (Lagneau-Ymonet and Riva, 2017). Forward contracts were done on the basis of central settlements taking place at the end of each month for all securities in both markets. The *Parquet* organized additional mid-month settlements for the riskiest assets.

When the settlement approached, bullish forward traders transmitted their orders to their *agents de change* or *coulissiers*. They could either fulfill their purchase obligation and put an end to the transaction, or roll over their position to the following settlement. In the latter case, the broker had

[11] Archives Nationales, Alexandre Ribot personal archives, Lettre de M. Ribot à M. Pallain, November 7, 1914, 563/AP/16. See also François Marsal (1930).
[12] There were 60 of them up to 1898, and 70 afterwards.

to find counterparty for his clients. In other words, he had to find someone providing the amount of cash needed to postpone the final repayment by 15 or 30 days.

To do so, he matched at first opposite orders among his own customers. In the second place, he compared his net position with those of his colleagues, looking for positions of opposite sign. Typically, forward purchases outnumbered forward sales, leaving a need for cash. The difference in volume between the two, at an aggregate level, was named "place position" (*position de la place*). In 1898, it amounted to some 3 billion francs on the *Parquet* and to a similar figure at the *Coulisse* for each end-of-the-month settlement[13]. The sum of the two gives a total of 6 billion francs per settlement, representing one fourth of the French GDP of the time.

In order to raise this money and clear the market, the first step consisted for *coulissiers* to invest a part of their own liquidity, and for *agents de change* to use a fraction of their seat's capital. Then, brokers at an individual and at an aggregate level called in another type of actor. Among brokers' clients there were banking, trading, and industrial firms, as well as individual investors, in possession of liquidity. This kind of customers acted as repo lenders. They entered the transaction by coupling a purchase on the spot market with a sale of the same asset on the following settlement. This kind of operation is called today a "reverse repo" (Adrian and Shin, 2010). From their point of view, this double operation was nothing but a money-lending transaction lasting the time of a settlement, 15 to 30 days. Remuneration was given in the form of an interest rate.

On the *Parquet*, the amount of cash that lenders gave to their brokers was equal to the market value of the collateral assets, as fixed by the governing body of the CAC, the *Chambre Syndicale* (CS). These prices, called *cours de compensation* (settlement prices) did not necessarily correspond to real transactions undertaken on the spot market. They were fixed for each asset on the basis of the prices done during the settlement day, mostly around the average price. The *Coulisse* conformed to this custom.

There were two reasons for establishing a specific price instead of using the price of an actual transaction. First, brokers wanted to avoid last-minute speculation intended at altering the market. Secondly, different forward orders were placed by different clients at different prices for the same security. Settlement prices were created to balance them out. The CAC had therefore created this procedure in order to allow for an orderly clearing[14].

[13] See Charousset (1898) and Allix (1901) for estimates on trade volume on the repo market before the 1898 reform.

[14] See Deloison (1890) and François Marsal (1931). More details are also provided in the Appendix.

It should be noted here that this mechanism left no room for the applying of haircuts (or initial margins) on the value of the collateral asset. Repo transaction were only done at the settlement price[15]. Lenders were guaranteed by full ownership rights on the collateral asset during the whole period of the loan, as well as by the personal and office security offered by their broker[16].

As a consequence to the absence of haircuts, discrimination among different collateral securities involved applying higher interest rates to repos done on riskier collateral. The interest rates, or repo rates, were calculated on the basis of the settlement prices and the "repo prices". The latter were the prices paid by bullish forward investors to roll over their positions on that particular collateral asset up to the next settlement.

Contemporary stock markets were not all financed in the same way. Brokers in New York, as an instance, were funded by brokers' loans. The brokers' loans market was a market for collateralized loans different in several respects from the reports market. Settlement was quick in a few days, and was not centralized twice a month. Brokers' loans in the U.S. were contracted at a unique market rate, which was instantaneously adjusted. There were varying margins for different types of stock. The latter were changed less frequently.

## 2.2 The Reform

In 1898, the French parliament passed a new set of regulations reorganizing the financial market. The main measure consisted in the introduction of a Central Clearing Counterparty. The reform shaped a new institutional setting of the Paris financial market which remained unchanged up to World War 1. The reorganization intervened after a crisis in 1895 had severely hit the *Coulisse*, and tarnished the official market too.

The precondition for the 1895 crisis laid in another reform, passed in 1893. This reform, that introduced a financial transaction tax (FTT), had given the *Coulisse* a legal status. By allowing every intermediary to pay the FTT, it dismantled the *Parquet*'s monopoly on listed securities. This tax was introduced for two reasons. First, it increased government's revenues. Second, it provided information on financial market transactions (Lagneau-Ymonet and Riva, 2017). This reform resulted in the *Coulisse* taking the upper side on the *Parquet*. Figure 1 shows the annual stamp duties paid on securities transactions from 1893 to 1907. This amount can be used as a proxy for the relative importance of the two exchanges.

(Figure 1 here)

[15] Allix (1901). See also ACL, 7AH2, Circulaires Direction Générale. Memorandum dressed by Adrien Mazerat, General Manager of Crédit Lyonnais on November 29th, 1902.
[16] After the reform, additional guarantee was offered on the Parquet by the existence of the CCP.

In 1895, the Gold Mines crash hit the financial market, affecting mostly the *Coulisse*. According to many observers, the *coulissiers* had developed the market for gold mining stocks very speculatively (Hautcoeur, Rezaee, and Riva, 2010). In particular, information on most of stocks issuers was scarce, the market was opaque and shares did not comply with French regulations. Little is known about the origins of the crisis. It was plausibly caused by the explosion of a bubble created by stock market manipulation on these securities (Graham, 1996).

The crisis facilitated a campaign by the official brokers against the *coulissiers*, accused for having imposed losses to French savings. The *agents de change* wanted their monopoly back, justifying it with financial stability reasons. The government soon re-established the dominant position of the official brokers. In exchange, the Bourse had to be completely reorganized. Therefore, the so-called "financial market reorganization[17]" of 1898 did not restore the pre-1893 situation, but went well forward in shaping a new setting.

The reform included the following main points (Hissung-Convert, 2007). First, the reorganization introduced a central clearing party. Centralization of settlement operations was already the norm, but now the collective guarantee of the Parquet was enshrined in the law. The motivation of the legislator was that of providing the Bourse with additional credibility among small investors looking for security[18]. Nonetheless, the brokers guild protested against giving legal recognition to the joint liability mechanism. Their argument lay on anti-moral-hazard grounds. If no broker could face bankruptcy, any of them could take risks without sanction. The final text, adopted after long negotiations, aimed at both introducing the CCP and limiting the moral hazard[19]. Nonetheless, it was not considered enough by most *agents de change*.

Second, *coulissiers* and bankers had to pass through the intermediation of the *Parquet* for each transaction undertaken on listed securities[20]. The fiscal administration committed to enforce this particular point by suing those who illegally traded this kind of assets (Lagneau and Riva, 2017). About 70% of the *Coulisse* turnover in 1897 came from *Parquet*-listed securities[21]. Therefore, this

[17] Several pieces of historical literature – doctoral theses, books, pamphlets, and journal articles – were dedicated to what was called "*La réorganisation du marché financier*". See for instance Charousset (1898); Dubreuil-Chambardel (1898), and historical press.
[18] 'Le Temps', November 20th, 1899. See also François Marsal, 'Encyclopédie'.
[19] See an undated letter from the « Syndic au Ministre des Finances », accompanying the « Note remise par le syndic des agents de change, texte proposé en remplacement de l'amendement Viviani sur la solidarité, rédaction de M. Sabatier ». CAEF, box 64895. Cited in Haucoeur, Rezaee, and Riva (2010).
[20] On December 31st, 1897, more than 1,700 securities were listed on the stock exchange, representing a market capitalization of approximately 11 billion francs, about a half of the French GDP. Number of securities comes from DFIH database, version May 2017 (Hautcoeur and Riva, 2016); Market capitalization figure from Arbulu (1998); GDP from Lévy-Leboyer and Bourguignon (2008).
[21] A-CAC, MGA, 30 April 1898.

measure was a harsh blow for the OTC market, whose market share immediately dropped to one-third of total Parisian traded volumes.

Thirdly, the commissions perceived by official stockbrokers were strongly reduced, reaching a level lower than those payed in London and New York[22]. This measure most likely helped in attracting new investors on the market. Fourth, in order to handle more volume, the government raised the number of official brokers from 60 to 70. Finally, the very same year the *Cour de Cassation* legalized once and for all forward operations, hence providing the *Parquet* with additional protection against risk[23].

In the years following the reform, the CAC took some additional measures to adapt its functioning to the new setting. In particular, it had to face increased moral hazard due the introduction of the CCP mechanism. If no broker could face bankruptcy, any of them could take risks without sanction. The measures undertaken were the following. First of all, in January 1901 the syndic imposed a biannual internal survey on the size of repo exposures by brokers. Each agent de change had to provide the CCP with precise information on the type of clients and amount of funds invested in *reports* by their offices[24]. These pieces of information had to be supplied twice a year, although not a fixed date.

Moreover, newly admitted brokers were carefully screened, and the governing body of the exchange ensured that only brokers from wealthy families could acquire a seat (Riva and White, 2011). This requirement had a double reason. First, financially healthy brokers had more capital to cover losses from defaults. Secondly, the fact that *agents de change* came from the same social group helped in implementing a monitoring policy and in exercising moral suasion (Verley, 2007).

Finally, after some years of struggle, in 1901 an arrangement was found between *agents de change* and *coulissiers*, allowing the latter to act on the *Parquet* as commission brokers, or *remisiers*, in addition to trade unlisted securities and some foreign and domestic government bonds[25]. The reform, passed in 1898, was therefore completely effective three years later. The reorganization was successful in dealing with risk. No major crisis hit the *Parquet* between 1899 and the beginning of WW1. France even became a “safe haven” for capital during the 1907 international crisis.

[22] At the beginning of the twentieth century, the commissions to buy 100.000 francs worth of foreign securities amounted to 129.20 francs in London, 120 francs in New York, and 100 francs in Berlin and Paris (Crédit Lyonnais archives, box B.64.877, cited in Lagneau and Riva (2017).
[23] Arrêt of 22 June 1898. Cited in Hissung-Convert (2007).
[24] A-CAC, MCS, 4 and 25 January, 1901.
[25] See Boissière (1908) as well as Vidal (1910).

## 3. Accounting for the dispersion of repo rates.

Repo market microstructure did not allow the use of haircuts. Consequently, counterparty risk was managed by applying different risk premia to different collateral securities. For each end of the month, I calculate the dispersion of repo rates among underlying assets and use it as a measure of risk on the market. Dispersion increased in periods of tight monetary conditions, as rates on safer collateral did not change or lowered, while rates on riskier collateral increased.

I have all repo prices and settlement prices done on the *Parquet* for all end-of-the-month settlements from January 31st, 1880, to December 31st, 1913[26]. I exclude mid-month settlements in order to have exploitable series for surest collateral assets. The latter were only negotiated once a month. Figure 2 shows how information was organized on the Paris stock exchange official lists. For each security used as collateral in at least one repo transaction, the official list published the repo prices and the settlement price.

(Figure 2 here)

The first were the prices paid by forward buyers to roll over their positions to the following settlement; the latter represented the value of the collateral asset. Depending on the security, we can find one or two repo prices. If more than one price were agreed upon for the same collateral asset on the same settlement date, the official brokers published the higher and the lower. The positions were then settled at the average price. The formula used to calculate the annualized interest rate perceived by the lender was therefore, for each collateral asset (Haupt, 1894):

$$rate = \frac{average\ repo\ price\ X\ number\ of\ yearly\ settlements\ (12\ or\ 24)}{settlement\ price}$$

The number of total collateral assets, and therefore repo rates, ranges from 64 on January 31st, 1880, to 289 at the end of 1913. The average over the period is 144 rates, and the total sum over the 408 months is 58,786 rates. Figure 3 shows the variation of the repo rates on the *Parquet*. For each end of the month settlement (X axis) I plotted in green the range including the repo rates between the first and third quartile (the 50% central rates). In grey, the two ranges obtained by starting from each of the two quartiles and adding or subtracting 1,5 interquartile ranges[27]. In blue, outliers. The scale on Y axis is logarithmic, but the legend is converted in actual rates.

(Figure 3 here)

[26] I personally hand-collected most of them. I deeply thank the Equipex DFIH for providing me with the remaining data. All data are now in the DFIH Database. (Hautcoeur and Riva, 2012).

[27] The interquartile range or IQR is a measure of dispersion given by the simple formula IQR=75th percentile – 25th percentile. This kind of graphic representation is known as Tukey boxplot. Frigge et al. (1989).

We can note three main features of the plot. The first is that lenders protection against risk involved applying different risk premia to different securities. Rates dispersion reflect this attitude. The second is given by the presence of a high number of negative rates, most of the time outside the "normal" range. The third feature is a clear reduction in rates dispersion over the period, and in particular after 1895. Let us address here the first two aspects. The empirical analysis presented in Section 4 deals with the third feature.

