Exchange controls and the segmentation of international currency markets*

Victor Degorce†

September, 2023

Abstract

This article relies on a new hand-collected dataset of end-of-month exchange rates quoted in 17 national financial centers (i.e., countries) over the 1900-1999 period. By measuring deviations from the Law of One Price in international currency markets, this article puts forward two contributions. First, I provide a new long-run measure of financial integration. I reveal that currency markets were well integrated except during the Bretton Woods period when foreign exchange controls were widespread. I find that controls were also used, to a much moderate extent, during the interwar. My second contribution is to measure currency market integration at the currency level. I show that, during the Bretton Woods period, virtually all countries in my sample maintained controls against the US and Canadian Dollars. These controls split the world into two independent currency zones: a Dollar zone (including the US and Canada) and a non-Dollar zone (including Western Europe, Japan and Australia). Within each zone, the market for non-Dollar zone currencies was integrated. The two zones progressively merged starting in the early 1960s as exchange controls were abandoned.

JEL codes: F30, F31, F41, F42

Keywords: Foreign exchange controls, exchange rates, Law of One Price.

*The author would like to thank Emma Sarhdaoui for excellent research assistance, and Eric Monnet, Shinji Takagi, Alain Naef, Angelo Riva, Olivier Accominotti, and Emil Verner for helpful comments. Thanks are also due to the Bank of France, the Louis Bachelier Institute, and Natixis for their generous financial support.

†Julis-Rabinowitz Center for Public Policy and Finance (JRCPPF), Princeton University. degorce@princeton.edu.

1 Introduction

Controls on cross-border capital flows are a key instrument in government and central banks policy toolkit. In addition, they feature prominently in many theories of the international monetary system (Fleming, 1962; Mundell, 1963; Rey, 2015). Yet, we know surprisingly little about their effects and efficiency. One reason for this is that existing indicators of international financial integration are aggregate indicators that fail to capture the heterogeneous effect of controls.[1] Aggregate indicators are limited because controls might discriminate on the basis of currency and/or instrument of the transaction.[2] For example, France might be perfectly integrated with Germany while keeping tight controls on its transactions with the United States.

In this article I provide a long-run disaggregated measure of financial integration. I focus on one type of capital account restriction: foreign exchange controls. Exchange controls are restrictions on the sale and purchase of foreign (domestic) currencies by residents (non-residents). This is the most drastic form of capital controls, since it rules out any type of capital account transaction (e.g., flows of debt, equity, loans, FDI...) other than the ones authorised by the government. Today, exchange controls are no longer in use in developed economies but are still widespread in the developing world.[3]

Using a new hand-collected dataset of end-of-month exchange rates quoted in 17 national financial centers (i.e., countries) over the 1900-1999 period, I measure currency market integration at the country and *currency* level. That is, for each of the 17 countries in my database, I can test for the existence of foreign exchange controls against any of 16 currencies. Absent foreign exchange controls, the price of any currency against any other currency should be the same in every financial center in my sample.[4] On the other hand, the introduction of controls against a specific currency would lead to the emergence of two independent currency markets: one in the country imposing the controls, and one in the country issuing the currency targeted by the controls. To the extent that controls are effective, prices in the two markets may diverge significantly. I use this property to identify controls at the currency level, for all countries in my sample, over one century of data. My

[1]Another problem is that most indicators are *de jure* indicators (one exception comes from the work of Ilzetzki et al. (2019)).

[2]For anecdotal evidence see e.g., Valdés-Prieto and Soto (1998).

[3]See e.g., IMF 2022 Annual Report on Exchange Arrangements and Exchange Restrictions.

[4]This is the prediction of the sacrosanct Law of One Price. Although it has been tested in many different contexts, I am the first to provide a test using international currency markets.

contributions are twofold.

First, I provide a new long-run measure of financial integration. I reveal that currency markets were well integrated except during the Bretton Woods period (i.e., 1950s and 1960s) when the use of foreign exchange controls was (quasi) systematic among developed economies. I find that controls were also used (to a much moderate extent), during the interwar period. Based on these results, I argue that the existing literature has overlooked the distinction between foreign exchange controls and other types of capital account restrictions (i.e., capital controls). By restricting the sale and purchase of foreign (domestic) currencies by residents (non-residents), foreign exchange controls indeed prevent all types of capital transaction between residents and non-residents, other than the ones authorised by the government. This is different from other capital controls, which are generally focused on one specific instrument.

My second contribution is to measure currency market integration at the currency level. This is crucial since I find controls to be targeted against specific (e.g., hard) currencies. I show that, during the Bretton Woods period, virtually all countries in my sample maintained controls against the US Dollar and the Canadian Dollar. These controls split the world into two independent currency zones: a Dollar zone (including the US and Canada) and a non-Dollar zone (including Western Europe, Japan and, starting in the late 1960s, Australia). Within each zone, the market for non-Dollar zone currencies was integrated. However, due to restrictions on the sale and purchase of Dollars by non-Dollar zone countries, the pricing of non-Dollar zone currencies was significantly different between the two zones. Starting in the late 1950s, the two zones were gradually integrated as foreign exchange controls were abandoned. The integration was completed around the fall of the Bretton Woods system in the early 1970s.

My results speak to different strands of the literature. First, I contribute to the literature measuring financial integration in the long-run (Obstfeld and Taylor, 2004; Quinn and Voth, 2008). The key finding of this literature is that financial integration was high in the pre-1914 and post-1980 periods, and low in between (see also Eichengreen (2019)). The long-run measure of currency market integration provided in this paper is broadly consistent with this picture, with two notable differences. First, I find that controls were much less widespread in the interwar than during the Bretton Woods period. Second, for the postwar period, I find that the integration of international currency markets was restored as early as the 1960s (or early 1970s). This contrasts with other forms of capital controls which remained active until the

1980s or 1990s (Quinn and Toyoda, 2008). This result sheds light on the crucial, yet overlooked, distinction between exchange controls and other forms of capital controls. This is particularly relevant for economists working on international monetary policy transmission and on the Global Financial Cycle (Rey, 2015; Obstfeld et al., 2019; Jordà et al., 2020).

Second, this paper is related to a growing literature which uses disaggregated data to revisit key questions in macro-finance. Maggiori et al. (2020) for example study the effect of the currency denomination of debt on cross-border financing. Other important contributions include Coppola et al. (2021), and (Mian et al., 2020). The heterogeneous effects of government controls on capital flows, however, has not been studied. Interestingly, papers on the heterogeneous effects of trade policies (e.g., tariffs and quotas) on trade flows have received a lot of attention (De Bromhead et al., 2019; Arthi et al., 2020). This is all the more surprising since capital account restrictions and trade policies tend to go hand in hand (Nurkse, 1944).

Finally, my paper is perhaps most directly related to the work of Ilzetzki et al. (2019). Ilzetzki, Reinhart and Rogoff compile a 0,1 index of capital account restrictions by focusing on the existence (or absence thereof) of a premium on the black or parallel market for a given currency. My paper is similar to theirs in that it compares regulated exchange rates (i.e., the rates quoted in the country imposing exchange controls) to market-determined rates (i.e., the rates quoted outside the country imposing controls). However, we differ on a number of points. First, I use only official exchange rates, rather than black or parallel market rates. Second, I collect exchange rates from 17 national financial centers. This allows me to identify controls at the country and currency level. Their indicator, on the other hand, does not identify which currency is targeted by controls.

The article proceeds as follows. Section 2 presents the dataset and the empirical strategy. Section 3 looks at a new aggregated measure of currency market integration over one hundred years. This measure is then compared with a disaggregated (i.e., currency level) measure of currency market integration in section 4, while section 5 concludes.

2 Data and method

2.1 Data

This database is the result of a long and laborious data collection process which involved searching the archives of foreign central banks, visiting foreign libraries and universities, and digitizing scores of unpublished statistical sources. [5] I am confident that the primary sources unveiled in this work can be useful to other researchers.

I collected official foreign exchange quotations in 17 financial centers. One for each of the following 17 countries: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, United Kingdom, United States, Spain, Sweden and Switzerland. For most countries, quotations are taken from the same financial center throughout the entire sample (e.g., New York for the US, London for the UK, or Paris for France). For a few countries, the financial center can vary from one period to another (e.g., Zurich or Geneva for Switzerland, and Frankfurt or Berlin for Germany). The series are monthly (end-of-month) and span the 1900-1999 period.[6]

I do not include the pre-1900 period in my sample. Indeed spot transactions, for which the settlement is expected immediately (i.e., in practice, within the next 48 hours), became widespread only starting in the early 20th century (Einzig, 1962). Before that, spot transactions took place through bills of exchange drawn at longer maturities (e.g., from one week to a few months). In this case, arbitrage operations consisting of two simultaneous spot transactions in distinct financial centers were simply not possible.[7] For this reason, the pre-1900 period is excluded from my sample. In addition, I also exclude the post-1999 period. The reason for this is that, starting in the late 1990s, most financial centers stopped reporting onshore exchange rates, and instead reported exchange rates as quoted in the leading financial centers. This change in the statistical reporting of central banks is interesting in itself as it reveals the growing integration of world currency markets, but it prevents me from extending my analysis to the post-1999 period.

