Global risk-taking, exchange rates, and monetary policy*

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Abstract

Floating exchange rates have become increasingly ineffective at decoupling local risky rates from foreign rates. This is a new phenomenon and was not the case earlier in the 20th century. I introduce an open economy model that rationalizes this phenomenon with the growing role of leverage-constrained banks in global asset markets. I show that when leverage-constrained banks are marginal investors in global asset markets, mark-to-market of asset prices synchronizes risk-taking across currency areas, even when the exchange rate is floating. This international risk-taking channel accounts for around 30% of the spillovers of U.S. monetary policy into the risky rates of floats.

Keywords: Trilemma, Dilemma, Risk-Taking, Financial Spillover, Local Projection, Long-run data, Bank Leverage, Value-at-risk.

JEL Codes: F30, F42, G12, G15, G20, N10, N20

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1. Introduction

In this paper, I revisit one of the central ideas in international macroeconomics, the idea that floating exchange rates decouple local interest rates from foreign rates. The effectiveness of floating exchange rates in decoupling local interest rates has been confirmed by empirical evidence based on *safe interest rates*, such as central bank policy rates or government bond yields (Obstfeld *et al.* , 2005; Shambaugh, 2004). Recent research, however, has suggested that floating exchange rates can become overwhelmed by global financial forces that bind together *risky rates*, such as bank lending rates or corporate bond yields (Passari and Rey, 2015; Rey, 2016). On the basis of new long-run time series for safe *and* risky interest rates, I find that floating exchange rates have indeed become less effective at decoupling risky rates than safe rates. I introduce an open economy model that rationalizes this phenomenon with the growing role of leverage-constrained banks in global asset markets (see Adrian *et al.* , 2014, 2016).

In the empirical part of this paper I present two pieces of evidence for the decreasing effectiveness of floating exchange rates. First, in a co-movement analysis I show that, during the late 20th century, floating exchange rates reduced the co-movement of local safe rates with foreign safe rates by around 80%, while the corresponding figure for risky rates is considerably less, or statistically indistinguishable from 0, depending on which risky rate one looks at. I also show that this is a relatively new phenomenon. In the early 20th century, floating exchange rates were effective at decoupling risky rates.

Second, in order to compare the transmission of financial center monetary policy shocks to pegs and floats I look at the global effects of U.S. monetary policy shocks today and the global effects of U.K. monetary policy shocks in the early 20th century. For this purpose, I constructed a monetary policy shock measure for the Bank of England (BoE) from 1880 to 1913, and hand-collected an international dataset of monthly safe- and risky rates. On the basis of the new pre-1914 BoE shock measure, as well as the post-1970 Fed shock measure by Romer and Romer (2004), I compare the response of pegs and floats to financial center monetary policy shocks.[1] The results underscore the findings from the co-movement analysis: While floating exchange rates are effective at shielding local safe rates from financial center policy rate shocks, they are ineffective at shielding local risky rates. Again I can show that this is a recent phenomenon. Earlier in the 20th century floating exchange rates were still effective at decoupling risky rates from financial center

[1] I use the extended shock series provided by Cloyne and Hürtgen (2016)

policy rate shocks.

Why have floating exchange rates become less effective in decoupling risky rates? I argue that the growing role of leverage-constrained banks in global asset markets is key. More specifically I introduce an international banking model in which the interplay of leverage constraints, mark-to-market accounting, and costly equity adjustment gives rise to excess volatility in risky rates (see Adrian and Shin, 2009, 2010; Adrian *et al.* , 2014, 2016). In an open economy framework, this excess movement in risky rates overwhelms the floating exchange rate, which is already pinned down by the cross-country differential in safe rates.

To better understand the proposed mechanism consider a positive shock to the foreign safe rate. The nominal exchange rate adjusts to equalize expected safe returns across the two regions. At the same time foreign banks sell risky assets until their price has fallen sufficiently to compensate for the higher funding cost. The drop in risky asset prices furthermore erodes foreign and home bank equity. Subject to leverage constraints, and because raising new equity is costly, the banks will adjust their leverage by reducing their risk-taking even further. This sell-off of risky assets generates an excessive fall in risky asset prices (i.e., an excessive rise in risky rates). The nominal exchange rate cannot compensate for this excess rise in risky rates, because it is already pinned down by safe rates. Thus, the exchange rate ceases to function as an equalizer of expected returns for risky rates. Instead, risky returns are equalized across regions through risk premium spillovers, as banks arbitrage away expected return differentials between home and foreign risky assets. The calibrated model indicates that this *international risk-taking channel* can account for about 30% of the spillovers of U.S. monetary policy into the risky rates of floats.

The finding that floating exchange rates have become ineffective at decoupling local risky rates does not imply that floating exchange rates are not worth having. After all, a floating exchange rate provides economic policymakers with one more degree of freedom for achieving their policy goals. However, my findings suggest that the world economy has become a considerably more demanding environment to operate in for policymakers. Increasing financial spillovers can drive a wedge between conventional targets of monetary policy, such as output and employment gaps, and other policy goals, such as financial stability targets. This divergence in policy targets worsens the trade-offs involved in the application of existing policy instruments. Thus policymakers may find themselves in want of additional instruments in their policy toolkit.

My findings are also of relevance to current debates about how to robustify open economies against financial shocks from abroad (Passari and Rey, 2015; Rey, 2013). The finding that floating exchange rates were effective at decoupling risky rates in the early 20th century suggests that excessively volatile risk premiums and their international spillover is not an inevitable consequence of financial globalization. Hence, the implementation of capital controls – de facto financial deglobalization – is not the only way in which monetary authorities can reassert their control over local interest rates. Instead, my findings suggest that institutional reform, aimed at lightening the interaction between leverage-constraints and mark-to-market accounting, can help to reconcile capital mobility with monetary autonomy. In this regard, the institutions that underpinned financial globalization at the beginning of the 20th century are worth another look.[2]

This paper is closely related to several strands of literature. First, my work adds to the trilemma literature (Bekaert and Mehl, 2017; Bluedorn and Bowdler, 2011; Dornbusch, 1976; Fleming, 1962; Keynes, 1930; Klein and Shambaugh, 2015; Obstfeld and Taylor, 1997, 2017; Obstfeld *et al.* , 2005, 2017; Padoa-Schioppa, 1982; Shambaugh, 2004).[3] The trilemma states that each economy can pursue only two out of the following three macroeconomic policies: mobile capital, stable exchange rates and independent interest rates. The empirical trilemma literature has tested whether capital controls and floating exchange rates are indeed associated with more independent interest rates. Most contributions have found that this is indeed the case. My findings confirm this as far as safe rates are concerned.[4]

Second, this paper contributes to a recent literature that has challenged the trilemma's validity. The so-called dilemma view put forward by Rey (2013) proposes that floating exchange rates no longer provide an effective insulation against global financial forces (see Cerutti *et al.* , 2017; Georgiadis and Mehl, 2015; Ha, 2016; Miranda-Agrippino and

[2]This is not to say that systematic window-dressing is a solution. However, the proposed model mechanism opens the door for frictions, that delay the translation of asset price volatility into balance sheet volatility, to play a stabilizing role.

[3]This literature in turn is closley related another empirical strand of interantional macroeconomics, that tests the validity of (un-)covered interest rate parity (UIP) (see Bekaert *et al.* , 2007; Froot and Thaler, 1990; Lothian and Wu, 2011; Pikoulakis and Wisniewski, 2012)

[4]Obstfeld *et al.* (2017) present evidence that the transmission of global financial shocks is magnified under fixed exchange rate regimes. However, their findings indicate that the peg-float dichotomy is less marked when it comes to stock returns, debt and equity portfolio flows, as well as cross-border banking flows (also see Cerutti *et al.* , 2015). My findings confirm that the decoupling power of floating exchange rates depends on the type of financial variable. The proposed model furthermore suggests that the ease of arbitrage and the degree of leverage are crucial for understanding which financial variables can achieve decoupling through floating exchange rates.

Rey, 2015; Passari and Rey, 2015). As a result, the trilemma has turned into a dilemma, according to which monetary autonomy can only be established through capital controls. In this paper I confirm that extensive risk premium spillovers have rendered floating exchange rates ineffective at shielding local risky rates. My findings thus reconcile the trilemma and dilemma views. While I find that the trilemma holds for safe rates, the dilemma holds for risky rates.[5]

Finally, the open economy model I propose builds on closed economy models introduced by Danielsson *et al.* (2012) and Adrian and Boyarchenko (2013b), which study the macroeconomic implications of value-at-risk (VaR) constrained banks. More generally, this paper adds to the theoretical literature that analyzes the role of financial frictions in the international transmission of shocks (Alpanda and Aysun, 2014; Kalemli-Ozcan *et al.* , 2013; Kollmann *et al.* , 2011; Ueda, 2012). Among these, the model I propose is most closely related to accounts that highlight the role of asset prices in synchronizing financial conditions across borders (Dedola and Lombardo, 2012; Devereux and Yetman, 2010; Fostel and Geanakoplos, 2008).

The remainder of this paper is structured as follows: In the empirical part, sections 2.1.1 and 2.2.1 outline the econometric strategies I employ. Sections 2.1.2 and 2.2.2 introduce the annual and monthly interest rate datasets. Sections 2.1.3 and 2.2.3 present the empirical results. The international risk-taking channel is outlined in section 3. To quantitatively evaluate this channel I introduce, discuss and calibrate an open economy banking model in sections 4.1, 4.2 and 4.3. Finally, in section 4.4 I confront the model with the empirical results and assess to which extent the model accounts for the observed co-movement in risky rates among floats. Section 5 concludes.

2. Empirical analysis of exchange rate regimes and interest rates

This first part of this paper empirically characterizes the relation between exchange rate regime and interest rate co-movement in two ways. In order to connect to the existing literature on interest rate co-movement I start with a regression-based co-movement analysis that checks whether interest rates co-moved differently among pegs and floats.

[5]This strand of the literature is also closely related to another strand that analyzes the financial spillovers that emanate from financial centers (see Bruno and Shin, 2015; Canova, 2005; Ehrmann and Fratzscher, 2009; Kim, 2001; Miniane and Rogers, 2007). Relatedly, Forbes and Warnock (2012), Fratzscher (2012), Cerutti *et al.* (2015) and Ha and So (2017) present empirical evidence that global factors are important for understanding capital flows.

After that, this section presents a conditional analysis of the transmission of financial center monetary policy shocks to pegs and floats.

2.1. Interest rate co-movement analysis

2.1.1 Methodological approach

In order to see how globally synchronized risk premiums can render floating exchange rates ineffective compare the uncovered interest rate parity (UIP) equation with its risk premium augmented equivalent. In the basic UIP equation

$$i_{k,t} = i_{l,t} + \mathbb{E}_t e_{kl,t+1} - e_{kl,t}, \tag{1}$$

the co-movement of country k's nominal safe rate ($i_{k,t}$) with country l's ($i_{l,t}$) depends only upon the expected changes in the nominal exchange rate ($\mathbb{E}_t e_{kl,t+1} - e_{kl,t}$). For fixed exchange rates $\mathbb{E}_t e_{kl,t+1} - e_{kl,t} = 0$, and absent any frictions in international capital markets, arbitrage ensures that $i_{k,t}$ equals $i_{l,t}$, and hence safe rates co-move perfectly, i.e. $corr(i_{k,t}, i_{l,t}) = 1$. Floating exchange rates break this link: Given any home and foreign interest rate, $i_{k,t}$ and $i_{l,t}$, the expected change in the nominal exchange rate ($\mathbb{E}_t e_{kl,t+1} - e_{kl,t}$) adjusts until the non-arbitrage condition in (1) is satisfied.

In the risk premium augmented UIP equation

$$r_{k,t} = i_{l,t} + \rho_{l,t} + \mathbb{E}_t e_{kl,t+1} - e_{kl,t} \tag{2}$$

the co-movement of risky interest rates $r_{k,t} = i_{k,t} + \rho_{k,t}$ no longer only depends on the expected depreciation of the exchange rate, but also on the co-movement of the risk-premiums, $cov(\rho_{k,t}, \rho_{l,t})$.[6] Here I use the term "risk premium" to refer to any spread between safe and risky asset returns, regardless of whether it is related to fundamental default risk or not. For example, I also use the term "risk premium" to refer to interest rate spreads that open up due to limits of arbitrage.

The dilemma hypothesis as proposed by Rey (2013) posits that the ebb and flow in risk appetite is highly correlated internationally, i.e. $cov(\rho_{k,t}, \rho_{l,t}) >> 0$. In this scenario, even if two economies have a floating exchange rate and their fundamentals are otherwise

[6] Equations 1 and 2 can be derived as the linear Taylor approximations for the first order conditions of a risk neutral investor that can choose between investing in a safe or a risky asset. In this case r, ρ and e are log-deviations from steady state.

unrelated, their risky rates will nevertheless co-move, i.e. $cov(r_{k,t}, r_{l,t}) > 0$. It is in this sense that a floating exchange rate has become a less powerful tool in decoupling an economy from international capital markets.

Nominal interest rates are known to be highly persistent and are thus often treated as unit root processes (see Shambaugh, 2004), that are potentially affected by problems of spurious correlation (Granger and Newbold, 1974; Phillips, 1986).[7] This also holds for the five interest rates I'm studying here, for which the unit root test by Elliott *et al.* (1996) rejects the unit root hypothesis in only 10%, 5%, 9.5%, 4% and 2% of the spells for the short-term safe rate, the long-term risk free rate, mortgage rates, bank lending rate and private bond yield respectively.[8] In the following analysis I treat all interest rate series as near-unit root processes, whose asymptotic properties are more similar to the asymptotic properties of non-stationary processes than stationary ones (Phillips, 1988). In line with the existing literature I therefore base my analysis on the first differenced interest rate series in order to ensure correct results. After first differencing, equation 2 becomes

$$\Delta r_{k,t} = \Delta r_{l,t} + \Delta \rho_{l,t} + \Delta \Big[\mathbb{E}_t e_{kl,t+1} - e_{kl,t} \Big], \tag{3}$$

where Δ denotes the first difference-operator. For credible pegs the exchange rate is fixed, $\mathbb{E}_t(e_{kl,t+1}) = e_{kl,t}$, and thus equation 3 could be brought to the data as

$$\Delta r_{k,t} = \beta_1 \Delta r_{l,t} + \beta_2 \Delta \rho_{l,t} + u_{kl,t}, \tag{4}$$

where u indicates the error term. First differencing also nets out time-invariant country-specific level-characteristics in interest rates and risk premiums. These include interest rate-level differences due to differences in capital stock accumulation and overall economic development, as well as persistent institutional and political differences that are associated with persistent differences in risk premium levels.