Cash investors, in absence of haircuts, protected themselves against collateral risk by applying different rates to different underlying collateral assets. In Figure 3 we do not observe one rate for the whole market, or one rate by type of security, but a variety of rates each depending on collateral. Figure 4 depicts the dispersion of the rates measured by the Interquartile Range (IQR). The IQR or H-spread is equal to the difference of 75$^{th}$ and 25$^{th}$ percentiles. It is a robust measure of scale, not influenced by outliers, in contrast with variance. It can be calculated even in presence of negative values, as in our case, in contrast with other measures of dispersion such as standard deviation and Gini index.

(Figure 4)

The IQR takes values varying between 2 and 3 percentage points in "normal times" during the period 1880-1895, and between 1 and 2 percent afterwards. An IQR of 3 percent, when the average rate was around 3.5%, means that even excluding outliers, "normal" rates ranged between 2 and 5%. The high dispersion reflects collateral assets diversity with respect to risk perceived by investors.

In periods of crisis, dispersion increased. The IQR reaches levels of 6 to 8 percentage points in several moments between 1881 and 1895. The first high peak takes place in the months preceding the *Union Générale* crash and during the crisis itself. According to some metrics, the *Union Générale* crash was the worst crisis ever experienced by the French financial market (Le Bris, 2010). Speculation on the repo market played a fundamental role during the boom preceding the bust (Flandreau and Sicsic, 2003). Stock prices grew during the year 1881, especially those of the banking sector. The crisis, exploded in January 1882, threatened with failure 14 of the 60 Parisian stock brokers, and seven of them eventually proved insolvent (White, 2007). The Lyon stock market, the main regional exchange, was liquidated, and in the following years had to struggle to survive (Ducros and Riva, 2014).

The second and third moments in which the IQR reaches a level higher than 6% are in April 1886 and at the end of 1890. In these cases, new issues of government bonds were announced. Government bonds at the time were issued through the direct involvement of banks (Vaslin, 1999). Banks participated to bonds underwriting by paying a security deposit amounting to 15% of the issue price. Banks had a double incentive to participate to government bonds issues. Firstly, issue price was

usually lower than the expected market price, so that banks could make profits by reselling securities on the secondary market later on. Second, the ability to distribute bonds to their clients was a signal of strength of their networks, and contributed to increase their prestige.

Banks had an incentive in providing the Treasury with all the funds they could, as at the moment of the issue, bonds were distributed to subscribers in proportion to their relative participation to the initial call. Given this mechanism, the only way for banks to satisfy their own needs and the needs of their clients was to get a substantial share of their short-term funding back. A consistent part of it was at the time invested on the repo market. Massive withdrawals from the repo market led to marked rate hikes.

The fourth and last high peak in the IQR series takes place in 1895, during the Gold Mines Crisis. This crash, originated by the explosion of a bubble in South African gold mining stocks, hit primarily the *Coulisse*. Banks withdrew their funds from the OTC repo market, worsening the crisis. Because of the strong interactions between the two markets and the international dimension of the crisis, that partially hit the London Stock Exchange too, the *Parquet* was not spared (Hautcoeur, 2007).

All these periods have in common a sudden shock that hits investors' willingness to lend. In 1882 and 1895, repo lenders were reluctant to take possession of collateral, as artificially-inflated asset prices were bound to drop. In this tri-party-like repo market, investors did not directly face their counterparty. Therefore, they did not negotiate the terms by which the repo chain could continue, for example by applying a haircut. As a consequence, they preferred to withdraw funding rather than continue their lending.

In 1886 and 1890, lenders needed cash to subscribe to government loans issues. In all these cases, the repo chain was interrupted. Withdrawals resulted in an increased risk-premium associated to the riskiest collateral and consequently in the rise of repo rates dispersion. The French historical repo market represents therefore evidence on the hypothesis drawn by Copeland, Martin, and Walker (2014). According to them, tri-party repo cash investors, reluctant or unwilling to take possession of a collateral asset losing its value, do not use margins to mitigate risk. Rather, they prefer to withdraw funding and leave the market.

It shall be noted here that in similar circumstances taking place after the 1898 reform, the repo market experienced a rise in the general level of rates, but not an increase in dispersion. This was the case in 1901, when the government issued another loan, as well as during the international crises of 1906-1907 and 1911-1912.

Let us get back to Figure 3. The second feature of this plot is the presence of a high number of negative rates, the most of the time outside the "normal" range. Negative rates, or *déports*, can be explained by three main factors. Typically, these were particular cases in which a given collateral asset was highly demanded on the market. The usual example is that of an issue of new capital reserved to stock-holders.

Other instances include willing to own an asset in order to receive the payment of coupons (dividends or interests), or the need of holding a minimum quantity of stock to participate to the general assembly (GA). Remember that money lenders enjoyed full ownership rights over the asset during the period of the repo contract.

Let us think of the repo price as the difference between the forward and spot prices of the collateral asset at time t. Spot prices were increased by high short-term demand. Forward prices usually were not touched: at the time of the following settlement the period of subscription was over, the date of the GA was already passed, or the interest had already been paid. In other words, demand of securities was higher than demand of money for that particular stock on that particular date. The negative rate can therefore be interpreted as a premium for cashing in a coupon, participating to the GA or to the issue of new capital.

A second factor explaining negative rates is still security-specific, but deals with the medium run. Sometimes bad news about the issuer of the security lasted several months. In those cases, bears outnumbered bulls on the market for that particular asset. As a consequence, at each settlement forward prices were lower than spot prices, displaying expectations of further price reduction. This was the case for the Panama stock during the 1887 to 1889 period (Allix, 1901), as well as for the *Compagnie Générale Transatlantique* in the second half of the 1890s. In this case, the negative rate can be interpreted as a sign of bad health of the issuer.

## 4. Data

In order to take into account negative rates due security-specific factors, I hand-collected data on dates of capital issues, dates of General Assemblies, and dates of payments of dividends and interest. I chose to limit data entry to a portfolio of 49 securities. The sources I used to collect these data are the CAC's official yearbooks. This publication starts in 1880. This is the reason why this study starts at this particular moment.

I developed the portfolio in order to represent as much as possible any different kind of security and issuer. Repos in Paris were negotiated on a variety of assets. They could be negotiated on all securities admitted on the forward market. Specific regulation applied to these securities, as they needed to satisfy some additional requirements with respect to assets only admitted to spot transactions. At every settlement, if at least one bullish forward trader decided to rollover her position on a specific asset to the following settlement, at least one repo price for that collateral security had to be done.

On the official list, the official brokers published no prices in case of absence of negotiations, one price if one only transaction had been done, and two prices – the min and the max – in case of more than one repo transaction. In this latter case, repos were settled at the average price between the two (Haupt, 1894). As a consequence, we know how many collateral securities were used in *at least one* repo transaction at the Bourse. We can do so by counting the number of collateral securities displaying one or two repo prices at every settlement date on the official list.

(Table 1 here)

Table 1 shows the evolution of the different types of collateral used in the repo market, from 1880 to 1910. At the settlement of the end of December, 1880, 69 securities were used as collateral on the repo market. 40 of them were French private stocks, representing 57,97% of the total amount. 12 of them were foreign private stocks, representing 17.39% of the total amount. As a whole, the repo market was therefore done on stocks as collateral assets in 1880. Stocks represented three fourth of the market.

In the 1890s and at the beginning of the 20$^{th}$ century, the number of foreign securities progressively outnumbered that of French assets used as collateral. At the settlement of the end of December, 1900, 105 out of 184 assets used as collateral on the repo market were foreign stocks or bonds (57.06% of the total). Ten years later, at the settlement of the end of December, 1910, foreign assets represented the 62.02% of the total. This tendency was due to the admission on the forward market of an increasing number of foreign railways bonds, as well as bank stocks and public debt certificates.

(Table 2 here)

Table 2 presents how volumes invested in the repo market were shared among different types of collateral assets. This type of information was not public, and only thorough archival research has allowed me to disclose it for two dates, in 1906 and 1914. During this period, 5% to 10% of the overall volumes were invested on different types of French *Rente*. This was the surest part of the market. Most of the market was done on foreign stocks and bonds (67% in 1906, leaving only a 33% to French securities). Each of the two groups was characterized by a strong heterogeneity. Not necessarily French securities were surer than foreign ones.

In the portfolio that I build, I replicate as much as possible the relative proportion among types of securities shown in Table 1 and 2. The choice of the specific securities was made upon the examples given in the historical literature[28]. Table 3 presents the main characteristics of the assets composing the portfolio. I have a total number of rates of 15,186, distributed over 408 months. This number represents 27.5% of the entire population over the period. The median rate is 3.42% for both foreign and French assets. The two are characterized by a high dispersion and presence of outliers, both negative and positive. The most represented assets are government bonds as well as banks and railways assets, which were also the most liquid securities according to contemporary accounts.

(Table 3 here)

For each security of the portfolio, I calculate asset returns at every date (variable capital_gain). I then compute historical volatility of asset prices over 6, 12 and 18 months (volatility_6, volatility_12 and volatility_18). I compute proxies for assets liquidity. The Paris stock exchange official list published the price of every transaction done on the spot market for any security, if different from the immediately previous price done on the same day.

I can therefore use the number of prices published in the settlement day as a proxy for liquidity, as it represented the minimum number of transaction done on the spot market for that security. This variable in my database can vary between zero and twenty. I then average these "daily" liquidity measures over six, twelve and eighteen months in order to obtain historical liquidity proxies for both

[28] Descriptions of "typical" investments are found in Allix (1901), Guilmard (1913), as well as in newspapers. A quantitative assessment of volumes by type of security is possible for years 1906 and 1914. In 1906 the CAC performed a study on the FTT that can be used to estimate the distribution of forward transaction by type of security (A-CAC, B-0064877/1). During WW1, the BdF provided the CAC with a loan. One of the studies undertaken by the central bank before the loan describes the volumes invested on the repo market by type of collateral (A-BDF, 1069200401/147).

spot and forward markets of each portfolio asset (variables volatility_6, volatility_12 and volatility_18). Number and level of asset prices come from the DFIH database[29].

Finally, the model contains macroeconomic variables. In particular, I use the Banque de France interest rate (bdf_rate), to control for an influence of the central bank's monetary policy. Because monetary policy was implemented through quantities more than through rates during this period (Bazot, Bordo, and Monnet, 2016), I also use the first-differences of some balance sheet variables of the BdF (variables commercial_paper and advances). To take into account the influence of the interbank market, I use the so-called "Paris open market" rate, the interest rate at which main financial institutions lent money among themselves (variable open_mkt).

I then use the returns on a stock market index (Le Bris and Hautcoeur, 2010) and on a corporate bond index (Rezaee, 2012), to take into consideration the influences coming from the financial market. Finally, following Bordo and MacDonald (2005), I use the variation on the level of imports as a proxy for aggregate demand (variable imports). More detail on all these variables is available in the appendix.

[29] DFIH database, version May 2017 (Hautcoeur and Riva, 2016).

## 5. Empirical Strategy

Which were the determinants of repo rates? Was the 1898 reform effective in reducing risk on the repo market? When did the investors perceive that a change had taken place? I reply to these questions in three steps. First, I run a structural breaks test on the time series of the rate dispersion. The aim is to identify whether and when the introduction of the CCP reduced counterparty risk on the market. Second, I estimate an arbitrage model on a portfolio of selected securities by using a fixed-effect panel data approach. Finally, I apply a difference-in-differences estimator to my model to quantitatively test the impact of the reform on the repo market.

The most commonly used methodology to detect the number and location of structural breaks in a time series is the one developed by Bai and Perron (1998, 2003). Following Bai and Perron (2003), I begin by estimating the following general model subject to m breaks (m+1 regimes):

$$y_t = \delta_j c + u_t \qquad t = T_{j-1} + 1, \dots, T_j, j = 1, \dots, m + 1$$

My equation specification consists of the dependent variable (the times series of the IQR) and a single (constant) regressor. $u_t$ is the error term at time t, $\delta_j$ is the corresponding vector of coefficients and the indices ($T_1$, …, $T_m$) stand for the unknown break points. This approach estimates simultaneously the unknown coefficients and the endogenous breakpoints.

The algorithm computes the estimates of the break points based on the minimization of the sum of OLS squared residuals segment by segment, and convergence of the estimation is obtained under a large set of assumptions. In particular, different distributions are assumed for both the errors and the regressors. Wishing to allow for serial correlation in the errors, I specified a quadratic spectral kernel based HAC covariance estimation, using prewhitened residuals. The kernel bandwith has been automatically determined using the Andrews AR(1) method.

In order to test for multiple potential breaks, I used a test supF of no structural break, that is m=0 versus m=M globally determined breaks. Following Bai and Perron's (1998) approach, I applied the double maximum tests of the null hypothesis of no breaks against an unknown number of breaks, UDmax and WDmax , and used their reported critical values, which was in both case four. Then I implemented a test for l vs. l+1 breaks, applied to each and every segment. The model with l breaks is rejected in favor of a model with l+1 breaks if the overall minimum value of the squared residuals' sum is larger than the sum of the l+1 breaks model.

The structural break approach, as noticed among others by Oosterlinck, Ureche-Rangau and Vaslin (2013), has the main advantage for economic history that breaks are determined endogenously. This

means that what matters is the perception at the time of the events: ex-post biases are excluded. As highlighted by Frey and Waldenström (2007), this advantage is particularly emphasized by the use of financial market data, highly informative as they were published for the sake of market operators. It is clearly very useful in the context of this paper, as what matters is how risk was perceived by contemporary investors.