[5] It is also a collective enterprise, which benefited from the help and expertise of historians, archivists, and central bank statisticians from around the world.

[6] This preliminary version of the database does not cover the 1914-1918 and 1939-1950 periods. Both periods will be included in subsequent versions.

[7] Arbitrage operations could still be carried out by issuing a bill of exchange in a given center and buying a bill in a second center. In this case, the price of the two bills could diverge by an amount equal to the expected variation of the spot rate between the two centers (Flandreau and Komlos, 2006; Obstfeld and Taylor, 2004).

Existing long-run series of exchange rates generally report exchange rates quoted in a single financial center (e.g., New York or London). For example, Accominotti et al. (2019) and Vicquéry (2022) collect long run data on London exchange rate. Often, the source does not provide any information on the origin of the quotation (as in the IMF International Financial Statistics for example). Implicitly, this assumes that exchange rates quoted in London or New York should not differ from exchange rates quoted in any other financial center. I show that this assumption can be violated, sometimes severely, when international currency flows are disrupted.

Importantly, my focus is on exchange rates quoted in official (i.e., legal) currency markets, not on black market exchange rates. Official currency markets (as opposed to black or parallel markets) are monitored and regulated by central banks. The extent of the regulation, however, can vary widely. To identify and collect official exchange rates, I draw on a broad range of official statistical sources: statistical reports by central banks or national statistics institutes, financial newspapers, and central bank archives. On a few occasions, I rely on the work of other researchers. For the most recent decades, the data are sometimes available directly from the central bank's website. For the large majority of the sample, however, the data had to be collected directly from primary sources. Interested readers are referred to Appendix A which provides a country-by-country list of all the sources used.

Three important data caveats should be noted. First, the sources provide varying price information, including bid (buying) and ask (selling) prices, only bid prices, only ask prices, or only mid prices, depending on the financial center and period. It is therefore impossible to have a continuous measure of transaction costs (i.e., bid ask spreads) in every financial center for such a long sample. My approach to measuring currency market integration in the absence of transaction cost information is laid out in the next section (see "Method"). Second, the sources only report quotations of the domestic currency against foreign currencies. Exchange rates involving two foreign currencies (e.g., the French Franc against the Spanish Peseta in London) are never quoted (these exchange rates will be referred to as "cross-rates" in the rest of the paper). Of course, cross-rates can easily be computed. For example, the French Franc/Spanish Peseta exchange rate in London can be calculated by dividing (or multiplying) the exchange rate of the British Pound against the French Franc and the exchange rate of the British Pound against the Spanish Peseta. As explained in the next section, cross-rates are a key element in my empirical strategy. Last, quotations are collected for the same day of the month in every financial center, but the exact time of the quotation might differ from one center to another. The non-synchronicity of my observations is an important source of measurement error when computing deviations from the Law of One Price (particularly when exchange rates are very volatile), but is unlikely to bias my estimates. The following section explains why.

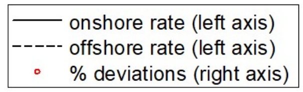
2.2 Method

My starting point is the Law of One Price, which states that identical goods should sell for identical prices. As noted by Lamont and Thaler (2002), the Law of One Price should hold particularly well in financial markets, where transaction costs are small, and arbitrage can be carried out instantaneously. Applied to currency markets, the Law of One Price predicts that the price of any currency, against any other currency, should be the same in every financial centers. If the price of (say) the French Franc in British Pounds was higher in London than in Paris, a French bank could reap a riskless (and instantaneous) profit by buying Pounds in Paris and selling them in London. Pounds would flow from Paris to London and equalize the two prices.

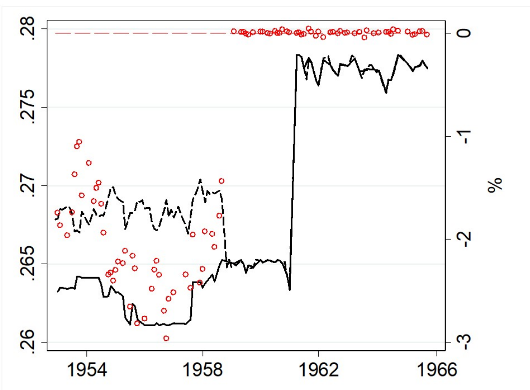
Foreign exchange controls prevent or hinder such arbitrage operations. If controls are strict enough, they can give rise to the development of two distinct currency markets: one operating within regulatory boundaries (onshore), and the other functioning outside these boundaries (offshore). As a result, prices in these two markets may diverge significantly. Over the course of the 20th century, I find numerous occurrence of this phenomenon. As Section 2 makes clear, these episodes are mostly clustered around the interwar and Bretton Woods period. Figure 1 presents four such examples. In each case, the solid black line represents the exchange rate within the onshore financial center, while the dash line represents the exchange rate in an offshore center. The red scatter plot shows the percentage difference between the onshore and offshore exchange rates (measured against the right axis). I will defer the discussion of how offshore financial centers are identified for the time being.

Panel A plots the price of the Dutch Guilder in US Dollars in the Netherlands (onshore center) and in Switzerland (offshore center). Panel B plots the price of the Swedish Krona in US Dollars in Sweden (onshore) and in Switzerland (offshore). Panel C looks at the price of the Portuguese Escudo in British Pounds in Portugal (onshore) and in the UK (offshore). Finally, Panel D compares the price of the Spanish Peseta in French Francs in Spain (onshore) and in the United States (offshore). All exchange rates are measured in foreign currency units against one unit of domestic

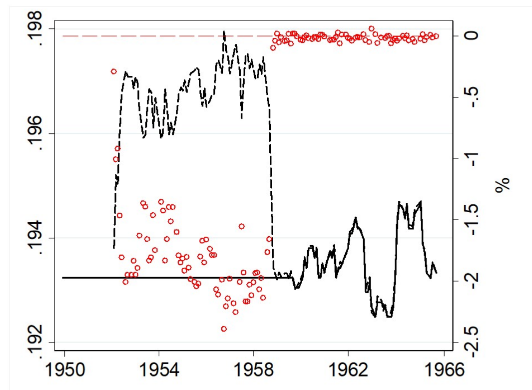
Figure 1: The segmentation of international currency markets



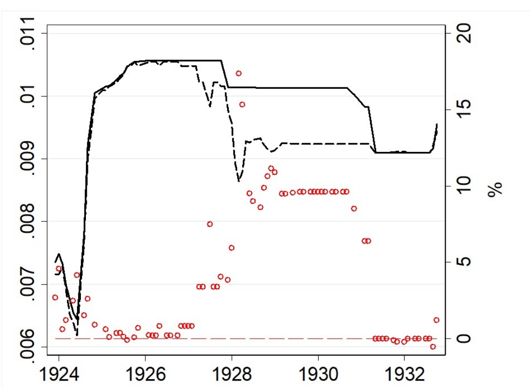
(a) NLG/USD in Amsterdam (onshore) and Zurich (offshore) (1952-1966)



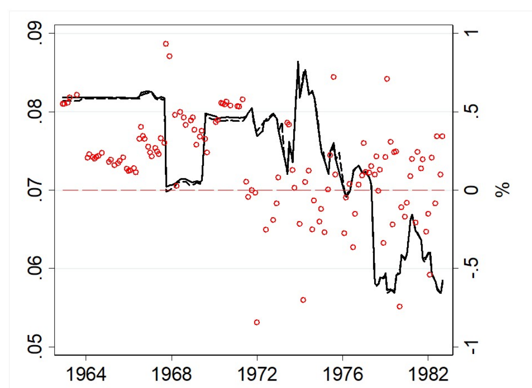
(b) SEK/USD in Stockholm (onshore) and Zurich (offshore) (1950-1966)



(c) PTE/GBP in Lisbon (onshore) and London (offshore) (1924-1933)



(d) ESP/FRF in Madrid (onshore) and New York (offshore) (1963-1983)



Notes: In each panel, the solid black line represents the exchange rate within the onshore financial center, while the dash line represents the exchange rate in an offshore center. Panel A plots the price of the Dutch Guilder in US Dollars in Amsterdam (onshore center) and in Zurich (offshore center). Panel B plots the price of the Swedish Krona in US Dollars in Stockholm (onshore center) and in Zurich (offshore center). Panel C plots the price of the Portuguese Escudo in British Pounds in Lisbon (onshore center) and in London (offshore center). Finally, Panel D plots the price of the Spanish Peseta in French Francs in Madrid (onshore center) and in New York (offshore center). The red scatter plots shows the percentage difference between the onshore and offshore exchange rates (measured against the right axis).

currency.