Among two countries k and l with an absolutely fixed exchange rate and an integrated financial market for safe bonds the expected coefficient estimate for β_1 would be 1. Historically, most fixed exchange rate regimes allowed for some fluctuations of the

[7] Nominal interest rates are no unit root processes strictly speaking as they are bounded from below by zero. Furthermore Stanton (1997) observes that while nominal interest rates are indistinguishable from a unit root process at low and medium interest rate levels, mean reversion is stronger when interest rate levels are very high or very low.

[8] I determined the lag length for the unit root test regressions according to modified AIC (Ng and Perron, 2001).

nominal exchange rate within a narrow target zone. Cases of absolutely fixed exchange rates are rare and restricted to currency unions, such as the euro area, or fully dollarized economies, such as Panama. For this reason the following analysis defines a peg as a country whose exchange rate stays within a narrow a +/-2% horizontal band. Obstfeld *et al.* (2005) present simulation evidence that in such target zone regimes UIP coefficient estimates should be expected to be substantially smaller than 1, around 0.5 and even smaller if central banks conduct an aggressive interest rate smoothing policy within their target zone band. In practice the presence of various kinds of arbitrage costs can be expected to drive another wedge between domestic and global rates, further lowering $\widehat{\beta}_1$ and $\widehat{\beta}_2$ (hatted parameters denote parameter estimates). Generally, however, $\widehat{\beta}_1$ should be expected to be positive and significantly larger than 0 among pegs.

The sign and size of $\widehat{\beta}_2$ depends on the extent of financial market integration for risky as well as safe assets. When the markets for both, safe and risky assets, are perfectly integrated $\widehat{\beta}_2$ should equal 1, i.e. risk premiums are equalized across borders (see Dedola and Lombardo, 2012). If either the market for safe or risky assets are not perfectly integrated there is some scope for ρ_k and ρ_l to deviate from one another. Practically $\widehat{\beta}_2$ might deviate from 1 not only due to frictions in international asset markets, but also due to imperfect cross-country comparability of the risk rate series. In general, however, among financially open economies and when comparing assets of the same risk-class across countries $\widehat{\beta}_2$ should be expected to be positive – particularly so for the case of extensive risk premium spillovers posited by the dilemma hypothesis.

For economies with a floating exchange rate, uncovered interest rate parity can be satisfied through movements in either the expected exchange rate $\mathbb{E}_t e_{kl,t+1}$ or the spot exchange rate $e_{kl,t}$ instead of movements in the safe rate or the risk premium. Consequently, estimates of β_1 among floats should be expected to lie below that among pegs. Various factors however suggest that $\widehat{\beta}_1$ will not equal 0. First, the lack of the expected change in the exchange rate in specification 4 constitutes an omitted variable problem.[9] Second, shocks might be correlated across countries provoking synchronized

[9] In this case the use of ex post realized exchange rates as proxies for their ex ante expected counterparts has proven of little help in alleviating this omitted variable problem. Several papers in the literature have shown that in the case of floating exchange rates the uncovered interest parity equation does not hold when proxying ex ante exchange rate expectations with ex post realized exchange rates (e.g. Froot and Thaler, 1990). A recent exception are Lothian and Wu (2011), who, using ex post realized exchange rates as a proxy for expected exchange rates, find UIP to hold on their 200-year sample for U.K, U.S. and French returns. The bias this omitted variable problem induces in β_1 could be positive or negative depending on economic circumstances. Foreign interest rate changes could be positively correlated with the expected depreciation term if there is an economic crisis with capital outflows that the central bank tries to rein in

central bank responses even among floats. Finally, even central banks that do not directly target the exchange rate respond to foreign interest rate shocks to the extent that any of their targets, be it inflation or output gaps, gets affected by it. Despite these caveats it will be informative to take a look at the regression results, also in order to get an idea of how the results presented here relate to results reported by key reference papers that have applied similar UIP regressions (Obstfeld *et al.* , 2005; Shambaugh, 2004). In order to sharpen the peg-float contrast, I will exclude countries that follow an intermediate exchange rate regime, such as a managed float or a crawling peg from the following analysis (see Klein and Shambaugh, 2015).

In the following I will make use of a regression equation that allows to directly compare interest rate co-movement among pegs and floats, and that allows to statistically test whether floating exchange rates have the power to decouple domestic interest rates:

$$\Delta r_{k,t} = \beta_0 + \beta_1 \Delta r_{l,t} + \beta_2 \Delta r_{l,t} * float_{kl,t} + u_{kl,t}\,, \tag{5}$$

where $float$ denotes a float dummy taking the value 1 for free floats and 0 for strict pegs. r the risky rate, and u is the error term. In this specification β_1 indicates the strength of the co-movement of domestic risky rates with foreign risky rates among pegs and β_2 indicates the efficacy of a floating exchange rate in decoupling the domestic risky rate from their foreign counterpart. On the basis of this specification it is possible to give an indication of the *decoupling power* of a floating exchange rate:

$$DCP = \frac{\widehat{\beta_2}}{\widehat{\beta_1}}\,. \tag{6}$$

The ratio quantifies the effectiveness of a floating exchange rate in decoupling local interest rates from foreign ones. A value of -1 indicates that a floating exchange rate has the power to completely uncouple domestic rates from foreign ones. A value of 0 indicates that floating exchange rates are completely ineffective. The analogous measure can be calculated for safe rates.

through higher policy rates. Such scenarios would result in an overestimate of the systematic co-movement in interest rates among floats. The same holds for the mirror image of this scenario, i.e. a safe haven where capital inflows put upward pressure on the exchange rate, but who at the same time lowers its policy rates. A downward bias in β_1 would follow from scenarios in which lower policy rates and an expected exchange rate depreciation are the result of an anticipated period of sluggish economic growth. In general, however, there is no reason to believe that among floats β_1 would be systematically overestimated due to this omitted variable problem, and hence among floats β_1 can be expected to be lower than among pegs if UIP holds.

Finally, the above argument assumes an open capital account. If effective capital controls are in place this constitutes another way domestic interest rates can diverge from the base country's rate. In order to sharpen the focus on the peg-float dichotomy the following analysis focuses on open pegs and open floats only, excluding bilateral country-pair-year observations in which any of the two countries in the pair has capital controls in place.

2.1.2 Data

In this section I introduce the dataset and discuss the important issue of exchange rate regime classification. The core of the dataset comprises annual interest rate data from the latest vintage of the Jordà-Schularick-Taylor (JST) Macrohistory Database (Jordà *et al.* , 2016, http://www.macrohistory.net/data/). This database ranges from 1870 to 2015 and covers 17 countries: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, U.K. and the U.S.. Combined, these 17 countries make up more than 30% of world GDP throughout the sample period. For the post-1950 period I extended this sample by an additional 156 countries for which interest rate data was available from public sources, either the IMF's International Financial Statistics, national statistical offices or national central banks (see table 16).

Interest rates: To compare the co-movement of short-term risk free rates with risky rates I make use of the short-term safe rate contained in the JST database. Concerning risky rates, there exist various candidate rates. Risk premiums differ according to the riskiness of the underlying investment projects. Lending secured by mortgages may carry a lower premium than bank lending to businesses. Furthermore, the institutional framework within which intermediation takes place matters for the riskiness of an investment. Most notable here is the distinction between bank lending and capital market based lending. For this reason the following analysis will also look at corporate bond yields. Long-run series from 1870 to 2015 on these risky rates have recently been compiled for the above listed 17 country sample by Zimmermann (2017) (mortgage- and bank lending rates) and Kuvshinov (2017) (corporate bond yields). The broader post-1950 sample draws from various public sources.[10]

[10]Data availability differs widely across series. Only few countries host liquid corporate bond markets. Coverage for the private bond yield series is thus generally lower than that for the mortgage rate- or bank

Maturity also matters. While short-term safe rates range from overnight rates (interbank lending) to 3-month rates (treasury bills) the maturity of the average corporate bond underlying the corporate bond yield series centers around 10 years.[11] In order not to confound risk premiums effects with term premiums effects the following analysis corrects for the term premium. This term premium is calculated as the difference between short-term safe rates and long-term safe rates. For the long-run 17-country sample the long-run government bond yield series I use also comes from Kuvshinov (2017), while for the additional 156 countries in the post-1950 sample I again draw from the IMF's International Financial Statistics, national statistical offices and national central banks.

Due to its scope the sample contains various extreme episodes, outliers that if not dropped would dominate any non-robust estimation procedure. I thus drop any country-pair-year observation in which the first difference of the domestic or base country interest rate exceeds 50 ppts. This excludes the most severe cases of hyperinflation and financial panic from the analysis.

Finally I followed Obstfeld *et al.* (2005) in making the following sample adjustments: I dropped country-pair-year observations in which one of the countries changes its exchange rate status from peg to float or vice versa. I deleted the war years 1914-1918 and 1939-1945, and in order to remove administered non-market rates from the sample I dropped spells during which interest rates stay constant for more than 2 years.

Exchange rate regime: The classification of the exchange rate regime has long been recognized as an important issue in the empirical trilemma literature (Klein and Shambaugh, 2015). Before World War 2 my peg dummy follows Obstfeld *et al.* (2004) and Obstfeld *et al.* (2005); thereafter I rely on the exchange rate regime classification scheme of Ilzetzki *et al.* (2008) (1940-1959) and the Shambaugh exchange rate classification dataset (1960-2014) (Klein and Shambaugh, 2008; Obstfeld *et al.* , 2010; Shambaugh, 2004).[12] Thus my peg dummy takes the value of 1 if a country was on the gold standard before 1940. From 1940 on it is 1 for economies, whose exchange rate stays within a +/- 2% band,

lending rate series.

[11]The average maturity of the mortgage contracts underlying the mortgage rate series are also at the longer end of the maturity range, whereas the bank lending series reflects the price of risky intermediation at shorter maturities.

[12]I switch from the Ilzetzki *et al.* (2008) to the Shambaugh (2004) exchange rate classification scheme at the earliest possible date in order to make my results more comparable to the latter, whose findings constitute a key reference for my analyisis.

and 0 otherwise.[13] The distinction between pegs and floats becomes less clear-cut over time, because the trilemma gets "cornered" more often by intermediate regimes, such as crawling pegs and managed floats (Klein and Shambaugh, 2015). In order to focus on the peg-float distinction I abstract from such intermediate regimes and focus on strict pegs and free floats only, strict pegs being defined as countries whose exchange rate remains within a +/-2% horizontal band.

With respect to the selection of the base country against which other countries peg, I for the most part follow Jordà *et al.* (2015) and Shaumbaugh's exchange rate regime classification dataset. With only a few exceptions in the 17-country pre-1914 sample, the U.K. is usually treated as the base country. For the Netherlands, Norway, Italy and the U.K. itself, however, Germany is considered the base country (see Morys, 2010, on the details of who followed who during the pre-1914 Gold Standard). In the interwar period exchange rate relations become more complex. With a few exceptions the following holds for the 17 country interwar sample: The U.S. is the base until its devaluation in 1933. Thereafter France takes over as base from 1933 to 1935. From 1936 onwards, with France's exit from gold, the U.S. becomes the general base again.[14] Exceptions to this general pattern are the following cases (see Eichengreen and Irwin, 2010): Two countries, Canada and Italy follow the U.S. after its exit from gold. Thus the U.S. remains their base throughout the interwar years. The sterling bloc, consisting of Australia, Norway, Denmark, Finland, Sweden and Japan leave the Gold Standard in 1931 shortly after the U.K., which thus remains their base country until 1939.[15] After 1945, and up to 1959 in general the U.S. continues to be the base for the 17 country sample. The only exception to this is Australia which remains part of the Sterling bloc. Furthermore Germany is treated as the U.S.'s base country. From 1960 on I for the most part rely on the base country classification from the Shambaugh exchange rate classification dataset.[16]

The peg dummy together with the base country indicator allows me to construct a bilateral dataset and a bilateral peg dummy which reflects the exchange rate regime prevailing between any country-pair at any point in time. Thus in years when Italy

[13] I follow Obstfeld *et al.* (2005) in not considering one-off re-alignements as breaks in the peg regime. Similarly, single-year pegs are recoded as floats, as they quite likely simply reflect a lack of variation in the exchange rate.

[14] In 1932, between the U.K. exit and the U.S. exit from gold France is treated as the base for the U.S..

[15] Here I deviate from the base classification by Jordà *et al.* (2015), who define a hybrid base interest rate as the average of French, U.K. and U.S. rates. The reported results however are robust to the base rate definition in Jordà *et al.* (2015).

[16] One exception is Australia, which up to 1966 is pegged to the British pound (GBP), at which point the U.K. devalues but the Australian dollar does not follow.

was pegged against Germany, and Germany against the U.S. also Italy and the U.S. are treated as a fixed exchange rate pair. Similarly in years when both, Canada and Japan, are pegged against the USD Canada and Japan are also treated as a fixed exchange rate pair. I construct the bilateral peg dummy that indicates whether the exchange rate between any two countries k and l is fixed or floating in three steps.