The structural break approach, either performed testing l globally optimized breaks against the null hypothesis of no structural breaks, or using the global information criteria (which compares information criteria for 0 to M globally determined breaks), gives as a result four breaks. Table 4 presents the results for the multiple breakpoint Bai-Perron tests of L+1 vs. L sequentially determined breaks. It is worth noticing that the indicated date is the first settlement of new regime.

The four breaks are the following: April, 1882; January, 1896; February, 1901; April, 1907. The break in 1882 is due to the *Union Générale* crisis, as well as the break detected between December 1895 and January 1896 is related to Gold Mines crisis. The April 1907 break detects a change in the internal organization of the repo negotiations that allowed for a more efficient management of the market[30].

The most interesting break for the sake of this analysis is the one taking place between January and February 1901. This is exactly the moment in which the syndic decided to introduce a monitoring mechanism. He imposed a biannual internal survey on the size of repo exposures by broker. Each *agent de change* had to provide the CCP with precise information on the type of clients and amount of funds invested in *reports* by their offices[31]. These pieces of information had to be supplied twice a year, although not a fixed date.

The introduction of the CCP itself had not been enough for investors to consider the whole market as safe. On the contrary, the introduction of the monitoring mechanism as a way to fight moral hazard had a strong effect on unifying interest rates. Investors were able to trust brokers more than before, as they were monitored by their peers. This reduced the incentive for lenders to ask for higher protection under the form of higher interest rates for some collateral assets. Given the historical and statistical evidence, in the following steps I consider February 1901 as the "break date".

The second step of my analysis consists in estimating an arbitrage model using a fixed-effect panel data approach. Arbitrage Pricing Theory (APT) was originally developed by Ross (1976). The idea underlying arbitrage pricing models is that the expected return of a financial asset can be modeled as a linear function of various macroeconomic or specific factors. According to this kind of models,

[30] A-CAC, MCS, 28 December 1906.
[31] A-CAC, MCS, 4 and 25 January 1901.

because of the law of one price assets that have the same risk must be exchanged at the same price. The interest of arbitrage models lies in their flexibility with respect to the standard CAPM framework. With respect to a standard APT model, I add to macroeconomic variables and market indices some security-specific and firm-specific variables, in order to take into account corporate governance practices.

The model I estimate is the following:

$$r_{it} = c + \alpha_i + X'_{it}\beta + d_t + u_{it}$$

Where $r$ is the repo rate for security $i$ at time $t$, $\alpha_i$ is the unobserved time-invariant individual security-specific fixed-effect, $X'_{it}$ is the time-variant $1\ x\ k$ regressor matrix, $c$ is a constant, $d_t$ are time fixed effects introduced to capture inflationist movements and moments of crisis, and $u_{it}$is the error term. It is worth remembering that I run the regression on a selected portfolio of assets, not on the whole population of repo rates.

I chose to use a fixed effect model in order to control for correlation between individual security-specific effects and the independent variables[32]. This kind of correlation is typical in financial models. Nonetheless, panel data fixed-effect models often suffer of cross-section dependence. In the context of my model, it would be the case if the behavior of one security is dependent from another.

This case being highly probable, I need to correct the error term to take into account heteroskedasticity, autocorrelation, and cross-section dependence. I do so by implementing Driscoll and Kraay's (1998) covariance estimator to produce standard errors. Driscoll-Kraay standard errors are robust to general forms of cross-sectional and temporal dependence when the time dimension is sufficiently large, as in my case.

As a robustness check, I show in the appendix the results of the same fixed-effect regression with different standard errors specifications. Even if standard errors change, the magnitude and sign of the effects remain the same, as well as their statistical significance. I ran the panel regression over three periods: a pre-reform one, covering 1880 - January 1901; a post-reform covering February 1901-1913, and the whole period. I selected the periods relying on the structural break test, and on archival evidence.

In order to quantitatively test the impact of the CCP introduction on the repo market, I then apply a difference-in-differences estimator to my model. To do so, I divide the 49 securities of my portfolio in

[32] Moreover, I perform a Hausman test to discriminate between a fixed- and a random-effect model. The test gives as a result Prob>Chi2 = 0.00. This result strongly rejects the null hypothesis of no difference between the two models, therefore rejecting the random effects model as inconsistent.

two groups. Those issued or guaranteed by the French state are the safe, or control, group[33]. The other ones are the risky, or treatment, group. The effects of the reform should only apply to the risky group, as state-owned or state-guaranteed securities were already safe assets before the reorganization. This is my identification assumption.

To apply the difference-in-differences strategy we need an assumption to hold. This hypothesis, which is called in literature the "Parallel Paths" assumption, postulates that the average change in the control group represents the counterfactual change in the treatment group if there were no treatment (Abadie, 2005). In the literature, it is common to check this assumption by testing for differences in pre-treatment trends in the two groups. If the two follow two parallel trends before treatment, results are robust to any possible confounder. In my case, safe and risky assets have to follow the same trend before the reform.

Figure 5 shows the parallel trends followed by the safe and risky assets in the years preceding the reorganization, and afterwards. In order to draw the graph, I avoid those moments of the year characterized by strong seasonality issues, such as payments of interest and dividends, or closure of accounts. I therefore take two points for each year to draw the trends, by using the months of May and November. The reform passed in 1898. From 1896 to that moment, and indeed until 1900, the two interquartile means of risky and safe assets follow parallel trends. Starting from 1901, year of the introduction of the monitoring policy, the difference between the two loses any importance.

(Figure 5 here)

Given that the parallel trends assumption holds, I can apply a difference-in-differences estimator to my model. The difference-in-differences model I run is the following:

$$r_{it} = c + \alpha_c + X'_{it}\beta + \lambda T_t + \delta D_{it} + \rho I_{it} + u_{it}$$

With respect to the previous model I added $T_t$ that are time fixed effects (pre-reform vs. post-reform), $D_{it}$ which are group fixed-effects (risky vs. safe), and the interaction term $I_{it}$ which captures the effect of the reform. In this specification I cannot use security-specific fixed-effects because they would be collinear with group fixed-effects. Therefore I substitute them with observable cluster fixed-effects, which capture common characteristics of clusters of assets such as being variable-income vs. fixed-income, issued by a public institution vs. private company, by a French company or public power vs. a foreign institution, and the sector of activity of the issuer. Finally, I substitute time fixed-effects with two sets of dummies for the months and for the years, for the same reason.

[33] I included French government bonds, the Bank of France stock, as well as stocks and bonds issued by railways companies, which were guaranteed by the State.

## 6. Findings

Upwards dispersion of repo rates was primarily due to counterparty risk, measured through volatility of asset returns, while downwards dispersion is explained by corporate governance factors. In particular, negative rates reflect a premium paid by investors to participate to capital issues by private companies. The introduction of both the CCP and the monitoring mechanism reduced the average interest rate for previously risky assets by 1.1 percentage points. All the repo market became safe.

Table 4 presents the main results of the panel data regression, run using a time span of 12 months for the calculation of historical volatility and liquidity. The complete table is shown in the Appendix. For robustness, I also present in the Appendix the results of regressions done by using different time spans (6 and 18 months). Main results do not change.

(Table 4 here)

The two variables having a statistically significant effect on the upwards part of the dispersion of rates are liquidity and volatility. Not surprisingly, more liquid assets were also considered as surer. Before the reform, having one more spot price published on the official list reduced by 0.166 percentage points the average repo rate. As expected, after the reform this variable is not anymore significant. There was no more difference between “safe” and “risky” assets.

The main explanatory variable with respect of upwards dispersion is risk, measured by the standard deviation of collateral asset’s price return (variable volatility). Volatility is calculated over the past twelve months. One standard deviation rise in volatility of collateral assets prices increases the rate by 11.7 percentage points over the whole period. This coefficient means that lenders used rates to protect themselves against counterparty risk in this tri-party-like repo market without haircuts, asking higher remuneration for higher risk. It is crucial to notice that the volatility variable has an even higher coefficient (13.4) before 1901, and loses its statistical significance afterwards.

Negative rates reflect a premium paid by investors to participate to capital issues or general assemblies of private companies. Negative rates are explained by capital issues (dummy variable issue, coefficient -11.4) and presence of a general assembly in the month following the settlement (dummy variable ga, coefficient -0.43). The premium paid to participate to a GA was therefore of the magnitude of half a rate.

That for being considered a stockholder and participate to the issue of new capital was extremely high (an 11.4 % rate on average, with peaks reaching 200%). An effect of this amplitude is explained by the custom of issuing new capital at face value or slightly below it. As an instance, in May 1888,

the *Crédit Foncier de France* issued 31 thousand new shares exclusively reserved to old stockholders. The issue rate was 500 francs (the face value of the stock), while the market price was around 1400 francs. The repo rate on the settlement of May 1888 reached a level of – 60%[34]. We can conclude that negative rates mainly reflected a premium paid by investors to participate to capital issues. It is crucial to notice that the reform had no effect with respect to negative rates.

The fourth column in Table 4 shows the results of the panel data regression run after adding the difference-in-differences estimator. The main coefficients estimated in the regression do not change. The interaction term, capturing the effect of the reform on those securities that were considered "risky" before the reform, is highly statistically significant and takes a value of -1.08. *Ceteris paribus*, the reform reduced the repo rates by 1.08 percentage points.

According to these metrics, the reorganization effectively decreased risk on the market. But what was the mechanism that reduced the dispersion of repo rates? According to the contemporary press, the introduction of joint liability (a CCP) among brokers reduced any incentive for the lender to ask for a particular collateral asset while investing on the repo market[35]. Before the reform, investors decided which securities to accept as collateral for their repos, demanding higher rates to be protected against higher collateral risk.

After the reorganization, lenders provided with cash their brokers, who in turn decided which collateral assets use for repo transactions[36]. Monetary conditions fully became the main determinant while negotiating repo loans. Lenders and borrowers started to think in terms of a unique monetary rate, instead of associating different rates to different securities. Particular negotiation conditions remained for highly demanded assets, those leading to negative rates, such as assets of companies issuing new stock or paying interests or dividends.

Risk was transferred from lenders to their brokers. Counterparty risk among brokers was not only managed through price adjustments, but mainly through careful selection of new agents de change, monitoring policy and moral suasion (Riva and White, 2011). Starting from 1901, the syndic imposed

[34] Other examples are the issues of new stocks by the *Société Foncière Lyonnaise* in November 1880 (issued at face value of 500 francs, market price around 600 francs, repo rate -50%) or by the *Banque de Paris et des Pays Bas* (*Paribas*) in June 1906. The stock was issued at 1350 francs while the market price was around 1600 francs. Repo rate is - 43.7%

[35] Le Temps, November 20th, 1899. The impact of joint liability legal sanction on clients' security perception is confirmed by François-Marsal (1933).

[36] As an instance, after the Agadir crisis in 1911, brokers called for banks' help to perform the settlement. In exchange for their services, banks wanted to have a voice over the choice of collateral assets, a practice 'abandoned since the beginning of the century'. The CAC denied this possibility. A-CAC, MCS, 20 September 1911.

to each agent to provide his deputies twice a year with precise information on the total amount of funds collected by their offices to be invested on the repo market[37].

The prescribed forms even distinguished between funds invested by bankers and those coming from simple customers. Information was usually provided every six months, but in case of crisis the accounts were controlled before and after the advent of the shock in order to carefully monitor the exposure of each broker. Monitoring among brokers was therefore strictly implemented, in particular within the repo market. This latter part of the reform was crucial in diminishing the perception of risk for investors.

These results are consistent with recent theory. First of all, the presence of a CCP involves that, in case of default of one of its members, losses will be distributed. This characteristic reduces the risk of disorderly liquidation of collateral (Oehmke, 2014). At the same time, it lowers the incentive for the lender to asking for higher protection in the form of higher interest rates for riskier collateral. Second, direct counterparty exposures were eliminated, and this in turn reduced incentives to run on borrowers, as predicted by Martin, Skeie, and von Thadden (2014). The reduced risk resulted in a lower general level of interest rates.

## 7. A side effect of the reform

The 1898 financial reorganization resulted in a leak out of volumes from the repo market. The design of the FTT payment mechanism provided financial institutions with an incentive to favor advances on securities to repos. Using original archival data, I find that volumes exchanged on the repo market decreased in favor of advances on securities granted by deposit banks to their clients.

The mechanism was the following. Private investors, attracted by competitive offers from deposit banks, withdrew their funds from the market and placed them in their banks accounts. Commercial banks, in turn, preferred to lend this additional cash against securities to private clients, instead of investing it in the repo market.

(Figure 6)

Figure 6 shows the volumes invested on the repo market in several years between 1898 and 1912. Sources are described in the Appendix. The blue column represents the total amount of funds invested on an end-of-month settlement, according to data availability. The orange column is the total amount invested by “clients” (non-banking institutions, mainly firms), while the grey column represent at each date the total amount invested by banks. The figure clearly shows that the strong reshaping of the repo market is mainly due to a reduction in the share of funds invested by

[37] A-CAC, MCS, 4 and 25 January 1901.