Panels B and C show typical examples of currency market segmentation, where the onshore rate is fixed while the offshore rates fluctuates (sometimes widely). As shown by Reinhart and Rogoff (2004), a similar pattern can be observed when comparing official and black-market exchange rates: the official rate is tightly controlled, while the black-market rate is free to adjust to actual and anticipated changes in economic conditions. In panel C, the offshore rate consistently anticipates devaluations of the onshore rate. Once again, this is reminiscent of the relation between black-market and official exchange rate (Reinhart and Rogoff, 2004; Ilzetzki et al., 2019). One important difference is that the foreign currency is not necessarily more expensive in the offshore center (see Panel A and B). This in stark contrast with the situation in black-markets where the foreign currency tends to sell at a premium. One tentative explanation is that participants to the offshore currency market have a free access to the foreign currency and have no reason to pay a premium. A second important takeaway from Figure 1 is that currency segmentation can also exist in cases when the onshore rate is not fixed (panels A and D).

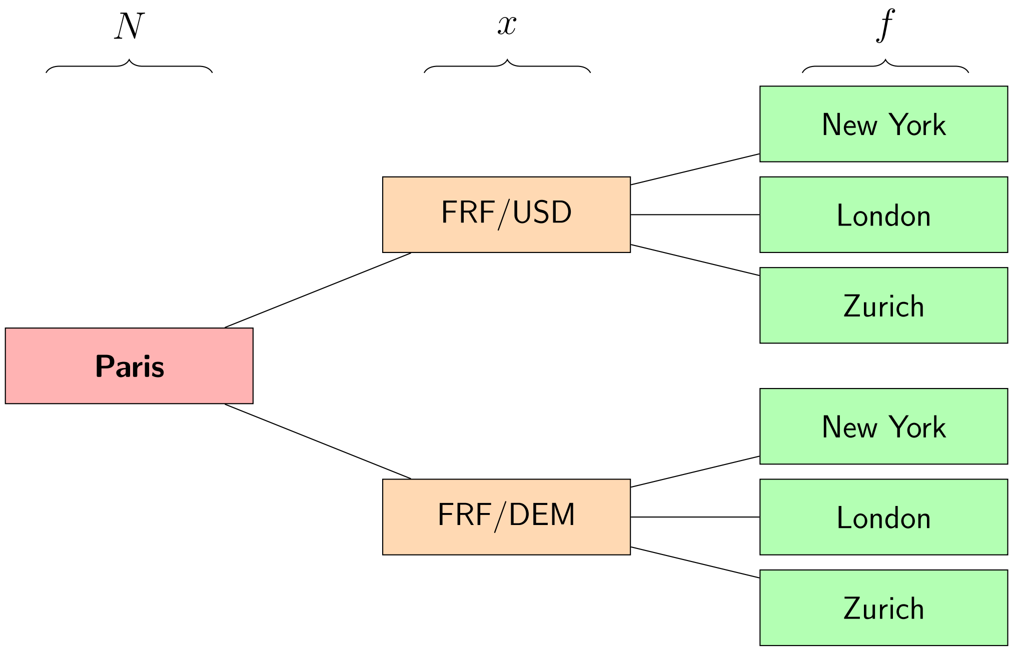
Figure 1 captures the essence of my method: measuring deviations between the price of currencies in onshore and offshore financial centers. Computing a time series of deviations requires three ingredients: an onshore center, an offshore center, and an exchange rate. A simple approach could be to calculate deviations between every pair of financial centers, and for every exchange rate. With 17 financial centers in my database, I could compute a total of 1088 time series of deviations ($17 \times \frac{16}{2} \times \frac{16}{2}$).[8] However, most of these deviations could not be interpreted. Historically, currency trading was often restricted to a few currencies except in the main financial centers. Other currencies were sometimes quoted but with minimal trading activity. In this case, a common practice was to to quote the same price for the foreign currency as the one prevailing in the leading financial centers.[9] Then, the onshore rate is *by construction* in line with offshore rates.

To circumvent this issue, my method focuses on a subset of all deviations. It works in two steps. First, I select a group of offshore centers. Ideally, offshore centers would include the largest and most liquid financial centers. In this context, the two natural candidates are New York and London. In addition, I also include Zurich (or Geneva) and Montreal, because of the absence of foreign exchange controls in Switzerland and Canada during the postwar period. Canada indeed abandoned foreign exchange controls in 1951 (Officer, 1971) while Switzerland played a central

[8]This calculation slightly overestimate the total number of time series I would obtain with a "naive" approach, since not all currencies are quoted in every financial centers (e.g., the Australian dollar is never quoted in Scandinavian centers).

[9]This was for example the case in Japan and in Australia, for most of the postwar period. I thank Shinji Takagi and the Reserve Bank of Australia's archivists for helping me clarify this point.

Figure 2: The empirical strategy



Notes: This figure presents an example of my method featuring one onshore financial center N (Paris), three offshore centers f (New York, London and Zurich), and two exchange rates x (FRF/USD and FRF/DEM). In this example, I can compute 6 series of deviations.

role as an offshore center throughout the postwar period, evident in its involvement with the development of euro dollars. Let the group of offshore centers be denoted by f. All other centers are categorized as onshore and denoted by N.

Second, for each onshore center, I select exchange rates of the domestic currency against two to five foreign currencies x. This includes two global currencies (the US Dollar and British Pound) and up to three regional currencies (e.g., the French Franc and German Mark for European centers). Thus, for each onshore center N, I can compute a total of $\sum_{x,f} N_x^f$ deviations. Figure 2 presents a simplified example of this framework featuring one onshore center N (Paris), two exchange rates x (FRF/DEM and FRF/USD), and three offshore centers f (New York, London and Zurich). Then $\sum_{f,x} N_f^x$ is equal to 6. Specifically, I can compute deviations between three pairs of centers: Paris and New York, Paris and London, and Paris and Zurich. For each pair of financial centers, the deviation can be computed for two different exchange rates: FRF/DEM and FRF/USD. Overall, applying this method to every onshore center in my sample restricts the total number of time series of deviations to 196 (that is, $\sum_{x,f,N} N_x^f = 196$). From here onwards, I will refer to this sample of 196 deviations as the full sample of deviations.

The advantage of this methodology is that it allows me to measure integration at the currency level. With this framework in mind, I need to establish a statistical test to determine if, based on a given time series of deviations, currency markets are integrated or not.

One approach would be to determine if deviations represent profit opportunities using transaction costs data. I do not use this method for two reasons. First, the only center for which bid-ask spread data are available for the whole 1900-1999 period is London.[10] Second, detecting profit opportunities would require a careful synchronization of all observations (i.e., quotations would need to be taken at the exact same time of the day). Such an exercise is (of course) impossible on a long-run sample. For these reasons, I rely instead on the time series property of the data.

Specifically, deviations should not include information that would help to predict future deviations. If past deviations cannot predict future deviations, the series is stationary. If past deviations can predict future deviations, the series is AR(1) and so has a unit root. To test for the presence of a unit root, I perform the augmented Dikey-Fuller test (Dickey and Fuller, 1979) on each of the 196 time series of deviations. The test is carried out over consecutive periods of 3 years. If the null-hypothesis that the variable contains a unit root cannot be rejected at the 90% confidence level, I consider that the deviations are not random. For the test to be valid, I require a minimum of 20 observations.

Figure 3 presents a graphical representation of this test, using three time series of deviations. The light red shaded area indicates periods for which the null-hypothesis that the variable contains a unit root cannot be rejected at the 90% confidence level.

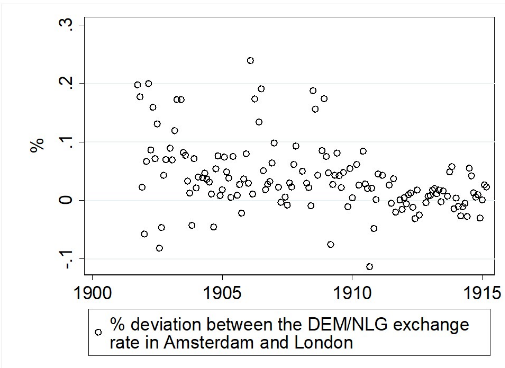
Figure 3 confirms that exchange rate volatility is an important source of measurement error. The floating exchange rate period of the early 1920s (panel B) and of the post-1970 period (panel C) are both associated with wider deviations from the Law of One Price. This is not surprising given that my observations are not perfectly synchronized.[11] However, this is not picked-up by the Dickey-Fuller test. A second important takeaway is episodes of foreign exchange controls are rare. Specifically, for the three times series of deviations plotted in Figure 3, I find evidence of currency

[10] I thank Olivier Accominotti, Jason Cen and David Chambers for sharing their data with me.