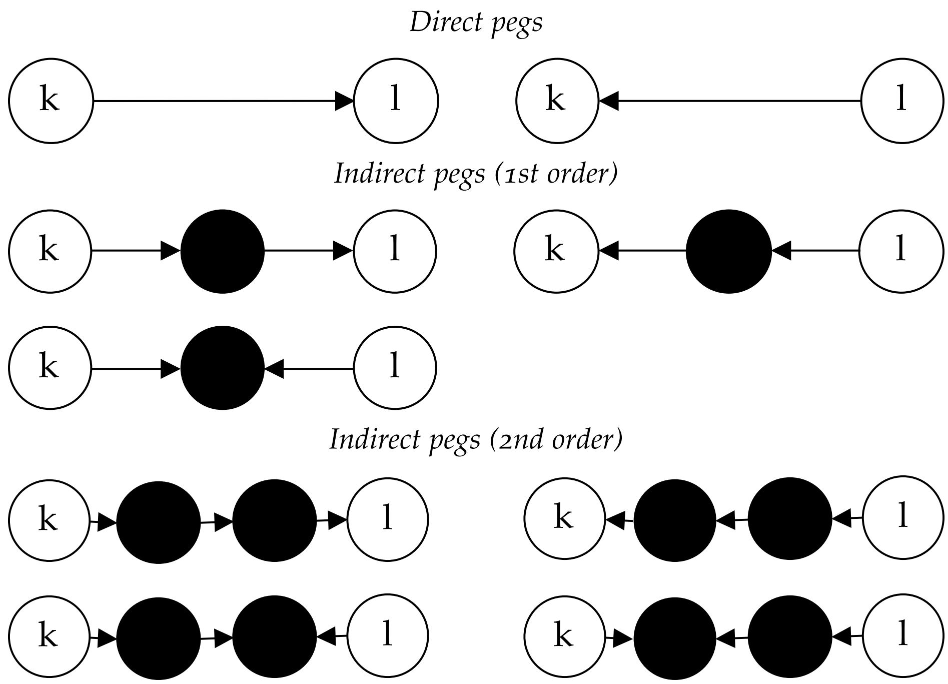
First, on the basis of the peg dummy and the base country series it is possible to determine country-pairs that entertain an indirect peg status. Historically, there exist hardly any cases of more indirect pegs than those of second order, meaning that two countries' exchange rates are linked to one another indirectly through a chain of pegs involving two other countries (see the above example on Italy and the U.S.). Figure 1 gives a schematic description of all possible indirect bilateral peg relations.

Second, I separate the country-pairs with indeterminate bilateral exchange rate status from the bilateral floats. If there were no missing values with respect to the peg status and the base country for any observations, the set of bilateral floats would simply be the complement of the bilateral peg set. However, there are several missing values for the peg and base country variables. Thus in many years it is impossible to determine whether a country-pair entertains an indirect peg. In this case I set the bilateral peg dummy to missing, with one exception: It is possible to determine that two countries' exchange rate is floating regardless of whether information on the respective base countries is missing if the peg dummy equals zero for both countries.

Finally, once the set of bilateral pegs and indeterminate cases have been identified the set of bilateral floats is the remaining complement. This approach allows me to exploit the many indirect pegs and floats contained in the sample. This approach drastically increases the number of bilateral country-pair observations over the more conventional approach of only considering country-pairs in which at least one of the countries is a canonical base country (either the U.S., the U.K. or Germany) (Obstfeld *et al.* , 2005; Shambaugh, 2004).

Capital controls: Capital controls are an important conditioning variable when testing the effectiveness of floating exchange rates in decoupling local interest rates. For the post-Bretton Woods period I use the latest vintage of the openness indicator by Chinn and Ito (2008) in order to separate open economies from ones with significant capital

Figure 1: *Bilateral pegs*



Notes: Circles indicate countries. Arrows indicate peg relations, with the arrow head pointed towards the base country.

controls in place.[17] The openness indicator by Chinn and Ito (2008) exhibits a trimodal distribution (see Klein and Shambaugh, 2015) of open economies, closed economies, and a middle group of countries with some capital controls, but fewer and less stringent ones than the closed economy group. I construct a capital control dummy that treats only observations with an openness indicator above or equal to .79 (separating the highest mode) as open economies and all others as closed.[18]

During the Bretton Woods era most countries had implemented capital controls of one kind or another. The few exceptions, such as Canada between 1952 and 1967 or Germany between 1957 and 1972 are documented in the dataset by Quinn *et al.* (2011) or by Beckers (2006). For the interwar years I rely on the capital control data from the League of Nations that has been compiled by Obstfeld *et al.* (2004), the capital account

[17]In some cases I fill missing values for the post-1973 data by gleaning at the openness indicator provided by Quinn *et al.* (2011).

[18]An important reason for this rather strict separation of economies with an open capital account from economies with partly regulated capital accounts is that for the international equalization of risk premiums for assets within the same risk class to occur capital markets for safe as well as risky assets have to be integrated (see Dedola and Lombardo, 2012).

openness information contained in Eichengreen and Irwin (2010) and again the openness indicator by Quinn *et al.* (2011). Finally for the pre-1914 years I follow Obstfeld *et al.* (2005) with respect to the capital control dummy in that I treat capital controls as alien to that period.

2.1.3 Results

In order to empirically assess the extent to which international co-movement in risk premiums has compromised the effectiveness of floating exchange rates I will first study the degree of co-movement of risk-premiums. After having established that risk premiums co-move globally, this section provides a quantitative assessment of the degree to which floating exchange rates have been overwhelmed by global co-movement in risk premiums.

The global co-movement of risk premiums: To analyze the co-movement of risk premiums I run regressions of the form

$$\Delta\rho_{k,t} = \beta_0 + \beta_1 \Delta\rho_{l,t} + \epsilon_{kl,t}, \tag{7}$$

where $\rho_{k,t}$ and $\rho_{l,t}$ denote the risk premiums in countries k and l respectively. The risk premium in mortgage rates and private bond yields is calculated as the difference between the risky rate and the long-term safe rate, whereas the bank lending risk premium is calculated as the difference between the bank lending rate and the short-term safe rate, due to the generally shorter maturity of the underlying bank loans. I furthermore compare the co-movement in risk premiums with the co-movement of safe rates.

The results displayed in table 1 indicate that there is significant co-movement in international risk premiums. Co-movement is strongest for the risk premiums calculated from mortgage rates and private bond yields. As a robustness check, figure 9 in the appendix shows the equivalent results obtained from risk-premiums that I have calculated by subtracting base-country safe rates instead of local safe rates from local risky rates (i.e. U.S., U.K., and Germany safe rates). For these risk premiums the co-movement is even closer.

Floats at risk? The previous paragraph has shown that risk premiums co-move internationally. To which extent does this practically invalidate the trilemma for risky rates? To address this question I estimate regression equation 5 and show the decoupling power of

Table 1: *International co-movement of safe rates and risk premiums*

	Safe rates		*Risk premia*		
	Δi^{ST}	Δi^{LT}	$\Delta \rho^{\text{Mort}}$	$\Delta \rho^{\text{Bank}}$	$\Delta \rho^{\text{Corp}}$
β_1	0.013**	0.038**	0.056**	0.013***	0.150**
	(0.006)	(0.017)	(0.027)	(0.005)	(0.073)
N	271204	15252	4874	7903	1449
R^2	0.04	0.23	0.29	0.17	0.10

Notes: Estimated β_1 coefficients from regression equation 7. Driscoll-Kraay standard errors in parentheses (accounting for 3 lags of autocorrelation). All specifications include country-pair fixed effects. Periods: Pre-1914 (1874-1913), Interwar (1925-1938), Bretton Woods (1950-1969), Post-Bretton Woods (1974-2015). Sample excludes WW1 (1914-1918) and WW2 (1939-1945) periods, as well as outliers, defined as absolute interest rate movements in excess of 50 ppts.

floating exchange rates (equation 6). The analogous measure for safe rates is obtained by substituting the risky rate r in equation 5 with a safe rate i and using the resulting coefficient estimates to form the DCP ratio.[19]

The coefficient estimates and the ratio are displayed in table 2. Clearly, among pegs there exists strong and significant co-movement of domestic interest rates with foreign safe- and risky rates. The estimated coefficients on the float-interaction term suggest that a floating exchange rate is effective at decoupling local safe rates. For them, a floating exchange rate achieves an -87% to -96% reduction in co-movement; similarly so for mortgage rates. With respect to the more risky bank lending rate and corporate bond yields the estimated coefficients suggest that floating exchange rates are ineffective, with insignificant DCPs of -19% and an insignificant 11% respectively. The evidence thus supports the thesis that a floating exchange rate is less useful in achieving domestic monetary autonomy when it comes to risky rates than for safe rates.

The emergence of a global risk premium co-movement: Is strong international co-movement in risk premiums a new phenomenon or have risk premium spillovers always overcome flexible exchange rates? In order to answer this question I look at the co-movement of risk premiums in four sub-samples: The pre-1914 Gold Standard era, the interwar years, the Bretton Woods era and the post-Bretton Boods period. The interwar subsample excludes the years 1919 - 1924 and 1931 - 1935, the chaotic construction- and

[19]In order to avoid giving excessive weight to Eurozone interest rates I only considered German interest rates and dropped other Eurozone members' rates from the analysis.

Table 2: *The decoupling power of floating exchange rates*

	Safe rates		Risky rates		
	Δi^{ST}	Δi^{LT}	Δr^{Mort}	Δr^{Bank}	Δr^{Corp}
β_1	0.10**	0.59***	0.27***	0.38***	0.47***
	(0.05)	(0.04)	(0.07)	(0.07)	(0.11)
β_2 $(float)$	-0.09*	-0.57***	-0.21***	-0.07	0.05
	(0.05)	(0.05)	(0.07)	(0.08)	(0.11)
DCP	-87%	-96%	-79%	-19%	11%
	(7.92)	(3.15)	(15.20)	(18.55)	(25.87)
N	17344	5854	4018	2451	1067
R^2	0.35	0.31	0.35	0.29	0.40

Notes: DCP – decoupling power of floating exchange rates. Driscoll-Kraay standard errors in parentheses (accounting for 3 lags of autocorrelation). All specifications include country-pair fixed effects. Periods: Pre-1914 (1874-1913), Interwar (1919-1938), Bretton Woods (1950-1972), Post-Bretton Woods (1973-2007). Sample excludes WW1 (1914-1918) and WW2 (1939-1945) periods, as well as outliers, defined as absolute interest rate movements in excess of 50 ppts. Standard errors in parentheses.

collapse-years of the interwar Gold Standard. The Bretton Woods subsample starts in 1950 and lasts until 1969, the beginning of a phase of speculative attacks that ushers in the end of the Bretton Woods era.

The subsample results are displayed in table 3. Safe short-term and long-term rates have exhibited significant international co-movement throughout the past 150 years. Unsurprisingly co-movement among safe rates was stronger in earlier sub-periods – the pre-1914 Gold Standard, the Gold Exchange Standard of the interwar years and the Bretton Woods system – all gold-based fixed exchange rate regimes. In contrast, extensive international co-movement of risk premiums is a rather new phenomenon that is unique to the post-1973 period. Only for the interwar years is there some indication of international risk premium co-movement as evidenced by the significant coefficient for the bank-lending risk premium.[20]

[20]For the subsample regressions I dispense with capital control regressors. The temporal dimension acts as a control for the degree of financial integration (see Obstfeld *et al.* , 2005). Capital controls were low or non-existent prior to 1914, they were then built up during World War I and subsequently rolled back until the international monetary system broke apart during the Great Depression. The Bretton Woods era was characterized by strict capital controls, which then again were rolled back after the Bretton Woods regime came to an end.

Table 3: *The rise of risk premium co-movement*

	Safe rates		*Risk premia*		
	Δi^{ST}	Δi^{LT}	$\Delta\rho^{\text{Mort}}$	$\Delta\rho^{\text{Bank}}$	$\Delta\rho^{\text{Corp}}$
			Pre-1914		
β_1	0.13***	0.17***	0.01	0.02	0.01
	(0.01)	(0.02)	(0.02)	(0.03)	(0.04)
N	3032	2542	1113	169	596
R^2	0.05	0.09	0.07	0.06	0.03
			Interwar		
β_1	0.25***	0.05	0.10	0.13**	-0.01
	(0.03)	(0.06)	(0.07)	(0.06)	(0.07)
N	686	609	382	190	278
R^2	0.24	0.10	0.08	0.43	0.22
			Bretton Woods		
β_1	0.05***	0.20***	-0.01	0.05	0.05
	(0.01)	(0.02)	(0.03)	(0.04)	(0.04)
N	6017	3328	943	805	739
R^2	0.24	0.09	0.06	0.10	0.02
			Post-Bretton Woods		
β_1	0.02***	0.03***	0.06***	0.03***	0.13***
	(0.00)	(0.00)	(0.01)	(0.01)	(0.04)
N	249943	33751	5498	13609	1246
R^2	0.04	0.11	0.15	0.06	0.02

Notes: Driscoll-Kraay standard errors in parentheses (accounting for 3 lags of autocorrelation). All specifications include country-pair fixed effects. Periods: Pre-1914 (1874-1913), Interwar (1919-1938), Bretton Woods (1950-1972), Post-Bretton Woods (1973-2007). Sample excludes WW1 (1914-1918) and WW2 (1939-1945) as well as outliers, defined as absolute interest rate movements in excess of 50 ppts.

The declining effectiveness of floating exchange rates: To get an idea of what the emergence of global co-movement in risk premiums means for the decoupling power of floating exchange rates over time this section presents a sub-period analysis of regression equation 5 and the decoupling power (DCP) ratio (equation 6). I consider the same four subsamples introduced earlier. Table 4 shows the results.

The pre-1914 era stands out as an era in which floating exchange rates had strong decoupling power. DCPs for the most part indicate that the co-movement from pegging the exchange rate is completely compensated for by floating.[21] The decoupling power in the interwar years is similarly strong. Note, however, that the coefficients for corporate bond yields reverse sign. During the Bretton Woods era DCPs among bank lending rates and corporate bond yields are low, while DCPs for safe rates and mortgage lending rates remain high. In the immediate post-WW2 decades financial regulation, capital controls and the sheer absence of some financial markets broke the link between domestic and foreign risky rates.[22] Finally, in the post-Bretton Woods era, the overall degree of independence afforded by floating exchange rates has reached its lowest point in the past 150 years. Among bank lending rates and corporate bond yields floating exchange rates' decoupling power ranges from -59% to a statistically insignificant -26%.

The appendix presents the results of various additional analyses, which check the robustness of the findings presented here. Removing countries of dubious data quality from the sample yields very similar results (table 10). Among advanced economies floating exchange rates are somewhat less effective at decoupling risky rates (table 11) than among emerging markets (table 12).[23] With an eye on sample comparability over time, table 13 considers only the 17 early developing economies that are part of the pre-1914 sample for the post-1973 sample. Again, floating exchange rates exhibit decoupling power for safe rates, but not for risky ones. Finally, instead of considering 1-year changes in interest rates I also looked at 2-year changes. Some findings in the literature suggest that this approach reduces errors-in-variables problems and thus gives UIP a fairer chance to be born out by the data (Chinn, 2006; Lothian and Simaan, 1998). The results are very

[21] A DCP statistic below -100% points towards negative interest rate co-movement among floats.