"individual" clients. Their part is 90% before the reform, in 1898, and fluctuates between 40 and 60% in the following period.

Where did clients money go? Remember that under the new regulatory regime, *coulissiers* and bankers had to pass through the intermediation of the *Parquet* for each transaction undertaken on listed securities. This measure meant that banks had to pay a commission fee plus the FTT for each repo transaction undertaken on a listed security. This measure was adopted to provide official brokers with a sort of compensation to the adoption of the CCP. The CCP in fact, centralizing risk, required them to be jointly responsible in case of distress experienced by one of them.

Deposit banks, starting from *Crédit Lyonnais*, the market leader, decided as a reaction to boost the market for advances on securities[38]. These instruments, called in French "*avances sur titres*", were not considered as stock market operations. Therefore, they were not subject to the FTT or to brokers' stamp duties (Allix, 1901). From a legal point of view, advances were different from repos as they were loans, not involving a double transfer of ownership. Moreover, they were usually granted for longer periods with respect to repos, usually two months[39]. Nonetheless, even if repos were initially done for a 15- or 30-days period, repo chains usually extended the period of the contract to several consecutive settlements.

From a practical point of view, the two contracts were ultimately very similar. Most bank balance sheets recorded advances and repos under the same account. The only difference from a practical point of view was that in the case of repos, banks were allowed to return other stocks than the ones they had purchased, while for advances it was the contrary. Lenders did not own the collateral asset during the period of the loan, so they were obliged to return the very same stock at maturity[40]. This difference had two consequences.

First, repo lenders could in theory dispose of the asset and use it for another loan, while advances lenders could not. Nonetheless, I have no evidence of re-hypothecation on French historical repo market. Indeed, usually lenders did not take direct possession of their assets and left them in deposit with their broker (Allix, 1901). As a second effect, banks applied haircuts to their advances, not being protected by full ownership rights over the collateral asset in case of default of the borrower. Haircuts depended on the category of the security. The presence of haircuts meant that banks did

[38] ACL, Circulaires Direction Générale. September 17th, 1901 ; June 3rd, 1902 ; November 29th, 1902.
[39] Crédit Lyonnais Archives, Circulaires Direction Générale. November 29th, 1902.
[40] M. Ullmann, Director of the Comptoir d'Escompte bank, 'Interviews on the Banking and Currency systems, National Monetary commission of the US Senate', p. 263.

not lend the whole market value of the collateral asset. In order to compensate for this "weakness", they offered lower rates with respect to those practiced on the repo market[41].

(Figure 7 here)

This type of facility, together with the widespread dissemination of deposit banks' branches in Paris and over the whole country, contributed to attract capital to banks and subtract it from the repo market and therefore the stock exchange. Figure 7 shows the total amount of advances granted against securities, the total amount of funds invested on the repo market, and the total amount of deposits at the 31/12 of each year from 1890 to 1913 in the balance sheets of the four main deposit banks plus the biggest financial institution specialized in short-term investment. The graph allows to assess the relative development of repos and advances on securities. Repos were progressively outnumbered by advances. The proportion became of 1:2.5 at the end of the period.

The banks are *Crédit Lyonnais*, *Société Générale*, *Comptoir d'Escompte* and *Crédit Industriel et Commercial*. The financial institution is the *Société Française des Reports et Dépôts* (SFRD), founded in 1881 and considered by contemporary authors as a serious institution. The figure represents the total amount of funds invested in repos and advances by these institutions (scale on the left), and the total deposits collected by these institutions (scale on the right, in blue). The sums of balance sheet items are calculated for December 31st of each year from 1890 to 1913. I personally hand-collected the data from a variety of sources, as it does not exist any complete series[42].

Crédit Lyonnais started only around 1898 to distinguish in its public statements between repos and advances, which were summed in a unique balance sheet item beforehand. I therefore used internal accounting documents to separate the two before 1898. Unfortunately, the series of internal documents only starts in 1890 and presents yearly data. Given that Crédit Lyonnais was by far the main single investor in the market, no interpolation from other banks' data is possible before 1890.

For the 1890-1913 period, the results are the following. Since 1890 and until 1897, the rate of growth of repos and advances is comparable to that of deposits. Starting from the 1898 reform, advances overtake repos, a tendency that becomes even more marked in the first decade of the 20th century, once the reform was fully implemented. In 1898, each month's "place position" amounted to 3

[41] Crédit Lyonnais Archives, Circulaires Direction Générale. 29 November 1902.

[42] I entered and cross-checked data coming from Crédit Lyonnais Archives (129 AH 28 and the series 31 AH 85 to 31 AH 310), published on the newspapers l'Economiste Français and Cote de la Bourse et de la Banque, as well as those communicated to stockholders of SFRD, Comptoir d'Escompte and Crédit Lyonnais in the circumstance of annual general assemblies.

billion francs on the *Parquet* alone[43]. In September 1911, just before the so-called Agadir crisis, the amount was reduced by a half: 1.4 to 1.6 billion francs according to different sources[44].

The reduction in volumes exchanged on the repo market is consistent with the tendency observed by the contemporary press, according to which by 1911 "the key regulator of the stock exchange [was] not anymore the forward market. The majority of business [was] done on spot transactions[45]". By 1914, volumes in the repo market had fallen even further. The "place position" at the end of July settlement in 1914 was some 600 million francs on the *Parquet*, plus 150 million francs at the *Coulisse*[46].

Advances investments by banks grew. Repo investments by banks remained stable. Repo total volumes decreased. The missing repo market volumes come from simple clients, capital investors that were not financial institutions. In 1898, these "individual investors" participated with 90% of the total funds supplied on the repo market (Charousset, 1898). In June 1911, according to my own estimates, they represented 53% of the market. I estimate this figure by exploiting data on 56 brokers (80% of the population) coming from the accounts entries verifications of brokers introduced by the syndic in 1900[47].

Clients' money did not vanish, though. Banks took possession of it, as shown by the increase in deposits displayed in Figure 6. Therefore, the reform stabilized and made the market surer, but resulted also in the spillover of some volume to a less regulated market. At that time, the banking market was much less regulated than the stock market. The only regulation applied was the general commercial law applied to any limited liability company. No specific law regulated the banking system.

[43] See Charousset (1898) and Allix (1901).
[44] The first figure is given by the CAC's *syndic* two months after the crisis (A-CAC, MCS, 11 November 1912). The second by the 1915's Finance Minister, Alexandre Ribot. (Intervention of Mr. Ribot at the *Assemblée Nationale*, in response to the interrogation of Mr. Monzie, on September 23rd, 1915).
[45] L'année financière du Temps, 1 January 1912.
[46] See Giraud (1918), as well as Vidal (1919).
[47] *Vérifications d'écritures*, conserved at CAC archives, CAEF. Description of the source and the estimation method is provided in the Appendix.

## 8. Conclusion

In this paper, I study the introduction of a central clearing party in the French historical repo market at the beginning of the Twentieth century. I find that this measure strongly reduced risk on the market, by reducing net exposures for market participants, by providing a prime counterparty and by effectively monitoring the CCP members. As a result, between 1895 and the beginning of WW1 no major crisis hit the Paris market. The repo market was resilient to the 1907 international crisis, in spite of its large size.

With respect to the current debate dealing with the introduction of a repo CCP in the US, however, some caveats must be highlighted. First of all, introducing a CCP involves transferring credit, liquidity and operational risk from market participants (banks and dealers) to CCPs. This shift implies that CCPs could themselves become sources of systemic risk. A way to moderate this type of risk consists in the implementation of supervision and monitoring practices over CCP clearing members.

Historical evidences shows that if monitoring and screening procedures are not implemented CCPs can fail, with potentially disruptive consequences upon their members (Bignon and Vuillemey, 2017). The historical case presented in this article provides an example of a CCP that successfully managed counterparty risk and fought moral hazard among its members. The introduction of a monitoring mechanism was indeed the key event drastically reducing risk on the market.

Second, a greater use of CCPs implies a higher collective reliance on a limited range of risk management techniques. The consequent synchronization of reactions to bad news can generate pro-cyclical shocks to the financial system. As an instance, CCPs demanded higher haircuts on riskier sovereign bonds during the 2011 debt crisis. Aggressive haircutting likely contributed in worsening trading conditions for Greek, Irish, Italian, Portuguese and Spanish bonds. Moreover, recent literature studying the same crisis finds that CCPs work well in times of moderate stress, but appear to be less effective in case of greater shocks (Boissel, Derrien, Ors, and Thesmar, 2017). Once again, the key point is how risk is managed inside CCPs and among its participants.

Finally, as documented in this paper, new regulation often introduces frictions. Frictions can reduce liquidity and eventually incentivize the development of opaquer and less regulated markets. In particular, the 1898 French reform resulted in the leak out of some volume from the repo market to the banking market, which at the time was subject to less regulation. In order to avoid such spillovers, any introduction of a repo CCP should be designed to attract new clients by offering competitive services or fees.

## Primary sources

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## Figures and tables

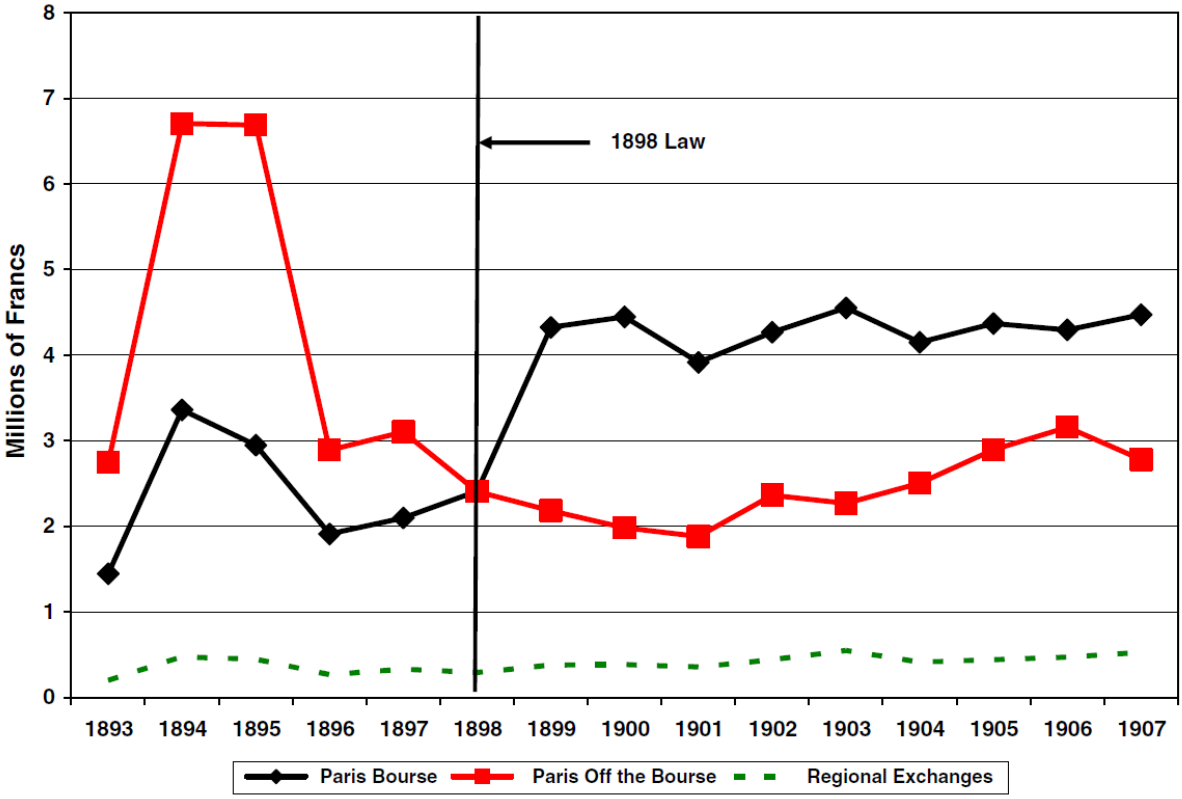
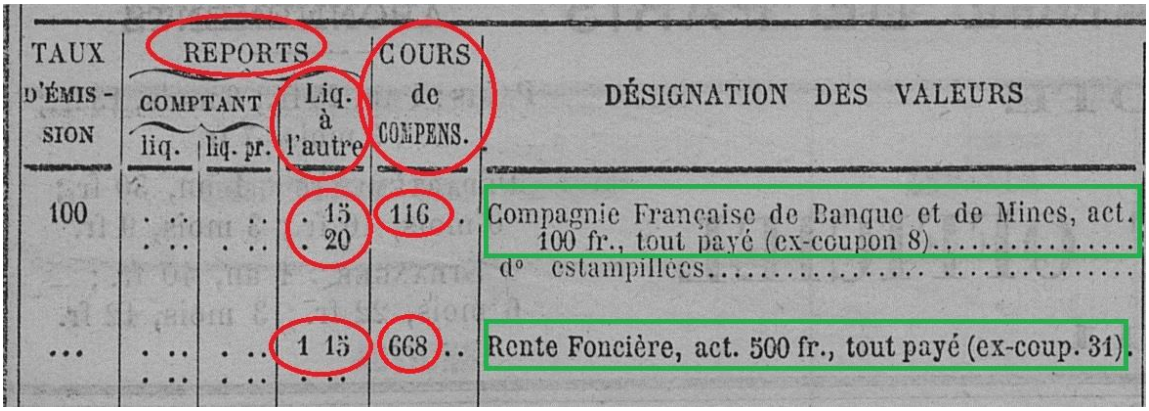