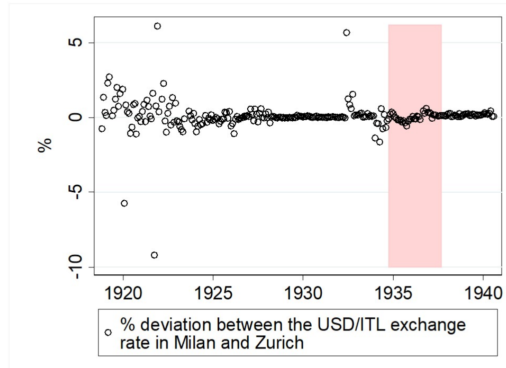
[11] Assume that the quotations are taken at 2pm in London and at 4pm in Paris. Any deviation between exchange rates quoted in London and Paris would therefore be equal to the "true" deviation (the one that I would have measured if both quotations were taken at 2pm or 4pm)), plus a measurement error equal to the variation in the exchange rate between 2pm and 4pm. This variation is small when exchange rates are managed (as during the classical Gold Standard, interwar Gold Standard, or Bretton Woods period), but can become substantial when exchange rates are floating.

Figure 3: The segmentation of international currency markets: A test

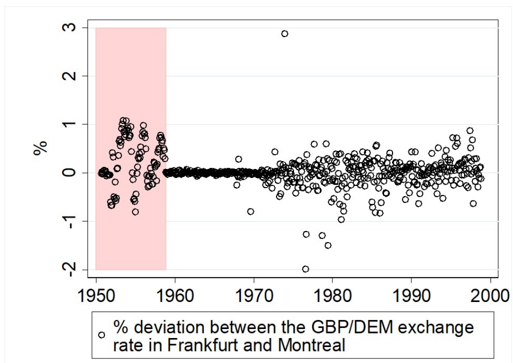
(a) Prewar (1900-1914)



(b) Interwar (1918-1939)



(c) Postwar (1950-1999)



Notes: Panel A plots the % difference between the price of the Dutch Guilder in German Marks in Amsterdam and in London. Panel B plots the % between the price of the Italian Lira in US Dollars in Milan and in Zurich. Panel C plots the % difference between the price of the German Mark in British Pounds in Frankfurt and in Montreal. I perform an augmented Dickey-Fuller test on each of the three variables. The test is carried out over consecutive periods of 3 years. The light red shaded area indicates periods for which the null-hypothesis that the variable contains a unit root cannot be rejected at the 90% confidence level.

market segmentation in only two periods: the late 1930s (panel B), and the early Bretton Woods years. The following section extends this finding to all of the 196 pairs in my sample.

3 Exchange controls and financial integration in the long-run

In this section, I look at foreign exchange market integration over the long-run using my 196 series of Law of One Price deviations. As explained in the previous section, these series are obtained by calculating the difference between exchange rates quoted in 13 onshore centers, and in 4 offshore centers (London, New York, Montreal and Zurich). For each onshore center N, I generate between 9 and 20 series of deviations N_x^f (where x is an exchange rate, and f is an offshore center). Then, for each of these series, I run the augmented Dickey-Fuller test over successive periods of three years. If the null-hypothesis that the variable contains a unit root cannot be rejected at the 90% confidence level, I consider that the deviations are not random, and that the exchange rate x is priced differently in the onshore market N and in the offshore market f. I repeat the same operation for all the thirteen onshore centers in my database (for a total of $\sum_{x,f,N} N_x^f = 196$ time series of deviations).

I consider that an onshore market N is not integrated with international currency markets if, for the same three-years period, one of two following conditions is met:

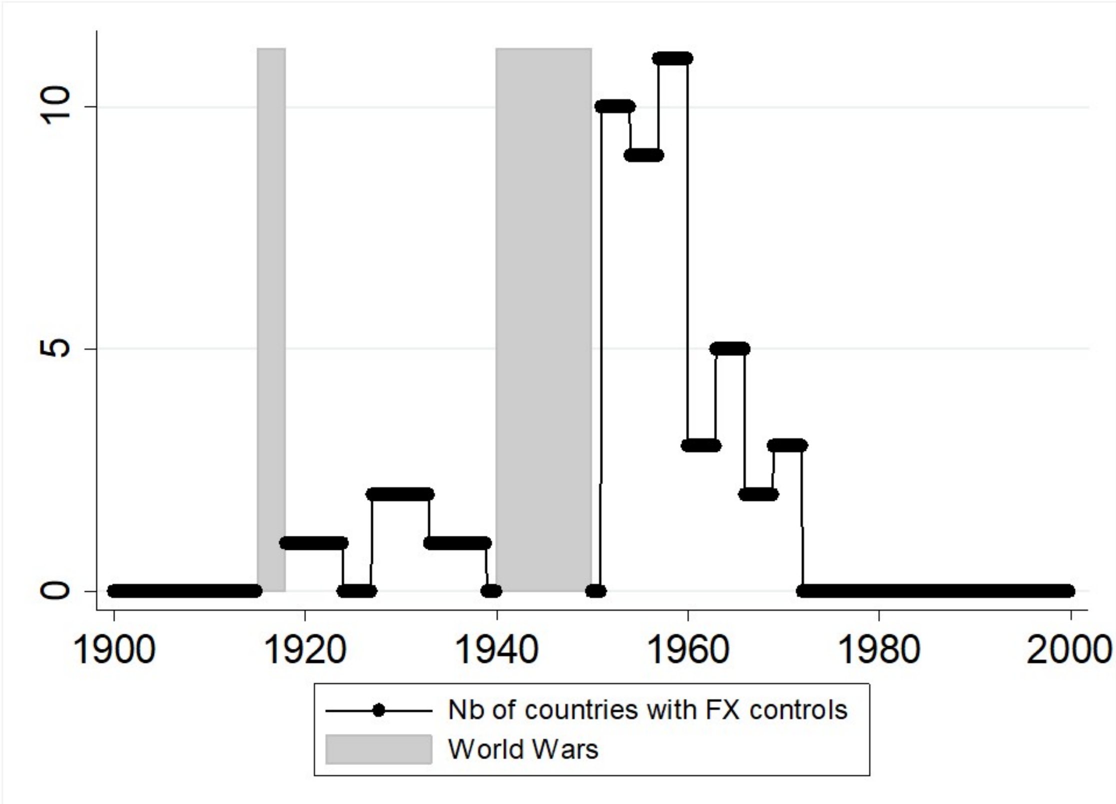
- For a given offshore center f, there are at least two exchange rates x that are priced differently in the onshore center N.
- For a given exchange rate x there are at two offshore centers f where the exchange rate is priced differently than in the onshore center N.

The point of these restrictions is to make sure that the foreign exchange controls originate from the onshore center N and not from any of the offshore centers, or from the country issuing the foreign currency. Requiring that both conditions be met at the same time does not affect my conclusions.

Figure 4 plots the number of countries with foreign exchange controls in my sample. Foreign exchange controls appear to be clustered around the Bretton Woods years. Controls are also evident, to a much moderate extent, during the interwar period. I do not find any evidence of international currency market segmentation during the classical Gold Standard (1900-1914). The broad pattern presented in Figure 4 is consistent with existing narratives of international financial integration during the 20th century (Obstfeld and Taylor, 2004; Eichengreen, 2019). The pre-1914 and post-1970 period are characterized by the absence of obstacles to international currency flows. Such obstacles appear in the interwar years, and are later institutionalized during the Bretton Woods period (1950-1970). Figure 4 shows that the Bretton Woods period is the only period when the use of restrictions on international currency flows was (quasi) systematic among developed economies (in 1958, 11 out of the 13 onshore countries in my sample had recourse to FX controls).

In the robustness checks section, I replicate this result by performing the Dickey-Fuller test on windows of two and five years (rather than three years, see Figure B1). One important limitation of my method is that it can easily miss short-lived episodes of currency market segmentation. This might explain, in part, why I find little evidence of controls in the interwar. However, shorter time windows would

Figure 4: Foreign exchange controls, 1900-2000



Notes: This figure plots the number of countries with foreign exchange controls in my sample. To identify countries with foreign exchange controls, I follow the following method. First, for each of the 196 time series of deviations, I perform the augmented Dickey-Fuller test over successive periods of three years. If the null-hypothesis that the variable contains a unit root cannot be rejected at the 90% confidence level, I consider that the deviations are not random, and that the exchange rate x is priced differently in the onshore market N and in the offshore market f. Second, I consider that an onshore market (i.e., country) N is not integrated with international currency markets if, for the same three-years period, one of two following conditions is met: (1) for a given offshore center f, there are at least two exchange rates x that are priced differently in the onshore center N; (2) for a given exchange rate x there are at two offshore centers f where the exchange rate is priced differently than in the onshore center N.

produce considerably more variance in my estimates. I therefore restrict the minimum number of observations in the Dickey-Fuller tests to 20.