[22] The Bretton Woods subsample is relatively short. The empirical UIP literature has long recognized that short samples are prone to yield paradoxical parameter estimates due to periods of imperfect expectation formation. For example, during the 1980s disinflation inflation expectations remained stubbornly high for a prolonged period. Such ex post expectation errors are more likely to dominate parameter estimates on short samples than on long ones (Lothian and Wu, 2011).

[23] This conforms with recent findings by Obstfeld *et al.* (2017) who show that, for a sample of emerging market economies, a floating exchange rate is still associated with more economic independence.

Table 4: *Effectiveness of floating for decoupling from global interest rates, all coefficients*

	Safe rates		Risky rates		
	Δi^{ST}	Δi^{LT}	Δr^{Mort}	Δr^{Bank}	Δr^{Corp}
			Pre-1914		
β_1	0.19***	0.42***	0.10***	0.33***	0.31***
β_2 ($float$)	-0.13***	-0.40***	-0.10	-0.27**	-0.41***
DCP	**-71%**	**-95%**	**-96%**	**-82%**	**-133%**
	(11.65)	(7.66)	(54.35)	(16.87)	(31.37)
N	3032	2542	1382	210	596
R^2	0.07	0.13	0.10	0.18	0.08
			Interwar		
β_1	0.38***	0.23	0.26**	0.79***	-0.13**
β_2 ($float$)	-0.38***	-0.26	-0.20*	-0.77***	0.11*
DCP	**-99%**	**-109%**	**-77%**	**-97%**	**-88%**
	(8.37)	(23.89)	(18.51)	(6.04)	(25.90)
N	686	609	519	216	278
R^2	0.28	0.11	0.10	0.33	0.06
			Bretton Woods		
β_1	0.14***	0.26***	0.16***	0.26***	0.31***
β_2 ($float$)	-0.16***	-0.16	-0.15***	0.02	0.15
DCP	**-115%**	**-63%**	**-94%**	**8%**	**48%**
	(46.02)	(35.91)	(38.27)	(24.17)	(37.71)
N	4907	2455	1110	771	518
R^2	0.32	0.12	0.17	0.18	0.18
			Post-Bretton Woods		
β_1	0.08***	0.14***	0.15**	0.23***	0.62***
β_2 ($float$)	-0.06***	-0.11**	-0.11*	-0.12***	-0.13
DCP	**-76%**	**-81%**	**-76%**	**-50%**	**-20%**
	(10.23)	(9.48)	(13.13)	(10.96)	(19.14)
N	165930	21100	10498	8912	674
R^2	0.07	0.19	0.16	0.13	0.30

Notes: *DCP* – decoupling power. Driscoll-Kraay standard errors in parentheses (accounting for 3 lags of autocorrelation). All specifications include country-pair fixed effects. Periods: Pre-1914 (1874-1913), Interwar (1919-1938), Bretton Woods (1950-1972), Post-Bretton Woods (1973-2007). Sample excludes WW1 (1914-1918) and WW2 (1939-1945) periods, as well as outliers, defined as absolute interest rate movements in excess of 50 ppts. R^2 and the number of observations N refer to the underlying regressions from which the parameters for the calculation of the decoupling power DCP have been obtained.

similar (table 14).

Sofar, the results suggest that risky rate co-movement differs in important ways from safe rate co-movement across exchange rate regimes. The presented co-movement analysis, however, does not distinguish between co-movement due to correlated exogenous shocks and co-movement due to endogenous transmission. For this reason the following section analyzes the response of pegs' and floats' interest rates to monetary policy shocks from financial center countries.

2.2. Financial center monetary policy transmission to pegs and floats

The second piece of evidence for the declining decoupling power of floating exchange rates in shielding local risky rates is born out by the study of the international transmission of financial center monetary policy shocks. For this purpose I look at the international spillover effects of two important financial centers' monetary policy: the Bank of England's discount rate policy, prior to 1914, and the Federal Reserve's interest rate policy, after 1973. The focus lies on discerning systematic differences in the reaction of pegs' and floats' interest rates. In contrast to the previous section's co-movement analysis this section makes causal claims as to the effectiveness of floating exchange rates in shielding local interest rates from monetary policy conducted in important financial centers.

Today, the U.S. dollar is an important vehicle currency that underpins today's global financial system.[24] U.S. monetary policy decisions thus have global reach (see Asgharian and Nossman, 2011; Bluedorn and Bowdler, 2011; Canova, 2005; Chudik *et al.* , 2013; Craine and Martin, 2008; Ehrmann and Fratzscher, 2009; Georgiadis, 2016; Hausman and Wongswan, 2011; Kim, 2001; Kose *et al.* , 2017; Maćkowiak, 2007). More particularly, Fed policy has been shown to influence risk appetite not only in the U.S. (Bekaert *et al.* , 2013; Gertler and Karadi, 2015) but globally (Miranda-Agrippino and Rey, 2015; Rey, 2016). Of particular interest here are recent findings that that U.S. monetary policy today has

[24] The U.S. dollar at the beginning of the 21st century makes up more than 30% of central banks' foreign exchange reserves, accounts for more than 40% of global exchange market turnover, 40% of OTC derivatives and the majority of international banking liabilities (Frankel, 2011). U.S. dollar-denominated assets of banks outside the U.S. amounts to around 10 trillion USD, about equalling the total assets of the U.S. commercial banking sector (Shin, 2012). USD credit extended by banks and bond investors to non-financial sector borrowers outside the USA is about 7 trillion USD. Also, around 80% of USD-denominated bank credit issued outside the U.S. has been issued by non-U.S. banks (see McCauley *et al.* , 2015). Furthermore U.S. equity markets constitute between 30 and 40% of global equity market capitalization and between 2000 and 2013 U.S. government and corporate bonds constituted between one third and one half of global bond market capitalization. About two thirds of the global stock of corporate bonds outstanding are issued in USD (according to Meryll Lynch Global Corporate and High Yield Index).

international knock on effects irrespective of exchange rate regime (Passari and Rey, 2015; Rey, 2016).[25]

Prior to 1914 the pound sterling was the world's leading foreign reserve-currency and its leading vehicle currency.[26] Thus financial conditions in London had international ramifications. Indeed in the late 19th century the global reach of U.K. monetary policy found its expression in the famous hyperbole that, if the Bank of England raised its discount rate to 7 percent, it could even ''attract gold from the moon''.

To see how effective floating exchange rates have been in decoupling domestic rates from financial center shocks I compare the interest rate responses of pegs and floats to U.K. monetary policy shocks prior to 1914 and U.S. monetary policy shocks in the late 20th and early 21st centuries. For this purpose this section introduces a monetary policy shock measure for the Bank of England (BoE) from 1880 to 1913, as well as a new dataset of hand-collected monthly policy- and risky rates. The BoE policy shock measure was inspired by the narrative policy shock measure introduced by Romer and Romer (2004) in that it isolates exogenous movements in the policy rate by accounting for the information available to policymakers at the time of their policy decision. On the basis of the new pre-1914 shock measure for BoE policy and the post-1966 shock measure by Romer and Romer (2004) for Fed policy it is then possible to analyze the differential response of pegs and floats to financial center monetary policy shocks in the pre-1914 and post-1973 eras.

[25]The transmission of U.S. monetary policy occurs through different channels. First, it affects the balance sheet capacity of global financial intermediaries that fund themselves in USD. This channel will be fleshed out in a model and quantitatively assessed in the second part of this paper. Relatedly, if contractionary U.S. monetary policy raises the USD exchange rate this impairs the risk-taking capacity of financial institutions whose USD liabilities exceed their USD assets (Bruno and Shin, 2015). Also, U.S. monetary policy may directly act as a focal point that synchronizes perceptions of asset price-risk among international investors (see Bacchetta and van Wincoop, 2013).

[26]The vast majority of foreign public debt was denominated in pound sterling (Chiţu *et al.* , 2014), about 60% of world trade was invoiced in this curreny (Eichengreen and Flandreau, 2012; Frankel, 2011), it made up the majority of central bank foreign exchange reserves (Lindert, 1969) and London was the world's preeminent financial hub dominating the global foreign exchange market (Flandreau and Jobst, 2005, 2009). At the same time the London stock exchange was the world's most extensive market place at which borrowers and lenders from all over the world were matched. About one third of all negotiable securities in the world were quoted there (Cassis *et al.* , 2016, p.299). The Bank of England was ascribed the role of "conductor of the international orchestra" of central banks (Eichengreen, 1987; Kindleberger, 1984).

2.2.1 Methodological approach

In order to analyze the international response to monetary policy in the financial center I estimate a set of impulse response functions through local projections (Jorda, 2005).

$$\Delta_{h+1} r_{k,t+h} = \alpha_k^h + \sum_{m=0}^{12} \beta_m^h \Delta r_{k,t-m} + \sum_{m=0}^{12} \gamma_m^h S_{t-m} + \sum_{m=0}^{12} \delta_m^h S_{t-m} float_{k,t} + u_{k,t+h}, \quad h = 0, ..., H \tag{8}$$

where α_k are country-fixed effects, $\Delta_{h+1} r_{k,t+h}$ are h-year changes rates in the interest rate r_k and $u_{k,t+h}$ are error terms.[27] The $\{\gamma_0^h\}_{h=1,...,H}$ in expression 8 allows me to sketch out the average behavior of international risky and safe interest rates over the H months following a U.S. policy rate shock S_t (post-1973) or a U.K. discount rate shock (pre-1914), while the $\{\delta_0^h\}_{h=1,...,H}$ allow me to investigate the differential in responses between pegs and floats. $float_{k,t}$ is a dummy variable that is 1 in periods when country k's exchange rate relative to the center country floats, has been floating for the previous 12 months, and will be floating for the following 36 months ($H = 36$). Analogously the dummy is 0 in months when the exchange rate is fixed in the current month, was fixed throughout the previous 12 months and continuous to be fixed in the 36 months to come. This definition ensures that estimated impulse response functions clearly distinguish between pegs and floats; any episodes in which countries switch from floating exchange rates to fixed ones and vice versa are thus eliminated from the sample. In all cases I make use of the bilateral peg dummy described in section 2.1.2.

In order to take into account differences in capital account openness I drop all country-month observations affected by capital controls from the sample in order to focus on the role of the exchange rate regime. For this purpose I use the capital control indicator described in section 2.1.2.

2.2.2 Data

Pre-1914 BoE monetary policy shocks: Prior to 1914 the BoE's key policy rate was its discount rate, i.e. the rate at which eligible paper (mostly 3-month bills of exchange) could be exchanged for BoE notes at the BoE's discount window.[28] In the spirit of Romer and Romer (2004) I consider a monetary policy rate shock measure which tries to correct for the endogeneity in discount rate changes by purging them of information that was

[27] This specification allows for a contemporaneous effect of the shocks S_t on the interest rate.

[28] The following description of BoE monetary policy operations draws extensively from Sayers (1976).

available to market participants and policymakers' at the time of the policy decision. The resulting shock measure constitutes discount rate changes that deviated from the rules implicit in the Gold Standard, and that came as a surprise to market participants and the wider public.

On which information was the BoE's discount rate decision based? Most crucially prior to 1914 the BoE's discount rate decision was informed by the composition of its balance sheet. Changes in the discount rate were primarily targeted at ensuring the gold-convertibility of BoE notes through a sufficiently high ratio of liquid assets (i.e. gold or assets that were quickly convertible into gold) to liquid liabilities. Most important in this respect was the "proportion". The proportion was the ratio of total reserves to the sum of deposits and post bills.[29] Total reserves were made up of notes, gold- and silver coins. The notes-part of total reserves was made up of "notes in the bank", i.e. notes that were backed by the Issue Department of the Bank of England with gold bullion or gold coin.[30] The proportion's prominence in the central bankers' minds is evident in the fact that it was calculated and reported in the BoE's daily accounts, with occasional counterfactual proportions being calculated and scribbled into the daily accounts by the directors.

Another item in the BoE's balance sheet that was influential in deciding upon the discount rate level was the weekly change in the value of bills discounted. If at the going rate the discount window was accessed frequently, and the resulting asset swap from (gold-backed) notes to discounted bills quickly lowered the BoE's Banking Department's reserves the BoE was more inclined to increase its discount rate. In this way discount rate policy was systematically countercyclical to money demand and economic activity more generally.

As regards timing, an up to date version of the balance sheet was presented to BoE directors every morning, including on Thursdays when the Court of Directors usually accepted the discount rate change proposed by the Governor. On Thursday mornings the Directors would be handed an individual copy of the BoE's balance sheet, which also was the last piece of information available to the Governor on the basis of which to make his discount rate proposal. Usually the bank's Governor stuck to the discount rate proposal already made by the Committee of Treasury on Wednesdays. Formally however

[29] Deposits included public and private deposits, the majority being private. Post bills constituted an alternative to bank notes, but were safer to send through post. They constituted only a minor part of the Banking Department's liabilities.

[30] The gold backing exempted a fiduciary note issue whose amount was increased on an irregular basis.

the Governor had the right to deviate from this proposal. Thus if the Thursday morning balance sheet should contain some new information according to which the Governor saw the discount rate proposal from the previous day unfit he could change it. In this sense the Thursday morning balance sheet, with the latest figures from Wednesday constituted the latest information set of decision makers at the BoE.[31]

Given this balance sheet information I regress the weekly change in the BoE's discount rate (Δi_t) on the proportion (p_t), the change in the proportion, the change in discounts (Δd_t), as well as 1 lag of all these. Finally I add the previous week's discount rate level (i_{t-1}) among the regressors, in order to capture mean reversion in the discount rate.

$$\Delta i_t = \alpha + \beta i_{t-1} + \sum_{m=-1}^{0} \gamma_m p_{t+m} + \sum_{m=-1}^{0} \delta_m \Delta p_{t+m} + \sum_{m=-1}^{0} \eta_m \Delta d_{t+m} + S_t \quad (9)$$

The estimated residual $\widehat{S}_t$ constitutes the resulting monetary shock measure.[32] This shock series is displayed in figure 2 (this is the monthly mean of the weekly shocks).