*Figure 1 – Annual stamp duties paid on securities transactions, 1893-1907. Source: Riva and White, Danger on the Exchange, from data published on the Bulletin de Statistique et Legislation Comparées.*



| TAUX D'ÉMISSION | REPORTS COMPTANT liq. | REPORTS COMPTANT liq. pr. | REPORTS Liq. à l'autre | COURS de COMPENS. | DÉSIGNATION DES VALEURS |
|---|---|---|---|---|---|
| 100 | . .. | .. | . 15 | 116 . | Compagnie Française de Banque et de Mines, act. 100 fr., tout payé (ex-coupon 8)..... |
| | . .. | . .. | . 20 | | d° estampillées..... ..... |
| ... | . .. | . .. | 1 15 | 668 .. | Rente Foncière, act. 500 fr., tout payé (ex-coup. 31). |
| | . .. | . .. | . .. | | |

*Figure 2 - Extract of the page 2 of Paris Stock Exchange Official List, January 31st, 1911. Courtesy of Equipex DFIH. DFIH database (Paris School of Economics), version May 2017. (Hautcoeur and Riva, The Data for Financial History).*

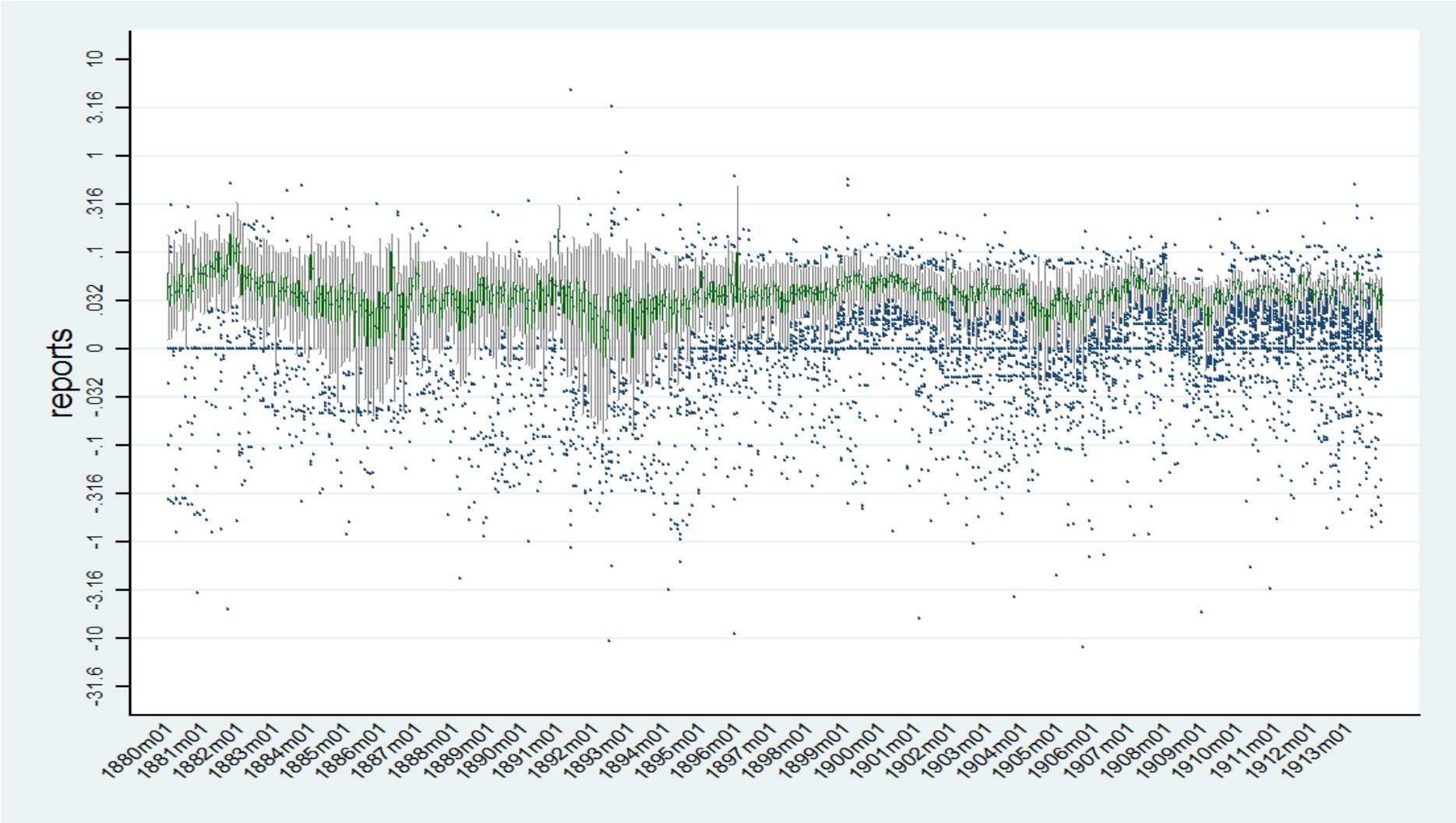



*Figure 3 - Tukey box plot. In green, for each end-of-the-month settlement, the range including the reports rates between the first and third quartile (the 50 % central rates). In grey, the two ranges obtained starting from the two quartiles and then adding ±1,5 IQR. In blue, outliers. On the ordinate axis, logarithmic scale. Legend of Y axis shows actual interest rates (.032 = 3.2%; .316=31.6%). Source : my elaboration from data published on Paris Stock Exchange Official Lists, 1880-1913, and collected partly by me and partly in the context of Equipex DFIH. DFIH database (Paris School of Economics), version May 2017. (Hautcoeur and Riva, The Data for Financial History).*

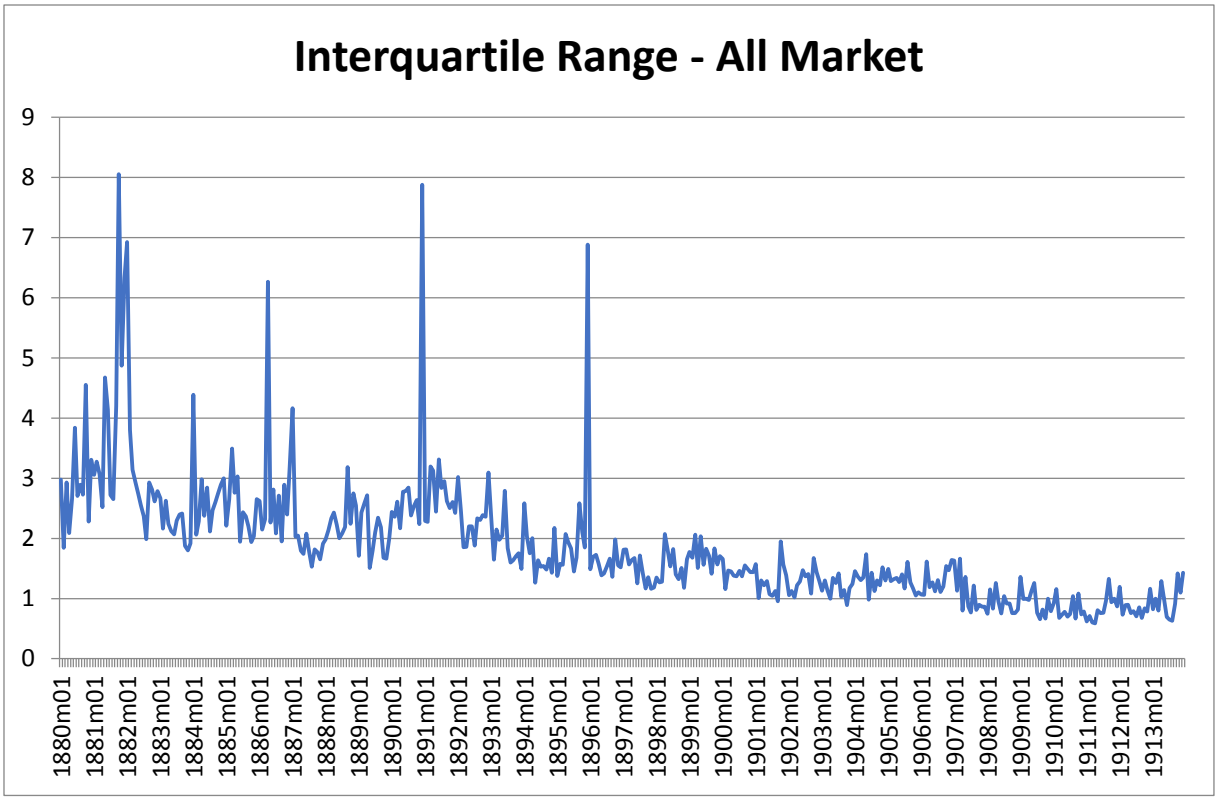



*Figure 4 - Dispersion of repo rates measured by the Interquartile Range (IQR). The IQR or H-spread is equal to the difference of 75th and 25th percentiles. All repo rates done at each end-of-month settlement from January 1880 to 1913 are included in the calculations. Source: my calculations from data published on the Paris Stock Exchange Official Lists.*

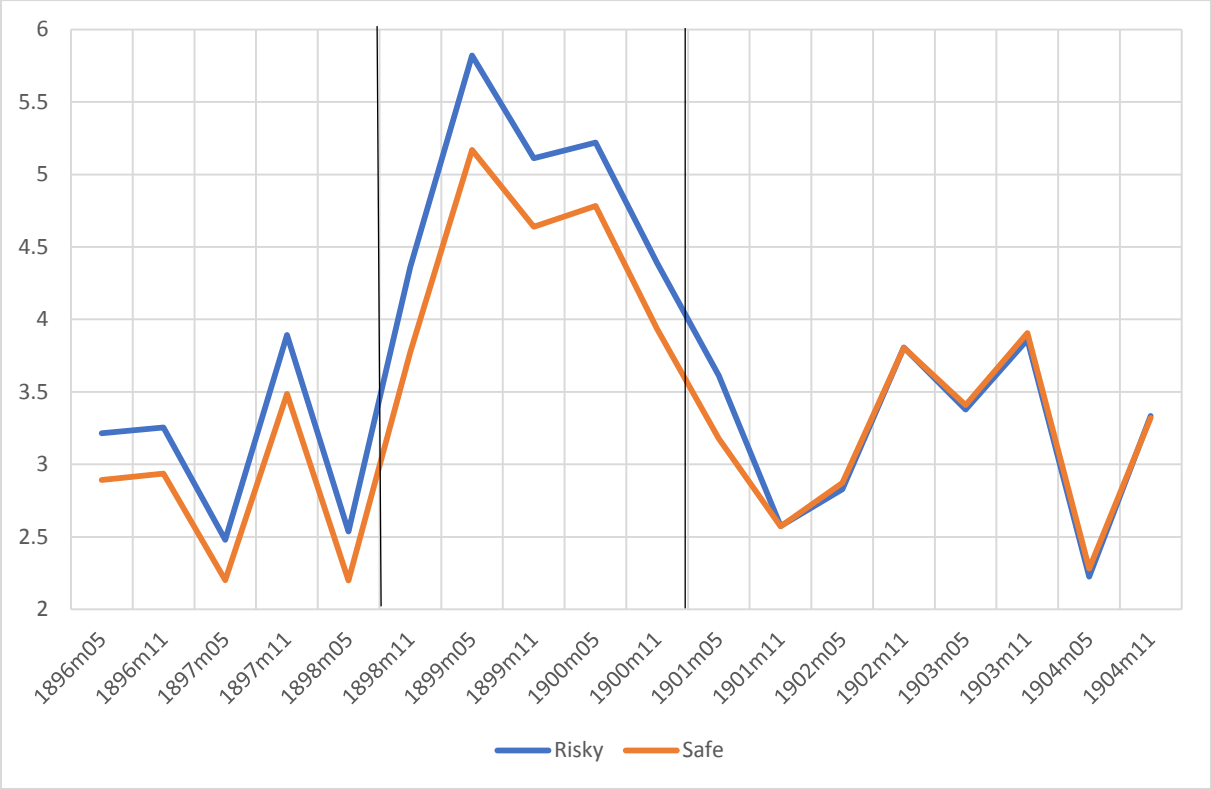



*Figure 5 - Risky and safe rates done on the repo market, 1896-1904. Source: my elaboration from data published on Paris Stock Exchange Official Lists.*