Importantly, this test captures the existence of foreign exchange controls rather than capital controls. Restrictions on capital flows remained active, often long after the dismantlement of exchange restrictions. While the distinction between exchange and capital controls is crucial, it has been overlooked by much of the literature. Foreign exchange controls are restrictions on the flows of currency across countries. Capital controls include restrictions on the flows of currency (foreign exchange controls), but also of short and long-term debt, equity, FDI, or any other form of capital, across countries. If flows of foreign exchange are restricted, then capital flows are (de facto) restricted. The reverse, however, is not true.

Imagine, as an example, that the Bank of France restricts the purchase of Pound Sterling by French banks (i.e., foreign exchange controls). Then it is (de facto) impossible for French residents to buy British bonds, stocks, or to make any type of investment in the United Kingdom. On the other hand, we can think of many examples where flows of capital are restricted, while currencies circulate freely across borders. Thus, foreign exchange controls can be assimilated to an extreme form of capital controls, whereby the domestic financial market is completely shut-off from foreign markets. In fact, it is foreign exchange controls, rather than capital controls, that theorists have in mind when devising models of the trilemma, dilemma, or of the international monetary system.

In most models, capital controls are represented by introducing a wedge between the return on domestic and foreign assets in the Uncovered Parity (UIP) equation, which allows countries some monetary policy independence (see e.g., Farhi and Werning (2012)). Such a wedge can indeed be maintained when foreign exchange controls are in place, and non-residents (residents) cannot buy the domestic (foreign) currency. On the other hand, this might not be the case with capital controls, depending on the type of control. Tight capital controls on the movements of short-debt debt might indeed hinder international arbitrage, and allow some leeway to the domestic central bank. However, they do not prevent non-residents (residents) from buying the domestic (foreign) currency. This is important in the case of currency crises, where most capital controls do not prevent the sale (purchase) of the domestic currency.[12] The speculative attacks again the Japanese Yen around the fall of the Bretton Woods system, while Japan maintained a vast array of capital controls, are one example of this.[13] Overall, my results show that there were very few periods in history when non-residents (residents) could not access foreign (domestic) financial markets. The Bretton Woods period stands as the only exception.[14]

After looking at the long-run trend for my full sample in Figure 4, Table 1 zooms in the postwar period and provides a country-by-country picture of foreign exchange

[12]To be sure, a currency crisis is possible even when foreign exchange controls are in place. For example, Naef (2022) shows how leads and lags of exports and imports payments were responsible for the 1947 British currency crisis, despite tight controls on the Pound.

[13]According to the Quinn-Toyoda index (Quinn and Toyoda, 2008), Japan scored 50/100 on capital market integration in 1971. This is below the sample mean for the 96 countries in their database.

[14]It it perhaps worth reminding ourselves that the Mundell-Fleming model dates from the early 1960s, at a time were foreign exchange controls were still in place in many developed countries. In his 1963 paper, Mundell explicitly refers to the dismantling of foreign exchange controls in the late 1950s to motivate his model (Mundell, 1963, Page 1).

Table 1: Foreign exchange controls and black (parallel) markets during the postwar period

Country	Year the domestic FX market is integrated with international markets	Year black (or parallel) markets are abolished	Nb of years the domestic FX market is segmented from international markets	Nb of years with black (or parallel) markets
Australia	n.a.	1955	n.a.	6
Belgium	1959	1990	9	41
Denmark	1959	1950	3	1
Finland	1962	1957	12	8
France	1959	1974	9	25
Germany	1959	1958	9	9
Italy	1965	1959	12	10
Japan	1965	1971	6	22
Netherlands	1959	1952	9	3
Norway	1962	1956	12	7
Portugal	1959	No black market	9	0
Spain	1971	1971	16	n.a.
Sweden	1959	1954	9	5

Notes: This table reports descriptive statistics on foreign exchange controls and black (or parallel) markets during the postwar period, for the 13 onshore centers (i.e. countries) in my database. Columns 2 and 4 are compiled using data from Ilzetzki et al. (2019). Columns 1 and 3 are compiled using the approach described in the previous section. Information is not available for Australia during the postwar because the Australian Dollar is not quoted in enough foreign financial centers.

integration. It also compares my results with the unified market analysis of Ilzetzki et al. (2019). Column 1 shows the year the domestic market is integrated with foreign currency markets (according to my measure). Column 2 shows the year the domestic currency market was unified (i.e., the year official and black or parallel markets were unified). Column 3 shows the number of years when the domestic country was segmented from foreign currency markets (according to my measure). Column 4 shows the number of years during which black or parallel markets were in operation. Columns 2 and 4 are compiled with data from Ilzetzki et al. (2019).

One striking result is that the unification of the domestic exchange market rarely coincides with the integration of the domestic market with foreign markets. Most often, the unification of the domestic exchange market predates the integration with foreign markets. This is the case, for example, in Denmark, Finland, Italy, the Netherlands, Sweden, or Norway. This result shows that, even in the absence of black (or parallel markets) foreign exchange markets are not necessarily integrated with foreign currency markets. In fact, Ilzetzki et al. (2019) acknowledge that "*Conceptually at least, a country can have a plethora of capital account restrictions and still have a de facto and a de jure unified exchange rate*". This results shows that this is indeed the case: a country's foreign exchange market can be segmented from foreign exchange markets, even in the absence of a black or parallel currency market.

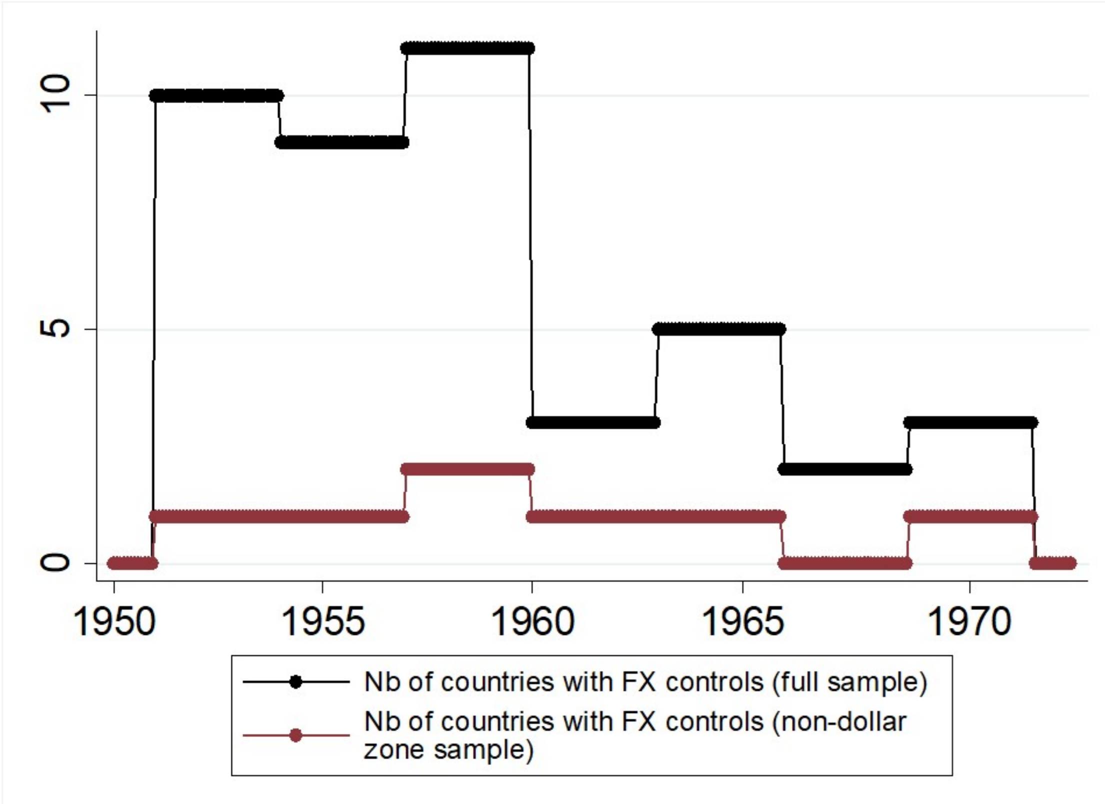
4 Are foreign exchange controls discriminatory?

From a conceptual perspective, it is easy to see why foreign exchange controls could be targeted against specific currencies. In particular, deficit countries have a strong incentive to discriminate against surplus countries. This was institutionalized by the Bretton Woods agreement through the "scarce" currency clause, which allowed deficit countries to impose temporary exchange and trade controls on a country that ran persistent payment surplus (see e.g., Eichengreen (2019, chapter 4)).

In the early Bretton Woods years, the main surplus country was the United States and the world economy suffered from a Dollar shortage. Europe, in particular, was striving to safeguard its limited dollar reserves while reconstructing intra-European trade and payments, notably through the European Payments Union (Eichengreen, 1993). In this context, can I find any evidence that controls discriminated against the dollar?