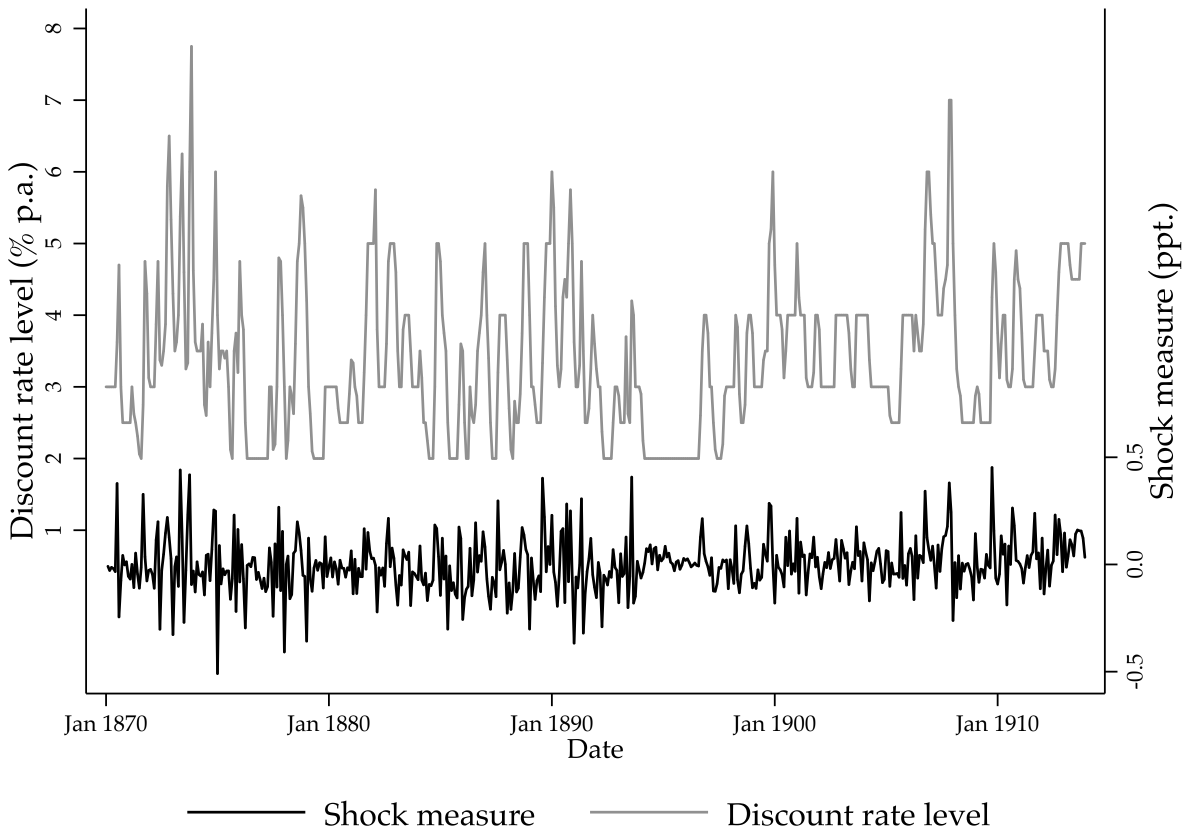
As a validation exercise I check whether the weekly shock series is correlated with changes in the mentioning of the BoE's discount rate policy in the news in the week following the discount rate decision. A surprising discount rate change should be reflected in a subsequent increase in the news coverage of the policy move. For this purpose I ran a word search for the term "bank rate" in the daily newspaper *The Guardian*. I then regressed the absolute value of the weekly discount rate shock on the weekly change in word counts for "bank rate". The results are shown in table 5. The correlation between the absolute discount rate shock and the word count is highly significant. Thus the calculated shock measure reflects policy moves that were perceived as surprising enough by contemporary observers to warrant increased news coverage.

Post-1973 Fed monetary policy shocks: For the post-1973 era I use the narrative shock measure that was introduced by Romer and Romer (2004) and subsequently extended

[31] Occasionally, in response to a crisis situation, the Governor had the power to enact a so-called "Governor's rise", i.e. an unscheduled change in the discount rate which then would be retrospectively accepted by the following session of the Court of Directors. In these cases I take the Governor's information set to have been the balance sheet at the day of the unscheduled discount rate change, containing balance sheet information up to the previous day.

[32] In contrast to the shock measure proposed by Romer and Romer (2004) this setup does not include any forward looking information. Indeed professional economic forecasts only became a common feature of economic policy making later. As such the focus on backward looking balance sheet information, provided though on a daily basis, reflects one of the more mechanistic aspects of central banking under the gold standard.

Figure 2: *Bank of England's discount rate and monetary shock measure*



by Coibion *et al.* (2012). This shock measure attempts to isolate exogenous variation in the intended Federal Fund rate by purging it from information about the economy that central bankers had at the time they decided upon their new policy rate. In contrast to the previously introduced shock measure for the BoE, today's central bankers base their decision not mainly on the central bank's balance sheet, but instead on the information they have about the past, present and expected future behavior of the economy. Thus Romer and Romer (2004) used the Federal Reserve's internal estimates and forecasts about past, current and future inflation, real output and unemployment to purge the intended Federal Fund rate of any anticipated movements and obtain a residual that can be interpreted as a monetary policy shock (analogously to equation 9). I use this monthly narrative shock series as the interest rate shock measure S_t from 01:1973 until 12:2008, in order to assess the impact of U.S. monetary policy on pegs' and floats' interest rates according to the local projection described earlier (equation 8).

Table 5: *Validation: Correlation with word counts from The Guardian*

	(1)	(2)
"Bank rate" count	0.7330***	0.7188***
	(13.1595)	(13.0578)
Month FE	No	Yes
Observations	2008	2008
adjusted R2	0.08	0.10

Dependent variable: Absolute value of discount rate shock. t-statistics in parentheses.

Pre-1914 monthly interest rate data: In order to investigate the international impact of pre-1914 U.K. monetary policy on pegs and floats respectively I collected monthly short-term policy rates and risky rates for Sweden, Denmark (pegs), Spain, Portugal (floats) and Japan (float until 1897 and peg afterwards).[33] The risky rate is either a bank lending rate or a corporate bond yield index which I constructed from the coupon rates and bond prices reported in local newspapers. The corporate bond yield index is an equal weighted average of the corporate bond yields of private companies. Importantly, the bond yield index only makes use of bonds that were denominated in local currency.[34]

Post-1973 monthly interest rate data: For the post-1973 years, the monthly time series for safe and risky rates come from the same sources as the annual data do: the IMF's International Financial Statistics, national statistical offices or national central banks. For the risky rate I use lending rates for unsecured bank lending to private corporations and households of relatively short maturities. The safe rate usually is the central bank's policy rate, a short-term money market rate or the current yield of a short-term government bond. In total the sample covers 48 countries (see table 17).

2.2.3 Results

Pre-1914 Bank of England policy spillovers: The top two panels in figure 3 displays how the world reacted to a +1ppt increase in the BoE's discount rate in the first era of financial globalization prior to 1914. The left figure displays how safe policy rates of pegs

[33] In Portugal gold convertibility ceased in 1891 from which point on the discount rate is not used to stabilize the exchange rate. In Spain gold convertibility ceased in 1883 and a de facto fiat money system was established as silver convertibility became irrelevant (Martín-Aceña, 2007).

[34] While floating pound-sterling denominated bonds on the London Stock Exchange was a first choice for many companies located in peripheral economies, a substantial fraction of bonds was nevertheless issued in domestic currency in the home market (Mitchener and Pina, 2016).

(black solid line) and floats (blue dashed line) responded. As can be seen, floats exhibited no response, while pegs exhibit a full +1ppt increase in their safe rate within about 12 months. The blue points on the floats' impulse response indicates whether the floats' response differs statistically significantly from the pegs' response according to a Wald test for equality of responses.

The upper right panel displays the equivalent IRFs for risky rates. Again the pegs exhibit a complete pass-through while floats respond little. In general floating exchange rates were an effective instrument for decoupling domestic interest rates – risky and safe – from BoE policy.

Post-1973 Federal Reserve policy spillovers: The lower half of figure 3 shows the differential effect of Fed interest rate shocks on pegs and floats. For safe rates, the pass-through among pegs is complete and takes place within six months. Floats' safe rates also react, but far less so, exhibiting about two fifth, or 40%, of the response of floats. The floats' response is indicative of the long-run increase in the global synchronization of underlying economic fundamentals (Bordo and Helbling, 2011), which induces central banks to synchronize policy rates, even among floats. The difference to the pegs' response, however, is still significant at the 95%-level throughout the 36-month horizon.

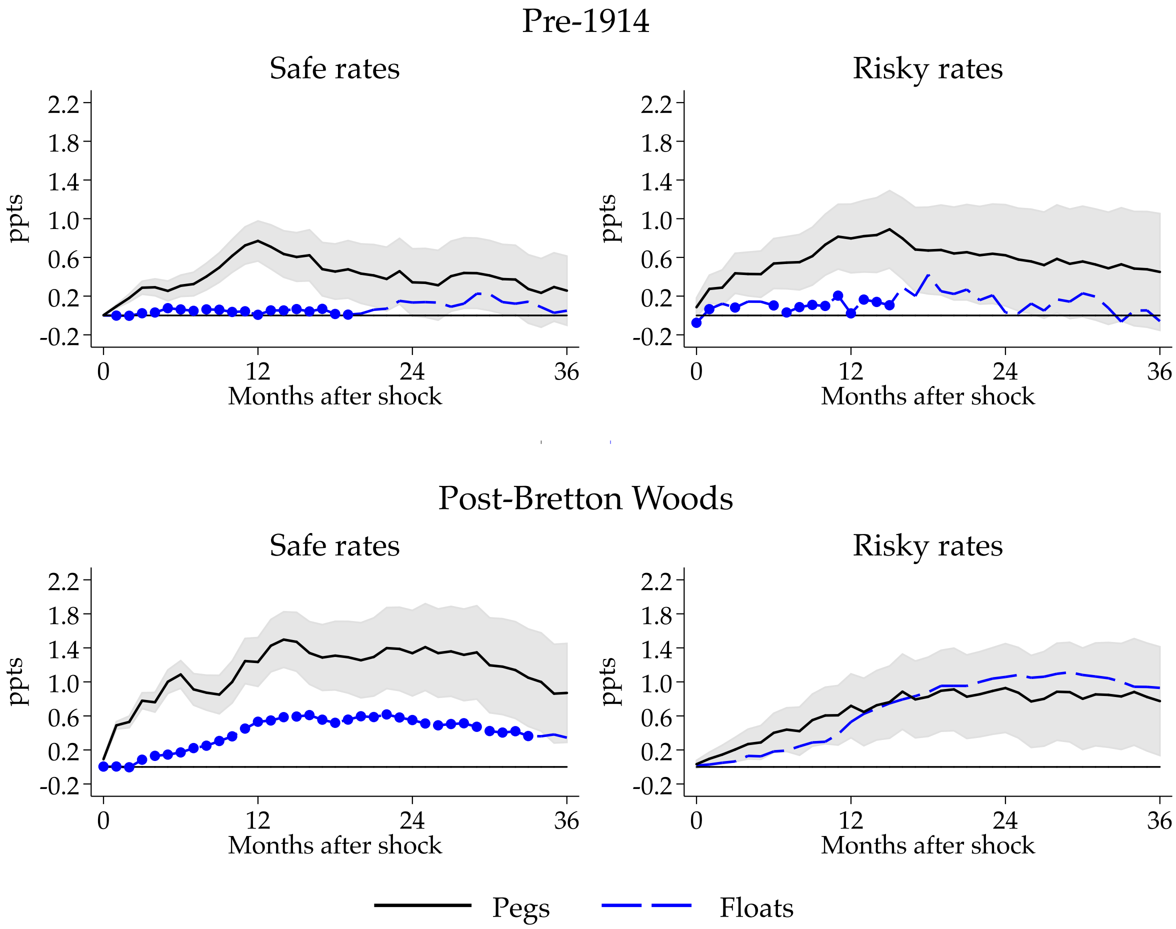
The difference between pegs and floats, however, is no longer significant for risky rates. In contrast to the early 20th century floating exchange rates have become much less effective in insulating an economy's risky rates from U.S. monetary policy shocks in the Post-Bretton Woods era of financial globalization. In particular, in the aftermath of a contractionary U.S. policy rate shock, the spread of floats' risky rates over floats' safe rates increases by around 0.4 ppts, closing the gap to the pegs' response. In contrast, the pegs' response does not exhibit a similar increase in spreads. All movement in the pegs' risky rate comes from movement in the safe rate.[35]

I also considered a subsample of advanced economies, on which most of the recent evidence in the dilemma literature is based on (Passari and Rey, 2015; Rey, 2016). I find that for advanced economies post-1973, floating exchange rates are associated with somewhat more risky rate independence in the short-run. After 12 months, however, the peg-float difference has again vanished (see figure 7 in the appendix).[36]

[35] The risky rate response for pegs is somewhat more sluggishly than the safe rate response. One reason for this might be that the risky rates are mostly bank lending rates, which have been shown to exhibit some rigidity (see Gerali *et al.* , 2010).

[36] It is well known that many emerging markets' ''safe rates'' contain a risk premium (Mauro *et al.* , 2002),

Figure 3: *Pegs' and floats' response to +1ppt policy rate shock from financial center*



Solid black line – response of pegs; dashed blue line – response of floats; Blue circles indicate the point-wise rejection of the null hypothesis that the peg response equals the float response at the 90% significance level, according to a two-sided Wald test. Confidence bands calculated on the basis of Driscoll-Kraay standard errors (accounting for 36 monthly lags of autocorrelation). All specifications include country fixed effects. Pre-1914 sample: 1880:1 to 1913:12; Post-Bretton Woods sample: 1973:1 to 2010:12.