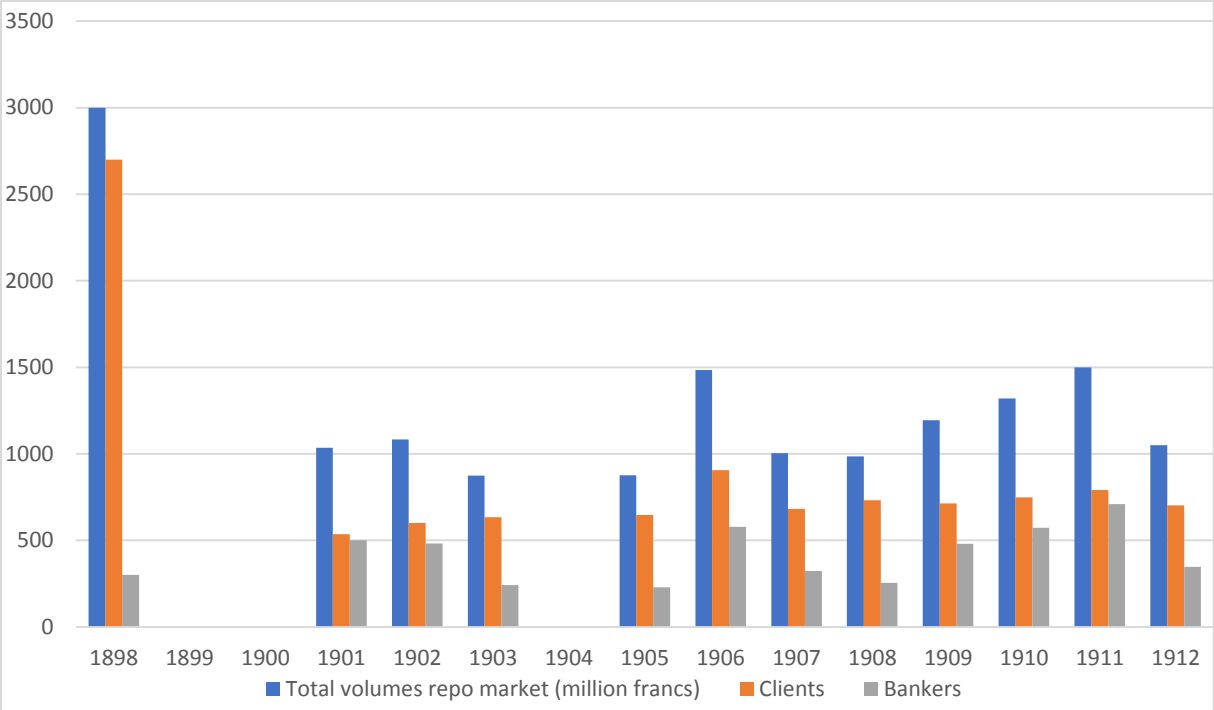



*Figure 6 - Funds invested on official repo market, 1898-1912. Sources: Charousset (1899) for 1898. Accounting verifications (CAC archives) for 1901-1912 (excluding 1906). Internal study by CAC for 1906.*

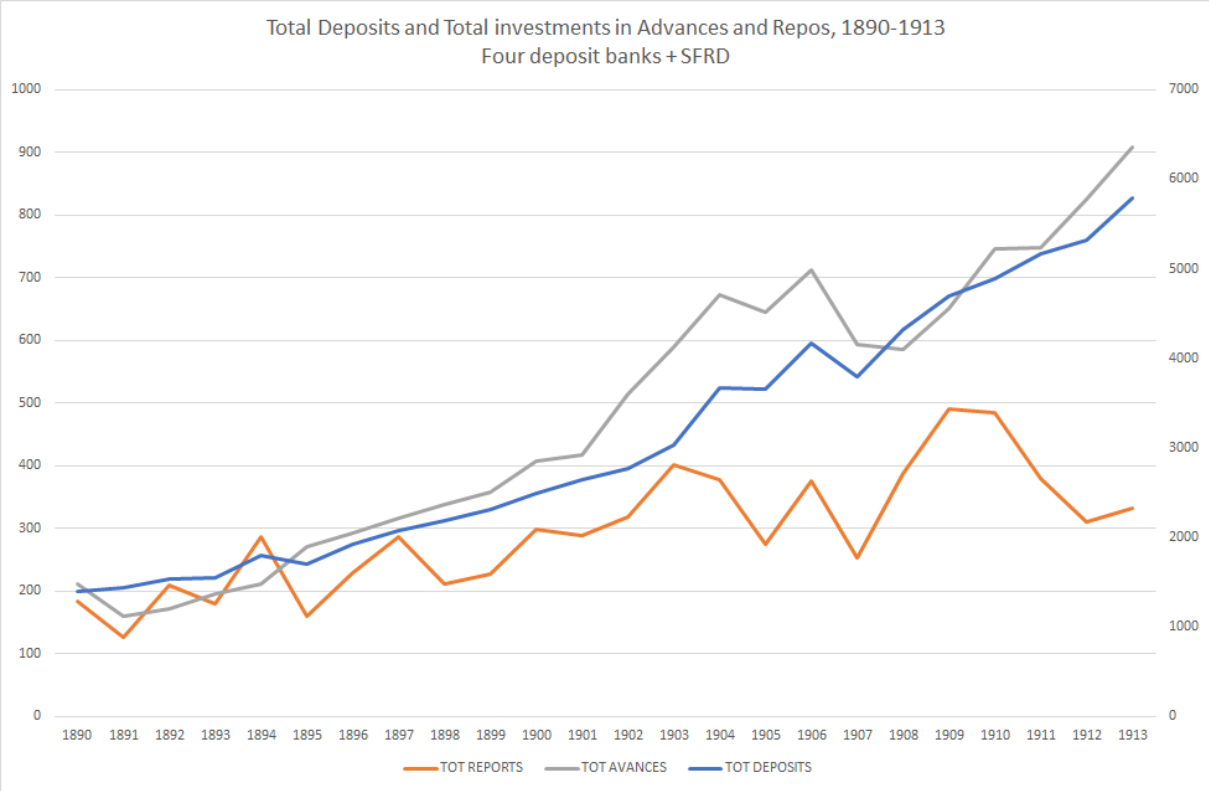



*Figure 7 - Total amount of funds invested in repos and advances, and total amount of deposits (scale on the right), by the four main investment banks and a firm specialized in short-term investment. Balance sheets data from December 31st of each year from 1890 to 1913. Source: author's DB.*

| Type of security/issuer | 1880 | 1885 | 1890 | 1895 | 1900 | 1905 | 1910 |
|---|---|---|---|---|---|---|---|
| French private stocks | 40 | 40 | 50 | 44 | 58 | 65 | 75 |
| | 57,97% | 53,33% | 51,55% | 31,21% | 31,52% | 32,83% | 28,09% |
| French public bonds | 3 | 4 | 3 | 6 | 8 | 8 | 7 |
| | 4,35% | 5,33% | 3,09% | 4,26% | 4,35% | 4,04% | 2,62% |
| French private bonds | 4 | 3 | 2 | 8 | 13 | 11 | 17 |
| | 5,80% | 4,00% | 2,06% | 5,67% | 7,07% | 5,56% | 6,37% |
| Foreign private stocks | 12 | 18 | 17 | 20 | 33 | 43 | 58 |
| | 17,39% | 24,00% | 17,53% | 14,18% | 17,93% | 21,72% | 21,72% |
| Foreign public bonds | 10 | 10 | 25 | 41 | 50 | 54 | 79 |
| | 14,49% | 13,33% | 25,77% | 29,08% | 27,17% | 27,27% | 29,59% |
| Foreign private bonds | 0 | 0 | 0 | 22 | 22 | 17 | 31 |
| | 0,00% | 0,00% | 0,00% | 15,60% | 11,96% | 8,59% | 11,61% |
| **TOTAL** | **69** | **75** | **97** | **141** | **184** | **198** | **267** |

*Table 1 – Number of securities used in at least one repo transaction done on the Parquet on the 31/12 settlement, by type of collateral. Source: Data collected by the author on Paris stock exchange official lists, and integrated with information coming from DFIH database, version May 2017 (Hautcoeur and Riva, The Data for Financial History).*

| Type of security | 1906 | 1914 |
|---|---|---|
| French perpetual bonds | 5.39% | 9.41% |
| French shares and bonds | 27.45% | - |
| Foreign public bonds | 31.08% | - |
| Foreign shares and bonds | 36.08% | - |
| French bonds, very good quality | - | 1.35% |
| French shares, very good quality | - | 5.41% |
| Public and private foreign bonds, good quality | - | 18.89% |
| Industrial shares, good quality | - | 27.71% |
| Overpriced industrial shares | - | 34.16% |
| Bad or very bad industrial shares | - | 3.06% |
| Total | 100% | 100% |

*Table 2 – Shares of volumes invested in the Paris repo market, by type of collateral asset. Sources: Figures for 1906 come from A-CAC, B-0064877/1,'L'Impôt sur les operations de bourse'. Figures for 1914 come from A-BDF, 1069200401/147, 'Note de la CAC concernant la liquidation de Juillet 1914, July 7, 1914'.*

| | | | | | | |
|---|---|---|---|---|---|---|
| French government bonds | 3 | 1 089 | 2.29 | 1.56 | -5.22 | 9.92 |
| French banks, stocks | 7 | 2 493 | 3.48 | 2.93 | -72.33 | 27.54 |
| French banks, bonds | 2 | 147 | 4.02 | 1.22 | 0.03 | 8.86 |
| French railways, stocks | 6 | 2 280 | 3.37 | 1.83 | -8.79 | 12.47 |
| French railways, bonds | 4 | 635 | 3.91 | 1.05 | 0 | 7.23 |
| Other French securities | 6 | 1 925 | 3.91 | 2.02 | -225 | 30.76 |
| Foreign government bonds | 8 | 2 560 | 3.13 | 1.91 | -11.34 | 61.78 |
| Foreign banks, stocks | 4 | 1 406 | 2.65 | 1.61 | -61.54 | 15.61 |
| Foreign railways, stocks | 5 | 1 718 | 4.27 | 2.29 | -20 | 27.43 |
| Foreign railways, bonds | 4 | 933 | 4.01 | 1.53 | -11.11 | 7.69 |
| Total French | 28 | 8 569 | 3.42 | 2.19 | -225 | 30.77 |
| Total Foreign | 21 | 6 617 | 3.42 | 2.12 | -61.53 | 61.78 |
| TOT | 49 | 15 186 | 3.42 | 2.16 | -225 | 61.78 |

*Table 3 -Descriptive statistics – Collateral assets composing the portfolio. Source: my DB.*

| | | | |
|---|---|---|---|
| Multiple breakpoint tests | | | |
| Bai-Perron tests of L+1 vs. L sequentially determined breaks | | | |
| Sample: 1880M01 1913M12 | | | |
| Included observations: 408 | | | |
| Breaking variables: C | | | |
| Break test options: Trimming 0.05, Max. breaks 5, Sig. level 0.05 | | | |
| Allow heterogeneous error distributions across breaks | | | |
| Sequential F-statistic determined breaks: | | | 4 |
| Break Test | F-statistic | Scaled F-statistic | Critical Value** |
| | | | |
| 0 vs. 1 * | 291.3758 | 291.3758 | 9.63 |
| 1 vs. 2 * | 254.2529 | 254.2529 | 11.14 |
| 2 vs. 3 * | 48.68823 | 48.68823 | 12.16 |
| 3 vs. 4 * | 19.25702 | 19.25702 | 12.83 |
| 4 vs. 5 | 9.397443 | 9.397443 | 13.45 |
| | | | |
| * Significant at the 0.05 level. | | | |
| ** Bai-Perron (Econometric Journal, 2003) critical values. | | | |
| | | | |
| Break dates: | | | |
| | Sequential | Repartition | |
| 1 | 1896M01 | 1882M04 | |
| 2 | 1907M04 | 1896M01 | |
| 3 | 1901M02 | 1901M02 | |
| 4 | 1882M04 | 1907M04 | |

*Table 4 – Multiple breakpoint test. Bai-Perron tests of L+1 vs. L sequentially determined breaks. Indicated date is the first settlement of new regime.*

| | 1880-1900 | 1901-1913 | 1880-1913 | diff-in-diff |
|---|---|---|---|---|
| | b/se | b/se | b/se | b/se |
| liquidity | -0.166*** | -0.209 | -0.107* | -0.069* |
| | (0.04) | (0.22) | (0.05) | (0.03) |
| volatility | 13.387*** | -1.286 | 11.741*** | 13.193*** |
| | (3.62) | (1.82) | (2.90) | (3.07) |
| general assembly | -0.500 | -0.369** | -0.435* | -0.445* |
| | (0.30) | (0.13) | (0.20) | (0.20) |
| issue | -6.054* | -21.943* | -11.382* | -11.460* |
| | (2.62) | (10.61) | (4.30) | (4.32) |
| risky group | | | | 0.480* |
| | | | | (0.24) |
| post reform | | | | 0.670* |
| | | | | (0.28) |
| interaction term | | | | -1.084*** |
| | | | | (0.19) |
| Cross-section fixed-effects | YES | YES | YES | NO |
| Cluster fixed-effects | NO | NO | NO | YES |
| Time fixed-effects | YES | YES | YES | NO |
| Months dummies | NO | NO | NO | YES |
| Years dummies | NO | NO | NO | YES |
| constant | 0.094 | 0.574 | 0.061 | -0.563 |
| | (0.31) | (0.53) | (0.23) | (0.33) |
| Within R2 | 0.168 | 0.169 | 0.120 | |
| R2 | | | | 0.142 |
| Obs | 5647 | 2817 | 8464 | 8464 |

*Table4 – Panel regressions results. Standard errors in parentheses. Standard errors calculated according to Driscoll and Kraay's (1998) methodology.*

## Appendix

### Data description – Macroeconomic variables

Number and level of spot prices for collateral assets come from the DFIH Database. The Data for Financial History DB is a long-run stock exchange database containing comprehensive quantitative and qualitative information on Parisian stock markets from 1795 to 1951. (Ducros et al., 2017a ; Ducros et al., 2017b).