To test for discrimination against the Dollar, I split my sample into two zones: a Dollar zone, and a non-Dollar zone. The Dollar zone includes two financial centers: New York and Montreal, and two currencies: the US Dollar and the Canadian Dollar. The inclusion of Canada in the Dollar zone is designed to reflect its geographical and financial proximity with the United States. The non-Dollar zone includes all other financial centers and currencies. It covers Western Europe, Japan, and Australia (all the onshore centers in my sample are part of the non-Dollar zone). My hypothesis is that countries in the non-Dollar zone restrict the purchase and sale of Dollar zone

Figure 5: FX controls during Bretton Woods - A tale of two currency zones



Notes: The black line plots the number of countries with foreign exchange controls in my sample of deviations (as in Figure 4). The red line plots the number of countries with foreign controls in the non-dollar zone sample. The non-dollar zone sample includes only the deviations N_f^x for which the exchange rate involves two non-dollar zones currencies (i.e., all currencies except the USD and CAD), and two non-dollar zones financial centers (i.e., all centers except New York and Montreal).

(i.e., hard) currencies by their residents, but that they do not impose controls on transactions in non-Dollar zone currencies (i.e., soft currencies).

My aim, therefore, is to measure integration within the non-Dollar zone and see how it compares with the aggregate picture presented in Figure 4. To do so I restrict my sample of deviations N_f^x to deviations where the exchange rate x involves two non-Dollar currencies, and for which both the onshore N and offshore f centers are situated in the non-Dollar zone. I call this sub-sample the non-Dollar zone sample. Deviations in the non-Dollar sample thus measure the extent to which non-Dollar zone currencies are free to circulate across non-Dollar zone financial centers.

Using the same method as the one developed in the previous section, I measure the number of countries with foreign exchange controls based on the non-Dollar zone sample, and I compare it with my estimates on the full sample (see Figure 4). Figure 5 presents the results. The black line reproduces the number of countries with foreign exchange controls based on my full sample of deviations (already shown in Figure 4), while the red line shows the number of countries with foreign exchange controls based on the non-Dollar zone sample. The black line can be seen as an aggregate indicator of currency market integration, while the red line represents a regional (i.e., non-Dollar zone) indicator of currency market integration.

The result is striking. Non-Dollar zone currencies are free to circulate across non-Dollar zone financial centers. The only exceptions to this pattern are Australia and Spain, which are the only countries to maintain controls against non-Dollar zone currencies.

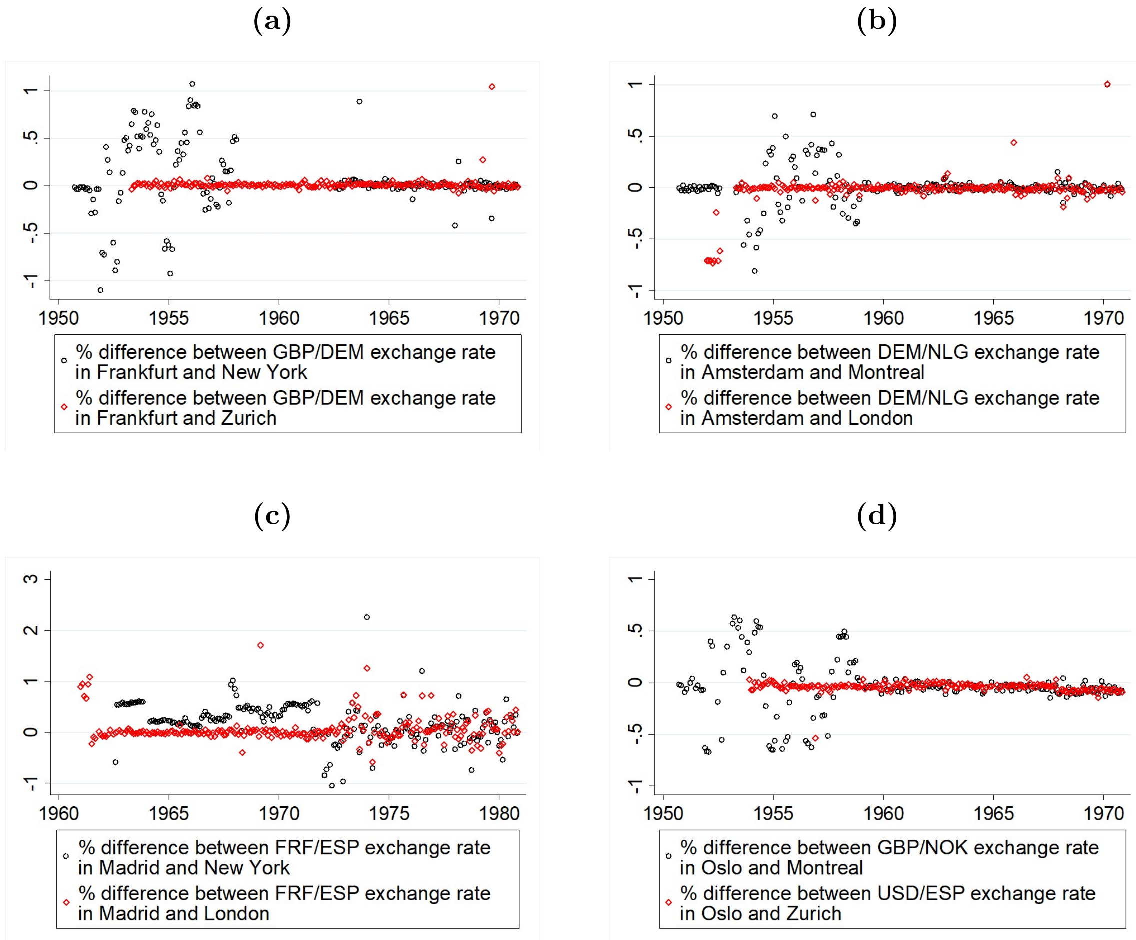
Figure 6 illustrates this finding with four case studies. In each panel, I focus on exchange rates involving two non-Dollar zone currencies. For each of these exchange rates, I measure two series of deviations: one between two centers located in the non-Dollar zone (deviations shown in red), and one between a center located in the non-Dollar zone and a Dollar-zone center (deviations shown in black). Deviations shown in red measure the extent to which non-Dollar zone currencies are free to circulate across non-Dollar zone financial centers. Deviations shown in black measure the extent to which non-Dollar zone currencies are free to circulate between Dollar-zone and non-Dollar zone financial centers.

In every panel, the result is the same: the market for non-Dollar zone currencies appear to be integrated across non-Dollar zone financial centers (as shown by the deviations in red). However, the pricing of non-Dollar zone currencies appears to be different in Dollar-zone financial centers than in non-Dollar zone centers (as shown by the deviations in black). Running a Dickey-Fuller test on each of the series validates this result.

Once again, this test confirms the existence of two segmented currency zones: a Dollar zone, and a non-Dollar zone. As a consequence of controls against the US Dollar in the non-Dollar zone, currency markets in the non-Dollar zone are segmented from markets in the Dollar zone. Interestingly, a major side effect of controls against the Dollar in non-Dollar zone countries is that the market for Dollars is segmented *within* the non-Dollar zone itself (e.g., the Paris market for Dollars is not integrated with the Zurich or London markets for Dollars...). This is shown in Figure B.2, in the Appendix.

Figure 5 and 6 highlight the second contribution of this paper: providing a disaggregated (i.e., currency level) measure of international financial integration. Existing indicators, like the one provided by Ilzetzki et al. (2019) or Quinn and Toyoda (2008),

Figure 6: A tale of two currency zones - Case studies



Notes: Panel A plots the % deviations between the GBP/DEM exchange rate in Frankfurt and New York (in black), and in Frankfurt and Zurich (in red). Panel B plots the % deviations between the DEM/NLG exchange rate in Amsterdam and Montreal (in black), and in Amsterdam and London (in red). Panel C plots the % deviations between the FRF/ESP exchange rate in Madrid and New York (in black), and in Madrid and London (in red). Panel D plots the % deviations between the GBP/NOK exchange rate in Oslo and Montreal (in black), and in Oslo and Zurich (in red).

are aggregate indicators. Figure 5 and 6 reveal that aggregate indicators conceal important information because controls on currency flows tend to be targeted against specific (e.g., hard) currencies. Based on the aggregate indicator presented in Figure 4, one could be mislead into thinking that the world economy in the 1950s and 1960s was a collection of closed economies. Figure 5 and 6 reveal that it was instead characterized by the existence of two integrated currency zones. Accounting for this is crucial to understand the development of European economies during the postwar (Eichengreen, 1993, 2006).

5 Conclusion

This paper puts forward two main contributions. First, I provide a new long-run measure of financial integration. I reveal that national currency markets were well integrated except during the Bretton Woods period (i.e., 1950s and 1960s) when the use of foreign exchange controls was (quasi) systematic among developed economies. I find that controls were also used (to a much moderate extent), during the interwar period.