In sum, these results underscore the long-run decline in the ability of floating exchange rates to decouple local risky rates. The absence of extensive risk premium spillovers in the early 20th century rendered floating exchange rates effective in decoupling safe, as well as risky rates from their global counterparts. By the late 20th century, however, risk premium spillovers have become pervasive enough to seriously qualify the effectiveness of floating exchange rates with respect to risky rates.

which quickly react to U.S. monetary policy.

3. Why do risk premiums co-move?

What lies behind the late 20th century rise in international risk premium synchronization? The early and late 20th century financial globalizations were both underpinned by financial openness. Financial openness allows international investors to engage in arbitrage until return differentials between assets within the same risk class are eliminated, and hence risk premiums are equalized (see Dedola and Lombardo, 2012).[37] Explanations based solely on financial openness, however, beg the question of why risk premium co-movement among floats is specific to the late 20th century and did not already occur in the early 20th century (see Quinn and Voth, 2008). To understand this, it is key to understand the differences in the financial institutions that underpinned both eras of financial globalization. In particular, the growing importance of globalized banks, and the interplay of leverage constraints and mark-to-market accounting they embody.[38]

3.1. The international risk-taking channel

To see how the combination of leverage constraints and mark-to-market accounting in global banks opens the door to extensive risk premium spillovers, even among floats, consider the following: When leverage-constrained banks become marginal investors in risky asset markets, bank leverage can become a driving force for excessive movements in risky assets' prices (Adrian and Boyarchenko, 2013b; Brunnermeier and Pedersen, 2009; Danielsson *et al.* , 2012).[39] Hence the movements in risky rates will be disproportional to movements in safe rates, which are set by the central bank. In an open economy this gives rise to a conflict between the international non-arbitrage conditions for safe and risky assets, because the nominal exchange rate can adjust to satisfy only one of the two.

[37]Also see Kollmann *et al.* (2011) and Alpanda and Aysun (2014) for theoretical accounts in which the international equalization of returns is driven by the optimizing behavior of a global bank, that exploits arbitrage opportunities across regions.

[38]While I concentrate on the explanatory power of differences in financial institutions Jordà *et al.* (2017) discuss several alternative explanations. For example, the pre-1914 Gold Standard introduced a desynchronizing force into global finance, because one region's gold inflows constituted another region's gold outflows. Thus, in contrast to today's fiat money system global liquidity supply in the 19th century Gold Standard was inelastic, rendering synchronized risk-taking less likely. Behavioral explanations that attribute financial excess variation to systematic mis-judgements in human psychology (Akerlof and Shiller, 2010; Kahneman and Tversky, 1979; Shiller, 2000) and to collective manias and panics (Kindleberger, 1978) face the difficulty of having to explain why international investors' behavior differs between the two eras of financial globalization, although they presumably were subject to the same cognitive constraints.

[39]Adrian *et al.* (2014) and Adrian *et al.* (2016) present empirical evidence that leverage-constrained banks are indeed influential marginal investors.

For example, the nominal exchange rate may satisfy the non-arbitrage condition for safe rates but not that for risky rates. This however is no equilibrium, because investors will shed the overpriced risky asset and buy the underpriced one until risky asset prices have adjusted sufficiently that the non-arbitrage condition for risky assets is satisfied. It is in this sense that risk premiums can overwhelm floating exchange rates and spill over from one currency area into another. Note the twofold role of banks here. First, as marginal investors their leverage constraint drives a wedge between the movement in safe and risky asset returns, and hence opens up the conflict for the nominal exchange rate to either equalize expected returns for safe or risky rates. Second, banks' international arbitrage activity ensures that the disproportional movement in risky rates spills over into the rest of the world.

From an individual bank's perspective the corresponding events depict themselves as follows: a fall in risky asset prices, that is not exactly offset by a movement in the exchange rate, affects the bank's leverage. Subject to a leverage constraint, and because issuing new equity is costly, the bank sells risky assets to fulfill its leverage constraint. The bank, however, does not sell risky assets indiscriminately. It sells home and foreign risky assets in a way that ensures that the non-arbitrage condition between the two is satisfied. This chain of events plays out simultaneously in different currency areas, because it pivots around a fall in global asset prices that affects banks everywhere. In this way risk-taking becomes synchronized, even among floats.[40]

3.2. Early vs. late 20th century financial institutions

How did financial globalization in the early 20th century look like to avoid extensive risk premium spillovers? In the early 20th century, financial globalization in general took the form of equity and debt securities traded on a stock exchange – first and foremost in London, but also in Paris and other Western European financial centers. The securities traded on these stock exchanges were a popular asset type with contemporary investors (Hoffman *et al.* , 2009). By the late 19th century, after decades of continuous refinements, stock exchanges had struck a balance between competition and market regulations that (international) investors and creditors preferred over alternative modes of intermediation (Cassis *et al.* , 2016, ch.11).

Among the financial institutions active on the stock exchange risk-sensitive funding

[40]Note that the international risk-taking channel described here is different from the one described by Bruno and Shin (2015), who focus on exchange rate valuation effects on banks' balance sheets.

and leverage constraints were less of a concern than they are for big global banks today. Investment trusts[41] and closed-end mutual funds were among the most active in underwriting overseas corporate securities. These institutions commonly pursued a long-term buy-and-hold investment strategy.[42] In the meantime, the composition of their portfolio, let alone its market value, could be hard to find out. Owing to the conservative balance sheet structure of these financial institutions, investors however also had less to worry about in the first place. Investment trusts typically invested less in equity than they issued ordinary shares themselves (Rutterford, 2009). The upshot of all this was the relative irrelevance of leverage constraints, and hence the absence of procyclical intermediary risk-taking. To the contrary, in times of crisis important global investors acted in a stabilizing way, by taking on debt in order to buy assets at depressed prices (Chambers and Esteves, 2014) .

Wealthy private individuals were another major participant on stock exchanges (Michie, 1986), contributing an estimated 5 to 10% of British capital investment abroad (Feis, 1964, p.24). Such investment typically is not affected by leverage constraints as it is rarely levered in the first place.

Finally, banks also played a role in early 20th century financial globalization. Especially so in Germany and France, where financial systems were more bank-based to begin with. However, banks tended to finance themselves through a comparatively stable base of deposits (Feis, 1964). This also was the case in Germany where a handful of great universal banks played a dominant role in underwriting, distributing and partly holding securities. Thus, to the extent that they were influential in foreign investment, the depositor-enforced leverage constraints of pre-1914 banks were most likely less stringent than those of today's banks, whose leverage faces surveillance from financial regulators and wholesale money market creditors alike.

The financial globalization that started in the late 20th century differed in crucial ways from that earlier in the 20th century. It was critically underpinned by large global banks – financial intermediaries that face leverage constraints and mark their assets to market.[43] Typical exemplars of today's global financial intermediaries are Wall Street investment banks and large European universal banks. These institutions' assets to capital ratio –

[41] The term investment trust here is meant to include investment trust companies, which are no legal trusts, but which made up the majority of investment trust after the 1870s.

[42] Consequently, these financial institutions had little turnover and made no attempt to act as market makers (Chambers and Esteves, 2014), a role which was firmly in the grips of stock exchanges.

[43] Many of these large banks were the result of mergers in which former investment banks became part of universal institutions (Cassis *et al.* , 2016, p.157).

a measure of their leverage – can be as high as 35 (see Eichengreen, 1999), but more typically centers around 10. These are commonly considered to be leverage-constrained institutions.[44]

Today's global banks have a much broader range of operations than banks in the early 20th century. They are influential players on many asset markets, such as commodity and derivative exchanges, the interbank bond market and over the counter (OTC) transactions. Due to their size banks can often act as market makers. The stock exchange, the unrivalled market place for securities in the early 20th century, has become only one among many market places over which global banks hold considerable sway. As a consequence, global banks' risk-appetite makes itself felt in asset markets throughout the world.

Vice versa, asset price movements throughout the world make themselves felt in global banks' risk-taking capacity. This is because the late 20th century has witnessed the spread of mark-to-market accounting practices. By comparison, pre-1914 investment companies, were intransparent. If they made their portfolios public at all, they did not mark their assets to market. Only after 1945 did business laws start to require financial trusts to reveal the current market value of investments in some way. It was even later in the 20th century that mark-to-market was turned into standard accounting practice (Newlands, 1997, ch.12). By the late 20th century, however, mark-to-market accounting had become so ingrained in global finance, that asset price movements anywhere could impact banks' balance sheets everywhere.

One particular type of formal leverage constraint that has come to characterize modern finance are value-at-risk (VaR) constraints.[45] In its simplest form a VaR constraint states that a bank's equity has to be sufficient to cover bad scenario losses. VaR is a risk-management metric that has its origins in the financial innovations of the 1970s and 1980s

[44]The exact forms and origins of the leverage-constraints faced by these institutions differ. Partly they are market enforced, partly they take the form of regulatory requirements. Leverage-constraints commonly address the need of the intermediary's creditors to counter problems of agency – ensuring the intermediary has enough 'skin in the game'. The late 20th century rise in bank leverage and leverage constraints thus are related to various factors that are beyond the scope of this paper, such as asymmetric remuneration schemes for bank management, limited liability, government guarantees, such as deposit insurance, and the preferential tax treatment of debt.

[45]A new literature on VaR based and related funding constraints has recently sprung up (Adrian and Boyarchenko, 2013a; Brunnermeier and Pedersen, 2009; Danielsson *et al.* , 2012). One particular advantage of this new generation of financial friction models over conventional credit-channel formulations based on Bernanke *et al.* (1999) and Kiyotaki and Moore (1997) is that they generate procyclical risk-taking. Empirically, Adrian *et al.* (2014) and Adrian *et al.* (2016) and have recently shown that intermediary leverage is a key for explaining observable asset price patterns. For this reason I model the bank's funding constraint as a VaR constraint, which states that the bank's value at risk needs to be covered by its equity.

that led to a proliferation of leverage and a growing need for an organization-wide risk metric. At the same time innovations in information technology and the falling price of computation power rendered VaR measures that had been proposed theoretically a few decades earlier practical (see Lintner, 1965; Markowitz, 1952; Mossin, 1966; Roy, 1952; Sharpe, 1964; Tobin, 1958; Treynor, 1961). As a consequence, VaR-like measures sprung up in trading environments during this period (see Garbade, 1987, 1986; Lietaer, 1971). Over the following years the spread of internal risk management techniques fed back into financial regulation and vice versa. In this way VaR-based measures spread even further and became enshrined into international financial regulation, such as the Basel accords or the EU's capital adequacy directive (CAD) (Holton, 2003).[46]

In order to quantitatively assess the extent to which the rise of VaR-constrained financial intermediaries can account for the observed international spillovers in risk premiums the following section introduces an international banking model in which banks mark their assets to market and face a VaR constraint.

4. A model of VaR constrained banking

This section rationalizes the empirical findings presented earlier through a two-country banking model with value-at-risk (VaR) constrained banks. In the two-country model leverage-constrained banks, that mark-to-market their assets, are marginal investors in global asset markets. Banks maximize the expected discounted utility streams of their local shareholders. They invest in an international portfolio of risky assets. This is funded through equity, as well as domestic and foreign debt, for which they pay domestic and foreign safe rates. The VaR constraint limits the banks' asset to equity ratio. Because the expected returns on risky assets exceed the costs of debt financing banks lever up to their VaR constraint.

The banks' optimizing behavior gives rise to arbitrage activity that ensures that the price for domestic debt equals the price for foreign debt plus the expected exchange rate change. In other words, uncovered interest rate parity holds for safe rates (in the

[46]As a consequence a new literature on VaR-based and related risk-sensitive funding constraints has recently sprung up (Adrian and Boyarchenko, 2013a; Brunnermeier and Pedersen, 2009; Danielsson *et al.* , 2012). One particular advantage of this new generation of financial friction models over conventional credit-channel formulations based on Bernanke *et al.* (1999) and Kiyotaki and Moore (1997) is that they generate procyclical leverage. Empirical support for this framework comes from Adrian *et al.* (2014) and Adrian *et al.* (2016) who have recently shown that intermediary leverage is a key for explaining observable asset price patterns.

linearized model). In equilibrium a similar non-arbitrage condition has to hold for domestic and foreign risky assets. However, when safe and risky rates do not move one-to-one, this gives rise to a conflict between the non-arbitrage conditions for safe and risky assets. The nominal exchange rate can adjust to satisfy only one of the two. For example, the nominal exchange rate may satisfy the non-arbitrage condition for safe rates but not that for risky rates. This however is no equilibrium, because investors will shed the overpriced risky asset and buy the underpriced one until risky asset prices have adjusted sufficiently, so that the non-arbitrage condition for risky assets is also satisfied. It is in this sense that risk premiums can overwhelm floating exchange rates and spill over from one currency area into another.

In the model, safe and risky rates do not move one-to-one, due to the interplay of leverage constraints, mark-to-market accounting practices, and costly equity adjustment. Consider any shock that puts downward pressure on risky asset prices. The drop in risky asset prices erodes foreign and home bank equity. Subject to VaR constraints, and because raising new equity is costly, the banks will adjust their leverage by selling risky assets, putting even more downward pressure on risky asset prices. The resulting sell-off of risky assets generates an excessive increase in risky rates.

Note the twofold role of banks here. First, as marginal investors they drive a wedge between the movements in safe rates and risky rates, and hence open up the conflict for the nominal exchange rate to either equalize expected returns for the one or the other. Second, banks' international arbitrage activity ensures that any excess movement in risky rates spills across borders.

4.1. Model outline

Figure 4 displays the model's two banks and their balance sheets. I outline the model from the *home* (H) bank's perspective. The *foreign* (F) bank's problem is symmetric, and foreign variables are denoted with a star superscript (*). In order to clarify the proposed international risk-taking channel the model exposition focuses on international capital markets and abstracts from all other markets.[47]

The *Home* bank maximizes the expected discounted utility stream of its shareholders, who receive utility from consumption (c_t). Shareholder income is made up of dividends

[47]The model abstracts from consumer price dynamics. All variables are nominal and banks maximize expected nominal profits, effectively assuming a stable price level.