The discount interest rate of BoF is to be found in the NBER Macrohistory DB, series m13014. The central bank's advances rate was usually kept above the discount rate by one half or one percentage point. As a consequence, it is not useful to add it as a variable, as the discount rate itself is enough.

The Paris open market rate was published by *The Economist* in London. It was the lower bound of French interest rates, since only the main Parisian banks could trade on this market certain kinds of the best paper (White, 1978). As such, this rate was structurally lower than the discount rate of the *Banque de France*, except for times of crisis. It is commonly used in the literature as representative of the Paris money market[48]. This rate is to be found in the NBER Macrohistory DB, series m13017.

I use the series of imports as a proxy for aggregate demand following Bordo and MacDonald (2005). Imports were published by the *Bulletin de Statistique et Legislation Comparée* and are available on NBER Macrohistory DB, series m07027. Nonetheless, the imports series incorporate a foreign supply dimension. Therefore, I use a quarterly series of railways revenues in order to check for robustness. The railways series has been constructed by Bazot, Bordo, and Monnet (2016) and is available as a supplementary material to their article. There is a vast literature using railways revenues as an indicator of economic activity during the Gold Standard, in both UK and Germany[49]. Moreover, Bazot, Bordo, and Monnet (2016) show that their series has a strong correlation with annual series of French activity.

Finally, I use monthly data on the BdF's bills portfolio and advances on securities as indicators of the monetary policy. Weekly data on the balance sheet of the BdF from 1898 onwards were collected by Patrice Baubeau and are available online on the BdF's website. Monthly data for 1890-1897 come from Bazot, Bordo, and Monnet's (2016) database.

[48] For instance, by Flandreau and Sicsic (2003), Riva and White (2011), Bazot, Bordo, and Monnet (2016).
[49] See for instance Goodhart (1972), Jeanne (1995), Bordo and McDonald (2005).

### Settlement Prices (*Cours de compensation*)

Settlement prices were used to clear all forward contracts, not only repo transactions. They were created to balance out different forward orders placed at different prices for the same security. In the time span between a settlement and the following, that usually lasted 15 days, *agents de change* collected sale and purchase orders by their clients. Forward prices changed day by day. Let us remember that all orders were centralized by the *agents*. Therefore, brokers found themselves with opposite orders placed at different prices, among their own customers and among customers of their colleagues.

On the settlement day, brokers had to clear the market for each asset. The only way to do so in an orderly fashion was to fix one price for each security and use it as the reference price. The price was decided by the *Chambre Syndicale* (the governing body of the CAC) on the basis of the last actual transactions undertaken on that asset. It could be the average price calculated over the settlement day, or the first price done. This price was used to compensate orders among brokers. On the other hand, it was not applied to clients. Their transactions with brokers were settled at the order price.

In the repo market, settlement prices were used to fix the market value of each security. In case of repo chains, when a forward position was rolled over from a settlement to the following, the settlement price of the collateral asset worked as the reference price over which the interest rate was calculated. In case of a new repurchase agreement, coupling a sale on the spot market with a repurchase on the forward market, settlement prices were the spot market prices used as a reference for repo spot sales.

## Estimation of volumes on the repo market

Data on volumes come from the accounts entries verifications of Parisian brokers. Starting from the January, 1901, the syndic (the head of the CAC) asked each agent de change to provide to his deputies precise information on the total amount of the funds invested in *reports* by their offices. This piece of information had to be supplied once or twice a year, depending on the occurrence of special events. The syndic, Maurice de Verneuil, had put in place this practice as a mean to control his fellows and reduce moral hazard. Brokers had to indicate whether funds invested on the repo market came from banks (*banquiers*) or other clients (*clients*).

Unfortunately, archives are incomplete, and this piece of information is not always available for each agent's file and for each date. For some cases, information on the total amounts is there but without any date. Nonetheless, for 10 dates I have information on 70% or more of the Parisian brokers. I discarded all dates for which I have information on less than 70% of the agents de change.

Using these data, I compute estimates of the total funds invested on reports market on the Parquet for each of the 15 dates. The idea at the basis of the procedure is that of respecting as much as possible the distribution of the volumes across agents de change. At the end of the procedure, I have 70 observations for each date, composed by the original sample and by randomly selected observations to fill the missing data.

The method I use is the following. First, I plot the distribution of the volumes by broker, for each of the 10 retained dates. Figure 9 is an example of such a plot, based on data for end of December, 1907. Funds employed by each agent's office were far to be normally distributed. Therefore, it makes no sense to multiply the sample mean on each date by 70 (the total number of brokers) in order to obtain the total amount invested in the market.

Second, using the Epanechnikov (1969) method, I determine the smoothing bandwidth of the kernel-density (Parzen-Rosenblatt) distribution for each date. Third, for each date I split the original sample into groups according to the bandwidth. Fourth, I let a statistical software randomly select n observations from the sample, respecting the relative weight of each group, where n = 70 – (dimension of the original sample).

Using these data, I can calculate the proportion between funds invested by banks and other clients on the Parquet. As an instance, clients invested for 460 million francs on the Parquet on the end of June settlement of 1911. The total amount invested by banks was of 412 million francs. The proportion is therefore 53:47. The sum of the two amounts gives a total of 872 million francs. This figure is a strong reduction with respect to Charousset's (1898) estimates on 1898 (3 billion francs).

Appendix Figures and Tables

| Variable | | Driscoll-Kraay's Standard Errors | | | | Robust Standard Errors | | | | Bootstrap Standard Errors | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1880-1900 | 1901-1913 | 1880-1913 | diff-in-diff | 1880-1900 | 1901-1913 | 1880-1913 | diff-in-diff | 1880-1900 | 1901-1913 | 1880-1913 | diff-in-diff |
| interbank rate | 2.531*** | 0.856*** | 1.478*** | 1.477*** | 2.531*** | 0.856*** | 1.478*** | 1.477*** | 2.531*** | 0.856*** | 1.478*** | 1.477*** |
| | (0.44) | (0.19) | (0.31) | (0.30) | (0.20) | (0.18) | (0.13) | (0.15) | (0.23) | (0.14) | (0.12) | (0.11) |
| bdf rate | -1.378*** | -1.109* | -0.608 | -0.577 | -1.378*** | -1.109*** | -0.608** | -0.577** | -1.378*** | -1.109*** | -0.608*** | -0.577** |
| | (0.37) | (0.46) | (0.35) | (0.39) | (0.22) | (0.27) | (0.17) | (0.21) | (0.21) | (0.27) | (0.17) | (0.22) |
| cac 40 | 0.100 | 0.043 | 0.110 | 0.107 | 0.100* | 0.043 | 0.110** | 0.107** | 0.100** | 0.043 | 0.110*** | 0.107** |
| | (0.08) | (0.08) | (0.08) | (0.08) | (0.04) | (0.06) | (0.04) | (0.04) | (0.04) | (0.06) | (0.03) | (0.04) |
| corporate bonds | -0.260 | -0.092 | -0.333* | -0.345* | -0.260** | -0.092 | -0.333*** | -0.345*** | -0.260*** | -0.092 | -0.333*** | -0.345*** |
| | (0.19) | (0.14) | (0.15) | (0.16) | (0.08) | (0.17) | (0.06) | (0.06) | (0.07) | (0.16) | (0.05) | (0.06) |
| imports | -0.011 | -0.027 | -0.014 | -0.015 | -0.011*** | -0.027 | -0.014*** | -0.015*** | -0.011*** | -0.027 | -0.014*** | -0.015*** |
| | (0.01) | (0.02) | (0.01) | (0.01) | (0.00) | (0.02) | (0.00) | (0.00) | (0.00) | (0.02) | (0.00) | (0.00) |
| bdf credit | -0.050 | 2.833 | 1.582 | 1.625 | -0.050 | 2.833 | 1.582* | 1.625* | -0.050 | 2.833 | 1.582* | 1.625* |
| | (1.76) | (2.27) | (1.53) | (1.53) | (0.67) | (1.88) | (0.75) | (0.77) | (0.60) | (1.61) | (0.74) | (0.71) |
| asset returns | 0.022 | 0.627 | 0.120 | 0.119 | 0.022 | 0.627 | 0.120 | 0.119 | 0.022 | 0.627 | 0.120 | 0.119 |
| | (0.03) | (0.55) | (0.10) | (0.10) | (0.05) | (0.58) | (0.10) | (0.11) | (0.04) | (0.65) | (0.10) | (0.12) |
| forward | 0.007 | -0.563 | -0.086 | -0.084 | 0.007 | -0.563 | -0.086 | -0.084 | 0.007 | -0.563 | -0.086 | -0.084 |
| | (0.03) | (0.50) | (0.08) | (0.09) | (0.05) | (0.53) | (0.08) | (0.09) | (0.05) | (0.60) | (0.08) | (0.10) |
| liquidity | -0.166*** | -0.209 | -0.107* | -0.069* | -0.166*** | -0.209 | -0.107 | -0.069 | -0.166** | -0.209 | -0.107 | -0.069 |
| | (0.04) | (0.22) | (0.05) | (0.03) | (0.04) | (0.23) | (0.06) | (0.06) | (0.05) | (0.23) | (0.06) | (0.07) |
| volatility | 13.387*** | -1.286 | 11.741*** | 13.193*** | 13.387*** | -1.286 | 11.741** | 13.193*** | 13.387*** | -1.286 | 11.741** | 13.193** |
| | (3.62) | (1.82) | (2.90) | (3.07) | (3.35) | (1.19) | (3.50) | (3.90) | (3.59) | (4.24) | (3.88) | (4.30) |
| intdiv | -0.099 | -0.098 | -0.095 | -0.092 | -0.099 | -0.098 | -0.095 | -0.092 | -0.099 | -0.098 | -0.095 | -0.092 |
| | (0.11) | (0.16) | (0.08) | (0.08) | (0.13) | (0.15) | (0.11) | (0.11) | (0.15) | (0.18) | (0.09) | (0.12) |
| general assembly | -0.500 | -0.369** | -0.435* | -0.445* | -0.500 | -0.369* | -0.435 | -0.445* | -0.500 | -0.369 | -0.435* | -0.445 |
| | (0.30) | (0.13) | (0.20) | (0.20) | (0.31) | (0.18) | (0.23) | (0.22) | (0.35) | (0.20) | (0.22) | (0.23) |
| issue | -6.054* | -21.943* | -11.382* | -11.460* | -6.054 | -21.943* | -11.382* | -11.460* | -6.054 | -21.943* | -11.382** | -11.460 |
| | (2.62) | (10.61) | (4.30) | (4.32) | (3.22) | (10.07) | (5.13) | (5.13) | (3.66) | (10.77) | (4.27) | (6.48) |
| variable | | | | -0.352 | | | | -0.352 | | | | -0.352 |
| | | | | (0.22) | | | | (0.28) | | | | (0.33) |
| Private | | | | 0.189 | | | | 0.189 | | | | 0.189 |
| | | | | (0.33) | | | | (0.78) | | | | (0.87) |
| | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| semipublic | | | | 0.213 | | | | 0.213 | | | | 0.213 |
| | | | | (0.27) | | | | (0.51) | | | | (0.75) |
| Bank | | | | 0.155 | | | | 0.155 | | | | 0.155 |
| | | | | (0.21) | | | | (0.42) | | | | (0.67) |
| Railway | | | | 0.673*** | | | | 0.673 | | | | 0.673 |
| | | | | (0.17) | | | | (0.46) | | | | (0.70) |
| Foreign | | | | 0.207 | | | | 0.207 | | | | 0.207 |
| | | | | (0.19) | | | | (0.52) | | | | (0.57) |
| risky group | | | | 0.480* | | | | 0.480 | | | | 0.480 |
| | | | | (0.24) | | | | (0.59) | | | | (0.62) |
| post reform | | | | 0.670* | | | | 0.670** | | | | 0.670* |
| | | | | (0.28) | | | | (0.21) | | | | (0.27) |
| interaction term | | | | -1.084*** | | | | -1.084*** | | | | -1.084*** |
| | | | | (0.19) | | | | (0.28) | | | | (0.29) |
| Cross-section fixed-effects | YES | YES | YES | NO | YES | YES | YES | NO | YES | YES | YES | NO |
| Cluster fixed-effects | NO | NO | NO | YES | NO | NO | NO | YES | NO | NO | NO | YES |
| Time fixed-effects | YES | YES | YES | NO | YES | YES | YES | NO | YES | YES | YES | NO |
| Months dummies | NO | NO | NO | YES | NO | NO | NO | YES | NO | NO | NO | YES |
| Years dummies | NO | NO | NO | YES | NO | NO | NO | YES | NO | NO | NO | YES |
| constant | 0.094 | 0.574 | 0.061 | -0.563 | 0.094 | 0.574 | 0.061 | -0.563 | 0.094 | 0.574 | 0.061 | -0.563 |
| | (0.31) | (0.53) | (0.23) | (0.33) | (0.18) | (0.58) | (0.21) | (0.38) | (0.17) | (0.51) | (0.22) | (0.42) |
| Within R2 | 0.168 | 0.169 | 0.120 | | 0.168 | 0.169 | 0.120 | | 0.168 | 0.169 | 0.120 | |
| R2 | | | | 0.142 | | | | 0.123 | | | | 0.123 |
| Obs | 5647 | 2817 | 8464 | 8464 | 5647 | 2817 | 8464 | 8464 | 5647 | 2817 | 8464 | 8464 |