My second contribution is to identify foreign exchange controls at the currency level. I show that, during the Bretton Woods period, virtually all countries in my sample maintained controls against the US Dollar (and the Canadian Dollar). These controls split the world into two independent currency zones: a Dollar zone (including the US and Canada) and a non-Dollar zone (including Western Europe, Japan and, starting in the late 1960s, Australia).

These findings open avenues for future research. In particular, the fact that post-war exchange controls discriminated against the dollar offers an ideal setting to test for the effect of capital account restrictions on trade flows. This will be the focus of follow-up papers.

References

Accominotti, Olivier, Jason Cen, David Chambers, and Ian W Marsh, "Currency regimes and the carry trade," *Journal of Financial and Quantitative Analysis*, 2019, *54* (5), 2233–2260.

Arthi, Vellore, Markus Lampe, Ashwin Nair, and Kevin Hjortshøj O'rourke, "The impact of interwar protection: evidence from India," 2020.

Autio, Jaakko, *Valuuttakurssit Suomessa 1864-1991. Katsaus ja tilastosarjat* number 1/1992, Bank of Finland Discussion Papers, 1992.

Bromhead, Alan De, Alan Fernihough, Markus Lampe, and Kevin Hjortshøj O'Rourke, "When Britain turned inward: the impact of interwar British protection," *American Economic Review*, 2019, *109* (2), 325–352.

Coppola, Antonio, Matteo Maggiori, Brent Neiman, and Jesse Schreger, "Redrawing the map of global capital flows: The role of cross-border financing and tax havens," *The Quarterly Journal of Economics*, 2021, *136* (3), 1499–1556.

Dickey, David A and Wayne A Fuller, "Distribution of the estimators for autoregressive time series with a unit root," *Journal of the American statistical association*, 1979, *74* (366a), 427–431.

Diesen, Emil, *Exchange Rates of the World*, Vol. 1-3, Økonomisk Literatur, 1922.

_ , *Exchange Rates of the World*, Økonomisk Literatur, 1923.

Eichengreen, Barry, *Reconstructing Europe's trade and payments: the European Payments Union*, University of Michigan Press, 1993.

_ , *The European economy since 1945: coordinated capitalism and beyond*, Princeton University Press, 2006.

_ , *Globalizing capital: a history of the international monetary system*, Princeton University Press, 2019.

Einzig, Paul, *The history of foreign exchange*, Macmillan London, 1962.

Farhi, Emmanuel and Ivan Werning, "Dealing with the trilemma: Optimal capital controls with fixed exchange rates," Technical Report, National Bureau of Economic Research 2012.

Flandreau, Marc and John Komlos, "Target Zones in Theory and History: Credibility, efficiency, and policy autonomy," *Journal of Monetary Economics*, 2006, *53* (8), 1979–1995.

Fleming, J Marcus, "Domestic Financial Policies under Fixed and under Floating Exchange Rates (Politiques finacierieures interieures avec un systeme de taux de change fixe et avec un systeme de taux de change fluctuant)(Politica financiera interna bajo sistemas de tipos de cambio fijos o de tipos de cambio fluctuantes)," *Staff Papers-International Monetary Fund*, 1962, pp. 369–380.

Ilzetzki, Ethan, Carmen M Reinhart, and Kenneth S Rogoff, "Exchange arrangements entering the twenty-first century: Which anchor will hold?," *The Quarterly Journal of Economics*, 2019, *134* (2), 599–646.

Jordà, Òscar, Moritz Schularick, and Alan M Taylor, "The effects of quasi-random monetary experiments," *Journal of Monetary Economics*, 2020, *112*, 22–40.

Klovland, Jan Tore, "Historical exchange rate data 1819–2003," *Norges Bank Occasional Papers*, 2004, (35).

Lamont, Owen A and Richard H Thaler, "Anomalies: The law of one price in financial markets," *Journal of Economic Perspectives*, 2002, *17* (4), 191–202.

Maggiori, Matteo, Brent Neiman, and Jesse Schreger, "International currencies and capital allocation," *Journal of Political Economy*, 2020, *128* (6), 2019–2066.

Mian, Atif R, Ludwig Straub, and Amir Sufi, "The saving glut of the rich," Technical Report, National Bureau of Economic Research 2020.

Mundell, Robert A, "Capital mobility and stabilization policy under fixed and flexible exchange rates," *Canadian Journal of Economics and Political Science/Revue canadienne de economiques et science politique*, 1963, *29* (4), 475–485.

Naef, Alain, *An Exchange Rate History of the United Kingdom: 1945–1992*, Cambridge University Press, 2022.

Nurkse, Ragnar, *International currency experience: lessons of the interwar period*, Vol. 2, League of Nations, 1944.

Obstfeld, Maurice and Alan M Taylor, *Global capital markets: integration, crisis, and growth*, Cambridge university press, 2004.

_ **, Jonathan D Ostry, and Mahvash S Qureshi**, "A tie that binds: Revisiting the trilemma in emerging market economies," *Review of Economics and Statistics*, 2019, *101* (2), 279–293.

Officer, Lawrence H, "Does the Canadian Experience Justify a Balanced View of Fixed vs. Fluctuating Exchange Rates?: Comment," *Journal of Money, Credit and Banking*, 1971, *3* (2), 363–365.

Quinn, Dennis P and A Maria Toyoda, "Does capital account liberalization lead to growth?," *The Review of Financial Studies*, 2008, *21* (3), 1403–1449.

_ **and Hans-Joachim Voth**, "A century of global equity market correlations," *American Economic Review*, 2008, *98* (2), 535–540.

Reinhart, Carmen M and Kenneth S Rogoff, "The modern history of exchange rate arrangements: a reinterpretation," *the Quarterly Journal of economics*, 2004, *119* (1), 1–48.

Rey, Hélène, "Dilemma not trilemma: the global financial cycle and monetary policy independence," Technical Report, National Bureau of Economic Research 2015.

Valdés-Prieto, Salvador and Marcelo Soto, "The effectiveness of capital controls: theory and evidence from Chile," *Empirica*, 1998, *25* (2), 133–164.

Vicquéry, Roger, "The Rise and Fall of Global Currencies over Two Centuries," *Banque de France Working Paper*, 2022.

Appendix A Sources

To compile this database, I relied on the help and expertise of researchers, archivists, and statisticians. I would like to thank, without implicating: Shinji Takagi, Paolo Piselli, Federico Barbiellini Amidei, Sébastien Lechevalier, Elena Martinez, Nuno Valério, Frans Buelen, Jan Annaert, Eric Monnet, Angelo Riva, Sarah Middleton-Jones, Eloisa Santos, Javier Jareño, Jane Boyko, Gitte Christiansen, Jeannie Jensen, Mira Barkä, Daniel Höffker, and Rasmus Christensen.

Australia: Daily Telegraph (August 1932-1939). The Age (1952-September 1957). Daily exchange rates, Commonwealth Trading Bank (October 1957-June 1980). Canberra Times (July 1980-November 1983). Historical Statistics of the Reserve Bank of Australia (December 1983-1999).

Belgium: Cours authentique de la bourse d'Anvers (1900-1914). La Dernière Heure; L'indépendance Belge; Journal de Bruxelles (1919). Rapports Annuels de la Banque de Belgique (1920-1937) & Bulletin d'Information et de Documentation de la Banque de Belgique (1926-1939). Cours authentique de la bourse d'Anvers (1950-1955). Le Soir (1955-July 1971). SCOB database, University of Antwerp (August 1971-1999).

Canada: Diesen (1922, 1923) (1918-1922). Financial Post (1923-1939). Personal communication by the Bank of Canada (1950-1999).

Denmark: Statistisk Arbog (1900-1914; 1918-March 1926). Protokol for vekselkurser og diskonto (April 1926-1939; 1950-1955). Reports and Accounts of Danmarks NationalBank (1956-1990). Danmarks NationalBank Statbank (1991-2020).

Finland: Autio (1992) (1900-1914). Diesen (1922) (1918-1920). Bank of Finland Statistical Yearbook (1921-1939; 1950-1971). Bulletin of Statistics, Statistics Finland (1972-1991). Online database of the Bank of Finland (1992-1999).

France: Bank of France archives (1900-1914; 1918-1939; 1950-1988). Cote officielle (1989-1998).

Germany: Berliner Borsen-Zeitung (1900-1914). Bank of France archives (1918-

1926). Vossische Zeitung (1927-March 1934). Stuttgarter Neues Tagblatt (April 1934-1939). Time series database of the Bundesbank (1950-1999).

Italy: La Stampa (1900-1914). Database of the Banca d'Italia (1918-1998).

Japan: Kinyu Youryaku (1906-1914). Diesen (1922, 1923) (1918-1922). Kinyu Youryaku (1923-1939). Bank of Tokyo Monthly Bulletin (March 1955-1972). Bank of Japan time-series (1973-1999).