Figure 4: *Model structure*

Home bank	
Risky assets h	Equity h
	Debt h
Risky assets f	Debt f

Foreign bank	
Risky assets f	Equity f
	Debt f
Risky assets h	Debt h

(m_t) and a fixed endowment (y), so that $c_t = m_t + y$.[48] The bank buys risky home and foreign assets (b_t^h and b_t^f) at market prices (q_t^h and q_t^f), and the bank funds these risky asset purchases through equity (k_t), as well as home and foreign debt (d_t^h and d_t^f) for which it pays risk-free rates (i_t^h and i_t^f). The superscript h denotes assets and debt denominated in home currency, and f those denominated in foreign currency. The bank is subject to a VaR constraint, which states that the bank's (book) equity must suffice to cover its value at risk.[49] The bank's maximization problem is furthermore constrained by the balance sheet identity and the law of motion for equity, which states that equity equals previous period's equity, plus profits, minus dividend payouts:

$$\max_{\{c_t, b_t^h, b_t^f, d_t^h, d_t^f, k_t\}_{t=0}^{\infty}} \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t u(c_t) \right\} \tag{10}$$

$$\text{s.t. equity law of motion:} \quad k_t = k_{t-1} + \Pi_t - c_t + y \tag{11}$$

$$\text{balance sheet ID:} \quad k_t + d_t^h + d_t^f e_t = q_t^h b_t^h + q_t^f b_t^f e_t \tag{12}$$

$$\text{VaR:} \quad \mathbb{E}_t\{VaR_{t+1}\} \leq k_t, \tag{13}$$

where capital (k_{t-1}) and beginning of period realized profits (Π_t) are state variables, y is a fixed endowment and e_t is the nominal exchange rate (Home currency/Foreign currency). The utility function has the CRRA form $u(c_t) = (c_t^{1-\sigma} - 1)/(1 - \sigma)$. In the context of the presented banking model $\sigma > 0$ can be interpreted as a dividend smoothing motive. This

[48]The endowment reflects any other income, besides bank dividends, that shareholders receive.

[49] The VaR constraint is based on book equity, because it features prominently in banking regulation as well as in banks' annual reports, for example in return on equity figures (Adrian *et al.* , 2015). The VaR constraint is formulated as an inequality constraint $\mathbb{E}_t\{VaR_{t+1} \leq k_t\}$, giving rise to a Kuhn-Tucker optimization problem. However, as long as the expected return on risky assets exceeds the cost of debt-financing, and as long as the cost of equity exceeds the cost of debt, the bank will lever up to the constraint and buy as many risky assets as possible, i.e. in equilibrium the VaR constraint will hold with equality.

also implies that issuing new equity ($m_t < 0$) is costly.

Profits (Π_t) equal the expected returns from investing in risky assets, minus previous period's bank equity, minus the cost of debt and the cost of adjusting the foreign portfolio:

$$\Pi_t = \tilde{q}_t^h b_{t-1}^h + \tilde{q}_t^f b_{t-1}^f e_t - i_{t-1}^h d_{t-1}^h - i_{t-1}^f d_{t-1}^f e_t - k_{t-1} \\ - \frac{\tau}{2}\left(d_{t-1}^f - o_d^f\right)^2 - \frac{\tau}{2}\left(b_{t-1}^f - o_b^f\right)^2. \tag{14}$$

$\tilde{q}_t^h$ and $\tilde{q}_t^f$ denote the gross return of the two risky assets. This gross return is comprised of a fixed coupon payment (c^h and c^f), the risky asset's price (q_t^h and q_t^f) and a repayment rate ($D_t^h, D_t^f \in (0,1)$), where $\tilde{q}_t^h \equiv D_t^h(q_t^h + c^h)$.[50] The risky assets can be thought of as corporate bonds with a default rate $1 - D_t$, i.e. only a fraction D_t of the risky assets pays a coupon and can be sold at price q_t this period. The remaining fraction $1 - D_t$ becomes worthless and pays no coupon.

The bank receives funding in H and F currency at the safe policy rates i_t^h and i_t^f. On the liability side there furthermore is bank capital – the bank's equity. As a consequence of $\sigma > 0$ the bank will not simply fulfill its VaR constraint through raising new equity. Instead, the bank will partly fulfill its VaR constraint through adjustments in risk-taking. Finally, o_d^f and o_b^f denote steady state gross foreign asset holdings. Foreign portfolio adjustment costs are needed in order to pin down steady state foreign asset- and liability holdings (see Benigno, 2009; Schmitt-Grohé and Uribe, 2003).

The bank's value at risk is defined as its bad scenario profits for next period

$$-\mathbb{E}_t\{VaR_{t+1}\} \equiv \mathbb{E}_t\{\Pi_{t+1}^{low}\} = \tilde{q}^{h,low} b_t^h + \tilde{q}^{f,low} b_t^f \mathbb{E}_t\{e_{t+1}\} - i_t^h d_t^h - i_t^f d_t^f \mathbb{E}_t\{e_{t+1}\} - k_t \\ - \frac{\tau}{2}\left(d_t^f - o_d^f\right)^2 - \frac{\tau}{2}\left(b_t^f - o_b^f\right)^2, \tag{15}$$

where $\tilde{q}^{h,low}$ denotes bad scenario gross returns on the risky home asset: $\tilde{q}^{h,low} \equiv D^{h,low}(q^{h,low} + c^h)$. $D^{h,low}$ and $q^{h,low}$ stand for a high default rate- and low asset price state.[51] Given a stationary distribution of risky asset prices, $q^{h,low}$ denotes a specific low percentile of that distribution.[52]

[50]The coupons ensure that in steady state risky asset returns exceed the cost of debt, and hence the bank levers up to its VaR constraint.

[51] In order to keep the exposition simple, this formulation abstracts from the correlation of returns across assets.

[52]Adrian and Boyarchenko (2013a) provide a microfoundation for VaR constraints in terms of a moral

The safe rate follows an AR(1) process

$$i_t^h = (1 - \chi^i)i^h + \chi^i i_{t-1}^h + \epsilon_t^{h,i}, \tag{16}$$

where i^h without time index denotes the steady state gross safe rate, χ^i denotes the safe rate's persistence and $\epsilon_t^{h,i}$ is normally distributed, $\epsilon_t^{h,i} \sim N(0, \sigma^i)$.[53]

The ex ante risky rate in the model is defined as the expected gross return on the risky asset

$$\mathbb{E}_t\{r_{t+1}^h\} = \mathbb{E}_t\left\{D_{t+1}^h \frac{(q_{t+1}^h + c^h)}{q_t^h}\right\}. \tag{17}$$

The bad scenario realization of r_t^h is defined by $D^{h,low}$ and $q^{h,low}$: $r_t^{h,low} = D^{h,low}\frac{(q^{h,low}+c^h)}{q_t^h}$.

The default rate also follows an AR(1) process

$$D_t^h = (1 - \chi^D)D^h + \chi^D D_{t-1}^h + \epsilon_t^{h,D}, \tag{18}$$

with persistence χ^D and $\epsilon_t^{h,D} \sim N(0, \sigma^D)$.[54]

The market clearing conditions are

$$b_t^{h\star} + b_t^h = b_S{}^h + \frac{1}{\psi}q_t^h \tag{19}$$

$$b_t^f + b_t^{f\star} = b_S{}^f + \frac{1}{\psi}q_t^f, \tag{20}$$

where b_S^h and b_S^f are exogenously fixed supplies of the risky H and F asset, respectively. ψ denotes the inverse demand elasticity of risky assets with respect to their price. When banks sell risky assets, this parameter determines how much asset prices fall before non-bank agents step in and stabilize asset prices.[55] Alternatively ψ can be interpreted as

hazard problem between the bank and its creditors.

[53] Assuming the interest rate to be an exogenous process can favor the finding of extensive risk premium spillovers in the sense that the safe rate is assumed not to work against the spillover. Or, put differently, the existence of extensive risk premium spillovers is predisposed on their not provoking an offsetting monetary policy response. Prior to 2007 monetary policy was usually not targeting risky asset prices.

[54] While the exogenous process for D_t is not bounded from below, in the calibration the innovation variance is small relative to its steady state, so that in the simulations D_t never becomes negative.

[55] These non-bank investors can be thought of as risk averse households who only step in once falling asset prices have increased expected returns sufficiently to compensate for the riskiness of the risky asset. Alternatively, Calvo (1998) provides an account in which leveraged investors that face margin calls need to liquidate their asset holdings and sell them to less informed counterparts. As a consequence of the

a supply elasticity which indicates by how much risky asset supply increases in the price of risky assets.

To focus on the international risk-taking channel I close the model with the foreign exchange market equation

$$e_t = 1 + \frac{1}{\phi} (ED_t^f), \tag{21}$$

where ED_t^f denotes the excess demand for foreign currency (see Branson and Henderson, 1985; Bruno and Shin, 2014).[56] Thus the exchange rate (home currency/foreign currency) is rising in the excess demand for foreign currency. This equation can be thought of as a stand-in for the balance of payment equation in a more fully fledged model of the world economy. It is supposed to complement the model's endogenous capital account dynamics with a current account counterpart. This is important because the resulting restriction on the exchange rate endows the model with plausible capital account dynamics. The parameter ψ can be interpreted as the current account's sensitivity with respect to the exchange rate, i.e. the trade elasticity. The full set of non-linear model equations is summarized in appendix A1. For the subsequent analysis I linearize the model around it's nonstochastic steady state.

4.2. International transmission of safe and risky rates

What does the linearized model say about international co-movement in safe and risky interest rates? To gain intuition the following exposition assumes that the foreign portfolio adjustment costs are negligible, i.e. $\tau \to 0$. Uncovered interest rate parity (UIP) holds for safe rates up to a portfolio adjustment term:

$$\hat{i}_t^h = \hat{i}_t^f + \mathbb{E}_t\{\hat{e}_{t+1}\} - \hat{e}_t, \tag{22}$$

where the hat ($\hat{}$) denotes a variable's percentage deviation from steady state. A fixed exchange rate thus implies perfect co-movement among safe rates. By contrast, among floats, central banks are free to set safe rates according to their policy goals, and the

resulting asymmetric information problem asset prices need to fall before less informed investors step in.

[56] ED^f is calculated as the capital flow residual resulting from subtracting all capital inflows from H into F from all capital outflows from H into F: $ED_t^f = \left(d_t^{h,\star} + e_t\, q_t^f\, b_t^f - d_t^f\, e_t - e_t\, D_t^f\, \left(q_t^f + c^f\right) b_{t-1}^f + e_t\, i_{t-1}^f\, d_{t-1}^f - q_t^h\, b_t^{h,\star} + D_t^h\, \left(q_t^h + c^h\right) b_{t-1}^{h,\star} - i_{t-1}^h\, d_{t-1}^{h,\star}\right)$.

nominal exchange rate will adjust to satisfy UIP-equation 22. In this way floating exchange rates provide effective insulation for safe rates and the trilemma holds.

How about risky rates? The non-arbitrage condition for risky rates is

$$\mathbb{E}_t\{\hat{r}^h_{t+1}\} = \mathbb{E}_t\{\hat{r}^f_{t+1}\} + \Omega(\mathbb{E}_t\{\hat{e}_{t+1}\} - \hat{e}_t) + (1-\Omega)(\hat{r}^{f,low}_t - \hat{r}^{h,low}_t), \quad (23)$$

where $\Omega \equiv \frac{i^h}{r^h}(1 + \frac{\lambda}{\beta\mu})$ and variables without time index denote steady state values. Unlike for safe rates, the exchange rate does not account for the entire risky rate differential across regions.

In the following calibration Ω is less than 1. In this case the second term in equation 23 indicates that expected exchange rate changes drive a smaller wedge between the home and foreign risky rate than they do between safe rates, thus contributing to risky rate co-movement among floats. The third term says that whenever the foreign-home spread in bad scenario returns goes up, the home risky return declines. The reason for this is that if foreign bad scenario risky returns are higher than home ones then asset demand shifts to the foreign risky asset.

Another perspective to look at this is through risk premiums. The risky rate equals safe rate plus risk premium (ρ_t): $r_t \equiv i_t + \rho_t$. To the extent that floating exchange rates decouple safe rates any co-movement in risky rates must come from risk premiums. The home risk premium's percentage deviations from its steady state can be expressed as:

$$\hat{\rho}^h_t = \hat{\lambda}_t(i^h - r^{h,low}) - \mathbb{E}_t\{\hat{\mu}_{t+1}\} + \left(\frac{i^h}{i^h - r^h}\,\hat{i}^h_t - \frac{r^{h,low}}{i^h - r^h}\,\hat{r}^{h,low}_t\right). \quad (24)$$

Equation 24 shows that the model gives rise to a risk premium that fluctuates endogenously with the development of three components: First, the marginal value of easing the VaR constraint ($\hat{\lambda}_t$), times the differential between the safe rate and the bad scenario risky return, with $i^h > r^{h,low}$. Intuitively, the tighter the VaR constraint, the larger the spread between risky and safe rates from which the bank could profit if its VaR constraint was marginally eased. Second, the risk premium is decreasing in the expected tightness of next period's law of motion constraint for equity ($\mathbb{E}_t\{\hat{\mu}_{t+1}\}$). The more abundant bank equity is expected to be in the next period, the less likely it is that the bank has to engage in costly equity issuance, and hence that shareholders have to cut their consumption. Therefore the bank engages in more risk-taking today, which drives down the risk premium. Finally, the risk premium is also decreasing in the differential between the safe rate and the bad scenario risky rate.

A comparison of the home risk premium in equation 24 with the foreign risk premium reveals their similarity, and hence their scope for co-movement:

$$\hat{\rho}_t^f = \hat{\lambda}_t(r^h - r^{h,low}) - \mathbb{E}_t\{\hat{\mu}_{t+1}\} + \left(\frac{i^f}{i^f - r^f}\,\hat{i}_t^f - \frac{r^{f,low}}{i^h - r^f}\,\hat{r}_t^{f,low}\right), \tag{25}$$

where I make use of the steady state relations $r^f = r^h$ and $r^{f,low} = r^{h,low}$. The first and second terms in equation 25 are identical to the first and second terms in equation 24. The equalization of risk premiums – the price of risk – is not surprising, given that financial markets are integrated. However, the bank's leverage constraint can, through its effect on the risk premium, cause the risky rate to move in excess of safe rates. Any such excess movement in the risky rate will be transmitted internationally by the bank's arbitrage activity. The bank will buy the risky asset with the higher return and sell the risky asset with the lower return until the non-arbitrage condition 23 is satisfied. In equilibrium, this gives rise to risky rates co-movement.[57]

4.3. Calibration

In this section I calibrate the model in order to evaluate the its quantitative implication for the co-movement of risky rates among floats. The model is calibrated in such a way as to render the F region's relation to the H region reminiscent of the U.S.'s relation to the rest of the world (ROW). However, except for the steady-state gross foreign asset positions and the fixed endowments the home and foreign segments of the model are calibrated symmetrically. The model is calibrated to a monthly frequency.