*Table 4 - Panel regressions results. Standard errors in parentheses. Standard errors calculated using 1) Driscoll and Kraay's (1998) methodology; 2) Robust estimate of variance (Huber 1967, White 1980 and 1982; 3) Bootstrap methodology.*

| Variable | | 12 months | | | | 6 months | | | | 18 months | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | b/se | b/se | b/se | b/se | b/se | b/se | b/se | b/se | b/se | b/se | b/se | b/se |
| interbank rate | 2.531*** | 0.856*** | 1.478*** | 1.477*** | 2.578*** | 0.869*** | 1.488*** | 1.478*** | 2.505*** | 0.850*** | 1.474*** | 1.474*** |
| | (0.44) | (0.19) | (0.31) | (0.30) | (0.43) | (0.19) | (0.31) | (0.30) | (0.45) | (0.18) | (0.32) | (0.30) |
| bdf rate | -1.378*** | -1.109* | -0.608 | -0.577 | -1.449*** | -1.118* | -0.627 | -0.588 | -1.338*** | -1.044* | -0.599 | -0.566 |
| | (0.37) | (0.46) | (0.35) | (0.39) | (0.37) | (0.46) | (0.36) | (0.39) | (0.38) | (0.46) | (0.36) | (0.40) |
| cac 40 | 0.100 | 0.043 | 0.110 | 0.107 | 0.099 | 0.039 | 0.111 | 0.107 | 0.096 | 0.038 | 0.108 | 0.104 |
| | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) |
| corporate bonds | -0.260 | -0.092 | -0.333* | -0.345* | -0.260 | -0.093 | -0.343* | -0.355* | -0.255 | -0.084 | -0.336* | -0.350* |
| | (0.19) | (0.14) | (0.15) | (0.16) | (0.19) | (0.14) | (0.15) | (0.16) | (0.19) | (0.15) | (0.15) | (0.16) |
| imports | -0.011 | -0.027 | -0.014 | -0.015 | -0.011 | -0.028 | -0.014 | -0.015 | -0.011 | -0.027 | -0.014 | -0.015 |
| | (0.01) | (0.02) | (0.01) | (0.01) | (0.01) | (0.02) | (0.01) | (0.01) | (0.01) | (0.02) | (0.01) | (0.01) |
| bdf credit | -0.050 | 2.833 | 1.582 | 1.625 | -0.130 | 2.775 | 1.535 | 1.586 | -0.046 | 2.848 | 1.563 | 1.611 |
| | (1.76) | (2.27) | (1.53) | (1.53) | (1.75) | (2.24) | (1.53) | (1.54) | (1.75) | (2.23) | (1.52) | (1.53) |
| asset returns | 0.022 | 0.627 | 0.120 | 0.119 | 0.025 | 0.631 | 0.124 | 0.122 | 0.023 | 0.630 | 0.122 | 0.120 |
| | (0.03) | (0.55) | (0.10) | (0.10) | (0.03) | (0.55) | (0.10) | (0.10) | (0.03) | (0.55) | (0.10) | (0.10) |
| forward | 0.007 | -0.563 | -0.086 | -0.084 | 0.006 | -0.561 | -0.087 | -0.086 | 0.007 | -0.565 | -0.085 | -0.083 |
| | (0.03) | (0.50) | (0.08) | (0.09) | (0.03) | (0.50) | (0.08) | (0.08) | (0.03) | (0.50) | (0.08) | (0.09) |
| liquidity | -0.166*** | -0.209 | -0.107* | -0.069* | | | | | | | | |
| | (0.04) | (0.22) | (0.05) | (0.03) | | | | | | | | |
| volatility | 13.387*** | -1.286 | 11.741*** | 13.193*** | | | | | | | | |
| | (3.62) | (1.82) | (2.90) | (3.07) | | | | | | | | |
| intdiv | -0.099 | -0.098 | -0.095 | -0.092 | -0.109 | -0.101 | -0.100 | -0.096 | -0.101 | -0.098 | -0.098 | -0.094 |
| | (0.11) | (0.16) | (0.08) | (0.08) | (0.10) | (0.16) | (0.08) | (0.08) | (0.11) | (0.16) | (0.08) | (0.08) |
| general assembly | -0.500 | -0.369** | -0.435* | -0.445* | -0.510 | -0.378** | -0.430* | -0.441* | -0.509 | -0.381** | -0.435* | -0.445* |
| | (0.30) | (0.13) | (0.20) | (0.20) | (0.30) | (0.13) | (0.20) | (0.20) | (0.30) | (0.13) | (0.20) | (0.20) |
| issue | -6.054* | -21.943* | -11.382* | -11.460* | -6.095* | -21.862* | -11.405* | -11.488* | -6.031* | -21.941* | -11.373* | -11.451* |
| | (2.62) | (10.61) | (4.30) | (4.32) | (2.61) | (10.54) | (4.30) | (4.32) | (2.62) | (10.63) | (4.31) | (4.32) |
| variable | | | | -0.352 | | | | -0.312 | | | | -0.330 |
| | | | | (0.22) | | | | (0.23) | | | | (0.22) |
| priv | | | | 0.189 | | | | 0.193 | | | | 0.183 |
| | | | | (0.33) | | | | (0.33) | | | | (0.32) |
| semipublic | | | | 0.213 | | | | 0.188 | | | | 0.202 |
| | | | | (0.27) | | | | (0.28) | | | | (0.27) |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bank | | | | 0.155 | | | | 0.142 | | | | 0.159 |
| | | | | (0.21) | | | | (0.20) | | | | (0.21) |
| railway | | | | 0.673*** | | | | 0.691*** | | | | 0.681*** |
| | | | | (0.17) | | | | (0.17) | | | | (0.18) |
| foreign | | | | 0.207 | | | | 0.230 | | | | 0.218 |
| | | | | (0.19) | | | | (0.19) | | | | (0.20) |
| risky group | | | | 0.480* | | | | 0.499* | | | | 0.484* |
| | | | | (0.24) | | | | (0.24) | | | | (0.23) |
| post reform | | | | 0.670* | | | | 0.656* | | | | 0.675* |
| | | | | (0.28) | | | | (0.28) | | | | (0.28) |
| interaction term | | | | -1.084*** | | | | -1.084*** | | | | -1.097*** |
| | | | | (0.19) | | | | (0.19) | | | | (0.20) |
| liquidity_6 | | | | | -0.130** | -0.203 | -0.094* | -0.071* | | | | |
| | | | | | (0.04) | (0.19) | (0.04) | (0.03) | | | | |
| volatility_6 | | | | | 12.745*** | -5.209 | 9.643** | 11.374** | | | | |
| | | | | | (3.14) | (3.60) | (3.14) | (3.24) | | | | |
| liquidity_18 | | | | | | | | | -0.193*** | -0.018 | -0.105* | -0.060 |
| | | | | | | | | | (0.05) | (0.18) | (0.05) | (0.04) |
| volatility_18 | | | | | | | | | 13.245*** | -5.034 | 11.082*** | 12.563*** |
| | | | | | | | | | (3.32) | (2.94) | (3.03) | (3.28) |
| Cross-section fixed-effects | YES | YES | YES | NO | YES | YES | YES | NO | YES | YES | YES | NO |
| Cluster fixed-effects | NO | NO | NO | YES | NO | NO | NO | YES | NO | NO | NO | YES |
| Time fixed-effects | YES | YES | YES | NO | YES | YES | YES | NO | YES | YES | YES | NO |
| Months dummies | NO | NO | NO | YES | NO | NO | NO | YES | NO | NO | NO | YES |
| Years dummies | NO | NO | NO | YES | NO | NO | NO | YES | NO | NO | NO | YES |
| constant | 0.094 | 0.574 | 0.061 | -0.563 | -0.030 | 0.552 | 0.034 | -0.593 | 0.188 | 0.092 | 0.052 | -0.610 |
| | (0.31) | (0.53) | (0.23) | (0.33) | (0.31) | (0.45) | (0.25) | (0.35) | (0.32) | (0.44) | (0.24) | (0.33) |
| Within R2 | 0.168 | 0.169 | 0.120 | | 0.169 | 0.170 | 0.119 | | 0.167 | 0.168 | 0.119 | |
| R2 | | | | 0.142 | | | | 0.142 | | | | 0.141 |
| Obs | 5647 | 2817 | 8464 | 8464 | 5647 | 2817 | 8464 | 8464 | 5647 | 2817 | 8464 | 8464 |

*Table 5 – Panel regressions results. Driscoll-Kraay's standard errors. Different time spans in: calculation of change in imports, calculation of assets capital gain, calculation of the average number of spot prices (measure of collateral liquidity), calculation of historical volatility.*

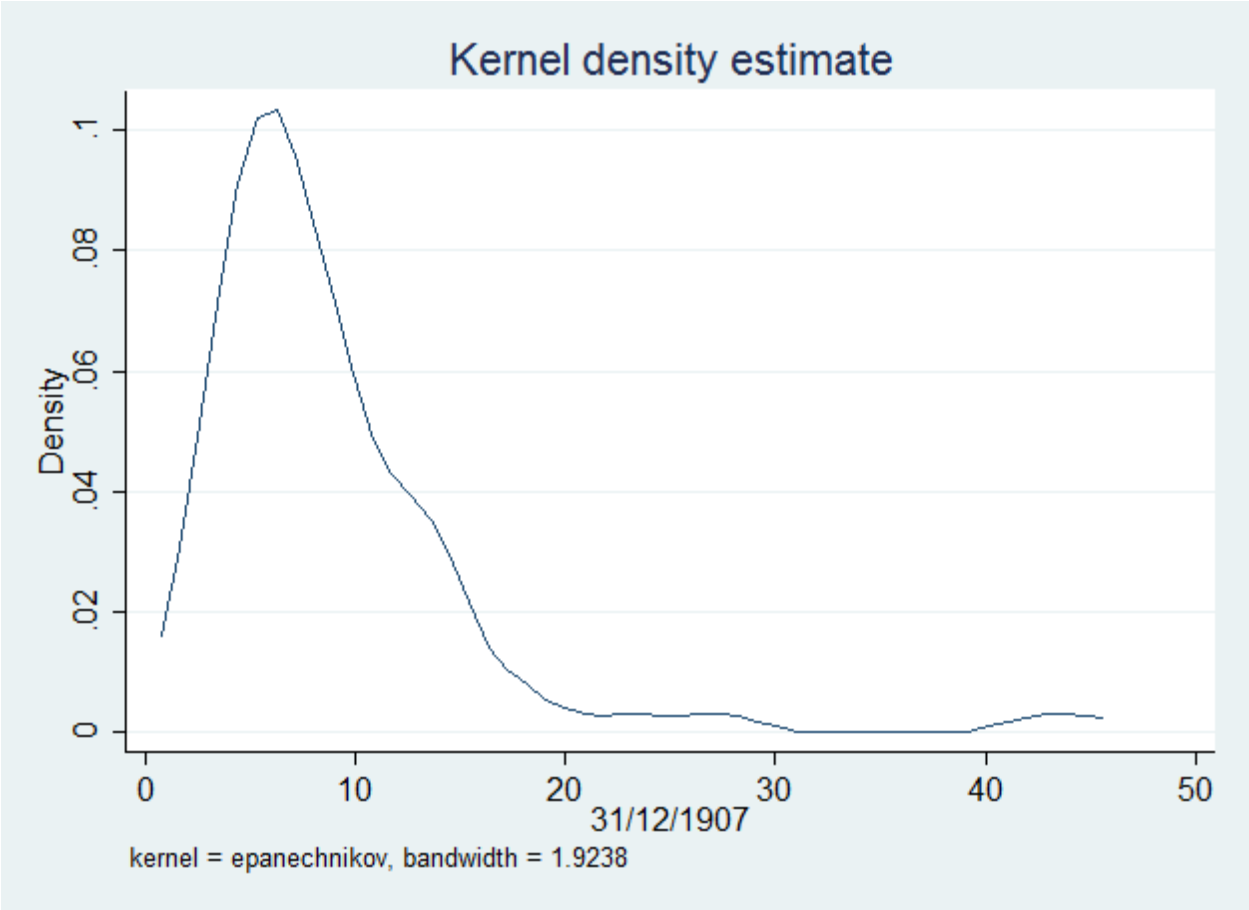



*Figure 9 - Kernel density (Parzen-Rosenblatt) distribution of repo volumes by broker, for 31/12/1907. On the horizontal axes, millions of francs. Source: author's DB. Kernel density estimates for the other 10 dates are available upon request.*