Netherlands: De Telegraaf & Algemeen Handelsblad (1900-1914). De Nederlandsche Bank Annual Reports (1918-March 1931). De Telegraaf & Algemeen Handelsblad (April 1931-1939). Officiële Prijscourant (1950-August 1952). Algemeen Handelsblad (September 1952-July 1957). Officiële Prijscourant (August 1957-1999).

Norway: Klovland (2004) (1900-1914). Diesen (1922, 1923) (1918-1922). Morgenbladet; Social-Demokrat; Aftenposten (1923-October 1925). Norges Bank archives (November 1925-1934). Nordlandposten & Halden Arbeiderblad (1935-1936). Norges Bank archives (1937-1939; 1950-1954). Aftenposten (1955-November 1981). Norges Bank API (December 1981-1999).

Portugal: Jornal do Commercio (November 1901-1907). Banco de Portugal BPstat (1908-1998).

United Kingdom: The Times (1900-1914). Accominotti et al. (2019) (1918-1999).

United States: Bank and Quotation Record (1900-1914). Bank of France archives (1918-1939). Bank and Quotation Record (1950-November 1963). Bank of France archives (December 1963-March 1973). FRED Database (April 1973-1999).

Sweden: Sveriges Riksbank's archives (1900-1914; 1918-1939; 1950-May 1961). Kurslistor Skandinaviska Banken (June 1961-1973). Svenska Dagbladet (1974-1992). Sveriges Riksbank API (1993-1999).

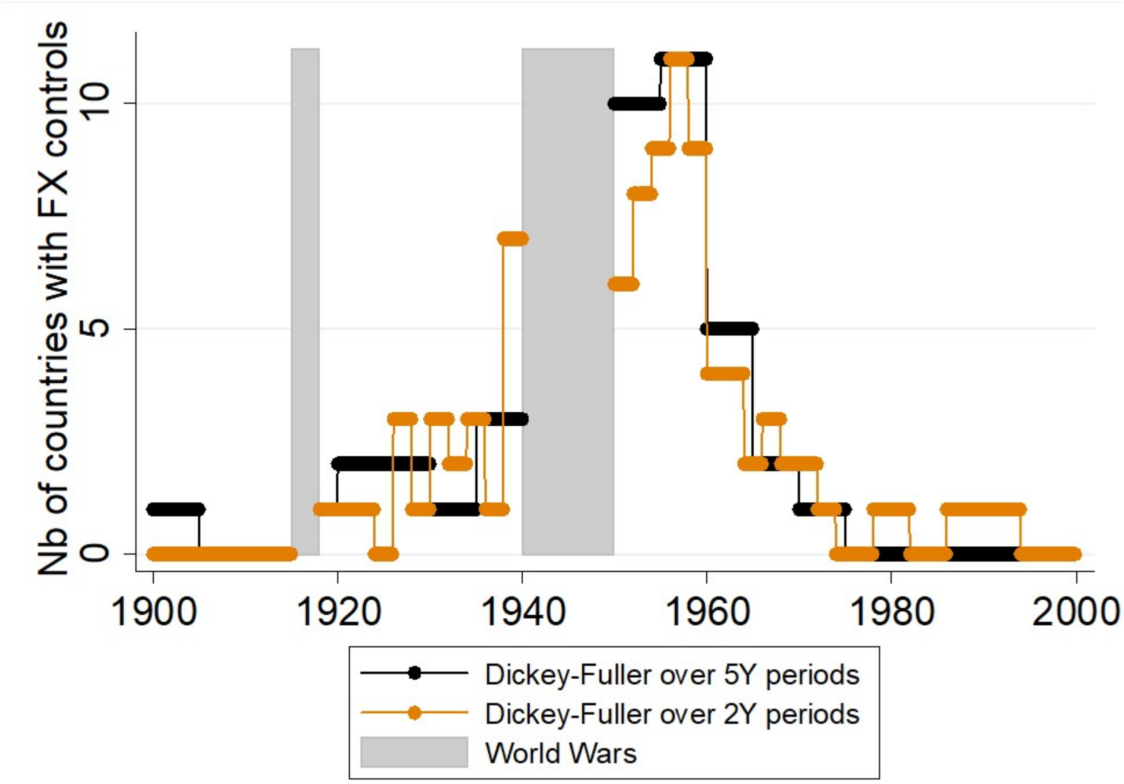
Switzerland: Neue Zurcher Zeitung (1900-1914; 1918-1925). Monthly Statistical Bulletin of the Swiss National Bank (1926-1939; 1950-1999). For the 1950-1971 period, the exchange rates of the Escudo, Peseta, and Finnish Markka are drawn from the Neue Zurcher Nachrichten.

Spain: Boletin de cotizacion oficial de la Bolsa de Comercio de Madrid (1900-1914; 1918-June 1936; August 1950-September 1959). Boletín Oficial del Estado (October 1959-1966). Banca de Espana database (1967-1998).

Appendix B Robustness checks

Figure B.1 below replicates the findings presented in Figure 4. This time, the Dickey-Fuller test is carried out on consecutive periods of 2 and 5 years (rather than 3 years, as in Figure 4).

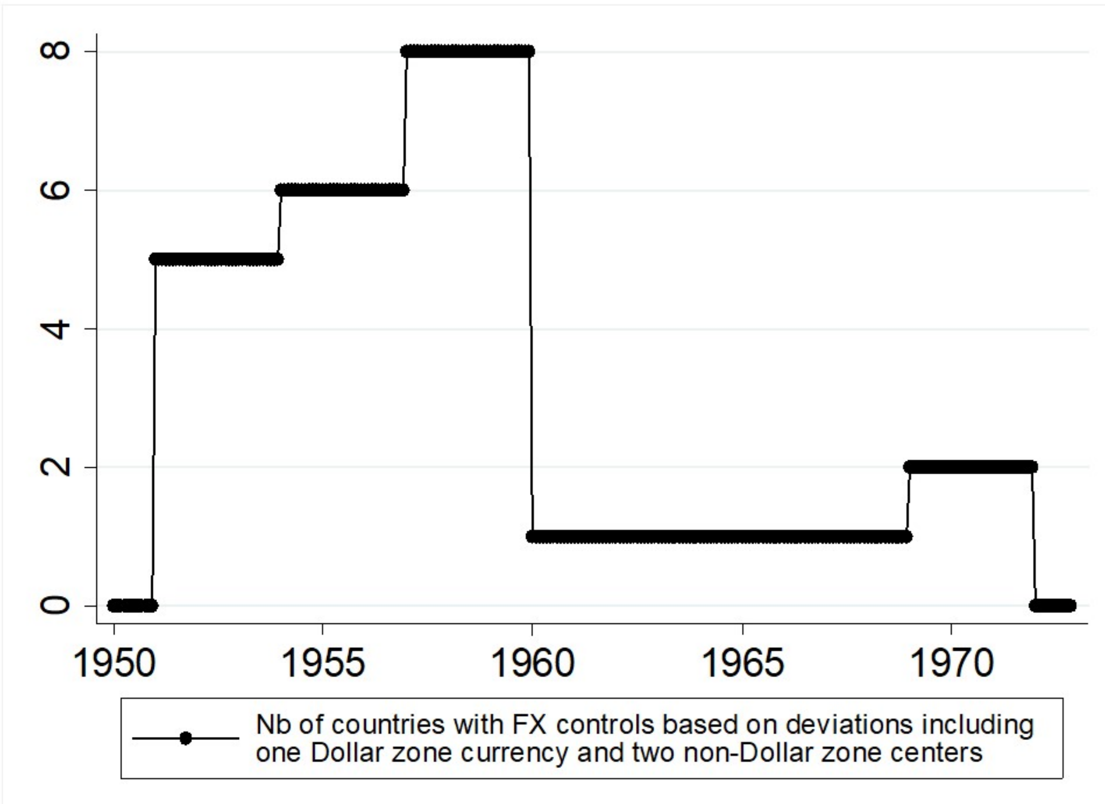
Figure B.1: Foreign exchange controls, 1900-2000



Notes: See Figure 4. The only difference with Figure 4 is that the Dickey-Fuller test is carried out over consecutive periods of 2 years (yellow line) and 5 years (black line).

Figure B.2 below plots the number of countries with foreign exchange controls during the Bretton Woods period (1950-1970) focusing on the sub-sample of deviations where both the onshore and offshore centers (N and f) are situated in the non-Dollar zone, and where the exchange rate x includes a Dollar zone currency and a non-Dollar zone currency.

Figure B.2: The segmentation of Dollar markets within the non-Dollar zone (1950-1970)



Notes: This figure plots the number of countries with foreign exchange controls in the sub-sample of deviations where both the onshore and offshore centers (N and f) are situated in the non-Dollar zone, and where the exchange rate x includes a Dollar zone currency and a non-Dollar zone currency. The number of countries with foreign exchange controls (based on this sub-sample) is calculated as in Figure 4 and 5.