The monthly time preference rate is set to an annualized 0.9967 (i.e. an annual $0.96 = 0.9967^{12}$). This corresponds to the annualized safe rate's steady state, which is set to 4% – the long-time empirical average of short-term safe rates. The monthly persistence of the safe rate is set to 0.85. The standard deviation of the safe rate shock is calibrated to match the standard deviation of the monthly narrative monetary policy shock series by Romer and Romer (2004). In order to reflect the co-movement in safe rates documented in section 2.2 I also calibrate the home and foreign safe rate shocks to be correlated with a correlation coefficient equal to 0.4. This is intended to account for the level of late

[57] This risk premium spillover mechanism can bite even for low levels of cross-border asset holdings. Only in the case of perfect autarky, when each bank holds only domestic assets and liabilities, is this asset price channel shut down.

20th century co-movement in fundamentals (see Bordo and Helbling, 2011) that induces correlated central bank responses, and hence correlated safe rates.

The parameter σ is gleaned from Kollmann *et al.* (2011). In their banking model they set $\sigma = 1$. The value of 1 is on the lower end of the values that are conventionally chosen when parameterizing a representative household's utility function. Among the most important shareholders of global banks are investment funds, which presumably are less risk averse than the average household.

The low repayment rate parameter (D^{low}) was set to $0.97^{1/12}$, implying an annualized bad scenario default rate of 3%. This reflects the higher end of annual default rates for corporate bonds over the past few decades (see Standard and Poor's Global Fixed Income Research and Standard and Poor's CreditPro). For example, the global default rate on corporate bonds during the 2008 financial crisis was slightly above 4%, while the default rate after the 2001 stock market crash peaked at slightly below 4%. The value for the standard deviation of the default shock (0.0003) was gleaned from Kollmann *et al.* (2011).[58]

The low asset price realization ($q^{h,low}$) has been set such as to target a steady state capital-asset ratio of 0.4. In the model, the asset side of the banks' balance sheets only depicts risky assets that are tradable. For big banks that manage a global portfolio such risky traded securities make up only about one quarter of their balance sheet (Baily *et al.* , 2015). In order to bring the model to the data I thus target four times the average pre-crisis bank capital-asset ratio of 0.1. This can be thought of as effectively netting out non-traded safe assets and safe liabilities, which are of no explicit interest with respect to the channel discussed here. As a result of this, the impact of asset price variations on bank equity will be quantitatively realistic.[59]

The risky bond coupon (c) is set to 0.005. Given the steady state price for the risky assets this implies a 5.5% per year coupon on the steady state value of the risky bond. This is a typical value located in the center of the range of empirically observable coupon rates for corporate bonds.

The inverse elasticity of risky asset demand (ψ) is set to 0.2. This value implies an

[58] Also see delinquency rates on commercial and industrial loans since the late 1980s for similar numbers (FRED, DRBLACBS).

[59] Top investment bank leverage ratios can be far higher, ranging from 25 to 35, while many other international investors' leverage can be far lower. E.g. a third of hedge funds claim they use no leverage at all (Eichengreen, 1999), while others' leverage ratios are exceedingly high. I decide to target a capital-asset ratio of 0.1 because it lies about in the middle of the range of leverage ratios characteristic of todays global financial institutions.

Table 6: *Calibration parameters*

Parameters		Value	Source/Target
i	SST safe rate	$1.04^{1/12}$	Longtime empirical average
β	Time preference rate	0.9967	$1/i$
σ	inverse EIS	1	Kollmann *et al.* (2011)
D^{low}	Low repayment rate	$0.97^{1/12}$	S *and* P Global Fixed Income Research
D	SST repayment rate	$0.985^{1/12}$	S *and* P Global Fixed Income Research
q^{low}	Low asset price	0.64	0.4 Bank capital-tradable assets ratio
c	Risky asset coupon	0.005	5.5% SST coupon
ψ	Inv. asset demand elast.	0.2	H asset price response (Jordà *et al.* , 2017)
τ	Portfolio adj. cost	0.0001	
ϕ	Inv. FX demand elast.	0.66	1.5 trade elasticity
b_S^h	H risky asset supply	36	Fin. Acc. of the U.S.; Lund *et al.* (2013)
b_S^F	F risky asset supply	64	—"—
o_d^f	H liabilities from F	4	—"—
o_d^h	F liabilities from H	1	—"—
o_b^f	H risky assets from F	5	—"—
o_b^h	F risky assets from H	5	—"—
y	H shareholder income	1.7	ROW/U.S. income
$y^\star$	F shareholder income	0.85	dividend income/total income (BEA)
Exogenous processes			
χ^i	Safe rate persistence	0.85	
σ^i	S.D. policy shock	0.003	Romer and Romer (2004) shock S.D.
$corr$	Safe rate correlation	0.4	see empirical analysis (section 2.2)
χ^D	Default rate persistence	0.98	Kollmann *et al.* (2011)
σ^D	S.D. default shock	0.0003	Kollmann *et al.* (2011)

average annualized 7.5% fall in ROW asset prices within the first 12 months in response to a +1ppt innovation to the U.S. safe rate. This conforms to recent post-1980 empirical evidence by Jordà *et al.* (2017) for the response of international equity prices to a +1ppt hike in the U.S. policy rate.[60]

I set the marginal portfolio adjustment cost (τ) to 0.0001. Given steady state foreign safe asset holdings of 4 this implies that a 1% deviation from steady state drives only a $4 \cdot 10^{-5}$ ppt wedge between the home and foreign safe rates, rendering the portfolio

[60] Empirical estimates for the international impact of U.S. policy rate innovations within the day are lower, ranging from 2.7% to 5% (Ehrmann and Fratzscher, 2009; Laeven and Tong, 2012). The stronger responses presented by Jordà *et al.* (2017) refer to a longer horizon of several years. As the interest here is to sketch the international response to U.S. policy shocks over the course of several years my choice of ψ targets the 7.5% figure.

adjustment term a technicality for the sole purpose of determining steady state foreign asset holdings.

The parameter governing the sensitivity of the exchange rate with respect to capital account imbalances (ϕ) is set to 0.66. This is consistent with standard estimates of the elasticity of international trade with respect to tradable goods' prices in current open economy macro models.

The parameters $o_d^f, o_d^h, o_b^f, o_b^h, b_S^h$ and b_S^f that describe global tradable asset supply and determine the steady state gross foreign asset positions are set in such a way as to render the F region's relation to the H region reminiscent of the U.S.'s relation to the rest of the world (ROW). For this purpose I draw from the Financial Accounts of the U.S. together with estimates of the world total of tradable assets (Lund *et al.* , 2013). I normalize the world total of tradable assets to 100. The fraction of U.S. tradable securities in the world total is .36. Correspondingly b_S^h is set to 36 while b_S^h is set to 64. Turning to steady state foreign liability holdings, o_d^f is set to 4, while o_d^h is set to 1. This reflects the asymmetric importance of the USD liabilities in the global financial system. The low value of 1 for o_d^h furthermore takes into account that 70% of the liability side of the U.S. external portfolio is denominated in U.S. dollars (see Bénétrix *et al.* , 2015; Lane and Shambaugh, 2010). In order to obtain realistic valuation effects I treat these liabilities as intra-U.S. liabilities in the current setup. Steady state foreign asset holdings (o_b^f and o_b^h) are set to 5 each. This corresponds to the U.S. holding 5/64=7.81% of ROW tradable assets, while the ROW holds 5/36=13.89% of U.S. tradable assets.

Finally, I set the fixed endowments y and $y^\star$ to 1.7 and 0.85. The U.S. value of 0.85 implies that approximately 6% of total income is due to dividends. This corresponds to personal income estimates from the BEA. The ROW value of 1.7 then follows from U.S. GDP being around one third of world GDP in the post Bretton Woods period.

4.4. Results

In order to link the model part of this paper back to its empirical part this section reports model outputs that correspond to the empirical results reported earlier: the decoupling power of floating exchange rates for safe and risky rates, as well as the differential response of pegs and floats to U.S. policy rate shocks.

4.4.1 Average global interest rate correlations and decoupling powers

First, consider the international correlation of safe and risky rates generated by the model. I run a stochastic simulation based on the linearized model to obtain international correlations for risky and safe rates depending on exchange rate regime status. Table 7 displays the result. Safe and risky rates perfectly co-move among pegs, resulting in a correlation of 1. For floats, interest rate co-movement differs whether one considers safe or risky rates. Safe rates' correlation is 0.40 due to the calibration matching fundamental safe rates' co-movement in the data. Risky rates' correlation on the other hand is 0.81.

Table 7: *Model correlations*

	(1) Safe rates	(2) Risky Rates
Pegs' correlation	1.00	1.00
Floats' correlation	0.40	0.81

Second, I calculate the decoupling power of a floating exchange rate on the basis of 500 simulations of the floater and peg model each. Each simulation is 480 months long, –40 years – i.e. comparable in length to the Post-Bretton Woods sample. For comparability with the empirical results I aggregate the simulated series to an annual frequency and take first differences. I then combine the data obtained from the simulations and run regressions according to equation 5. On the basis of the resulting regression coefficients I then calculate the decoupling power ratio 6. Table 8 displays the results. For safe rates the model exhibits a close to 100% decoupling power for floating exchange rates. By contrast, for risky rates floating exchange rates have only a 63% decoupling power. The safe rate-risky rate dichotomy in the decoupling power of floating exchange rates in the model thus bears out the same dichotomy as the data.

Table 8: *Model decoupling powers*

	(1) Safe rates	(2) Risky Rates
Decoupling power	110%	63%
	(45)	(35)

4.4.2 Global response to U.S. monetary policy shocks

What does the calibrated model say about the response of floats' risky rates to a monetary policy shock in the financial center? I consider a +1ppt innovation in the U.S. policy rate. I simulate the model twice, once with the ROW featuring a flexible exchange rate with respect to the USD, and once with a fixed exchange rate. In the fixed exchange rate model the ROW country's central banks sets its interest rate in such a way as to ensure a fixed nominal exchange rate.[61] The impact of a +1ppt safe rate shock in the U.S. on international safe and risky rates for the peg and the float are depicted in figure 5. The peg's response is depicted as a solid black line, the float's response as a dashed blue line. For floats I further analyze the case of zero underlying correlation, where safe rates between the U.S. and the ROW do not co-move at all (dotted blue line).

For safe rates the distinction in exchange rate regime is clear: The peg fully imports the foreign interest rate increase (solid black line), the float on the other hand does not. In accordance with the calibration, the float's safe rate reflects only 40% of the U.S. +1ppt hike, the degree of safe rate correlation observable in the data (dashed blue line). By construction, in the zero underlying correlation case the floating ROW safe rate does not respond at all.

How about risky rates? Here the peg-float dichotomy starts to blur somewhat. The floating economy's risky rate clearly reacts to the innovation in the U.S. safe rate, with the float's risky rate increasing by around 0.75 ppts (dashed blue line). The pegged home economy's risky rate reacts more than the float's risky rate (solid black line). On top of the full pass-through of the U.S. safe rate increase, the peg's risky rate also exhibits a risk premium spillover of about 0.25 ppts, a feature which was absent in the empirical impulse responses reported earlier.[62]

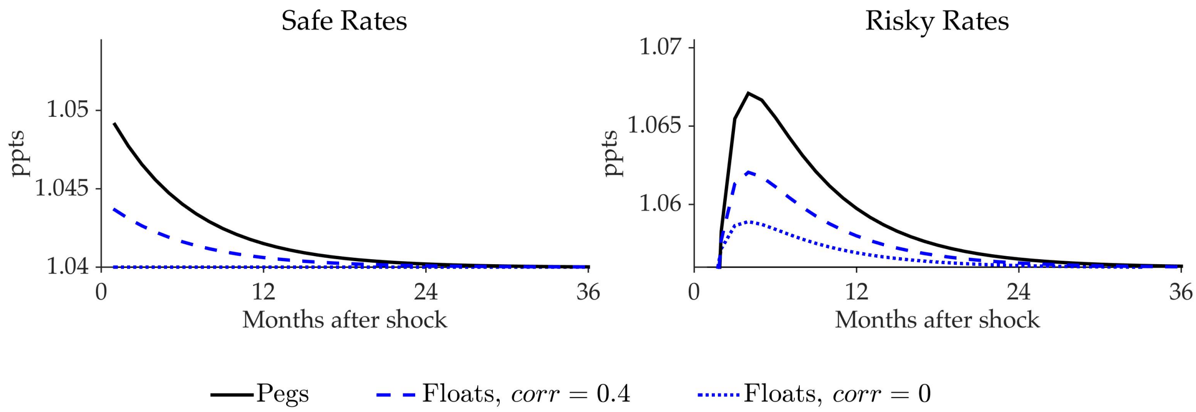
When the fundamental co-movement in safe rates is set to 0 the floats' response becomes weaker. The international risk-taking channel on its own, without any fundamental safe rate co-movement, can account for around 30% of the observed international risky rate response of floats (see dotted line in figure 5).[63]

[61] The home interest rate rule satisfies $i_t^h = i_t^f + \tau(b_t^f - o_b^f)/e_t + 0.01(1/e_t - 1/\bar{e})$, where the last penalty term on exchange rate deviations implies exchange rate stabilization (see Benigno and Benigno, 2008)

[62] The safe rate responses obtained from the model are not hump-shaped as are their empirical counterparts. In order to generate such an initially incomplete pass-through additional frictions would be necessary.

[63] The peg-float differential among safe rates is not the same as that among risky rates. In particular during the initial months the peg's and float's risky rate responses overlap. The non-arbitrage condition for risky rates (equation 23) shows why. First, $\Omega < 1$ lowers the distance between the peg's and the float's

Figure 5: *Pegs' and floats' response to a foreign +1ppt U.S. policy rate shock*



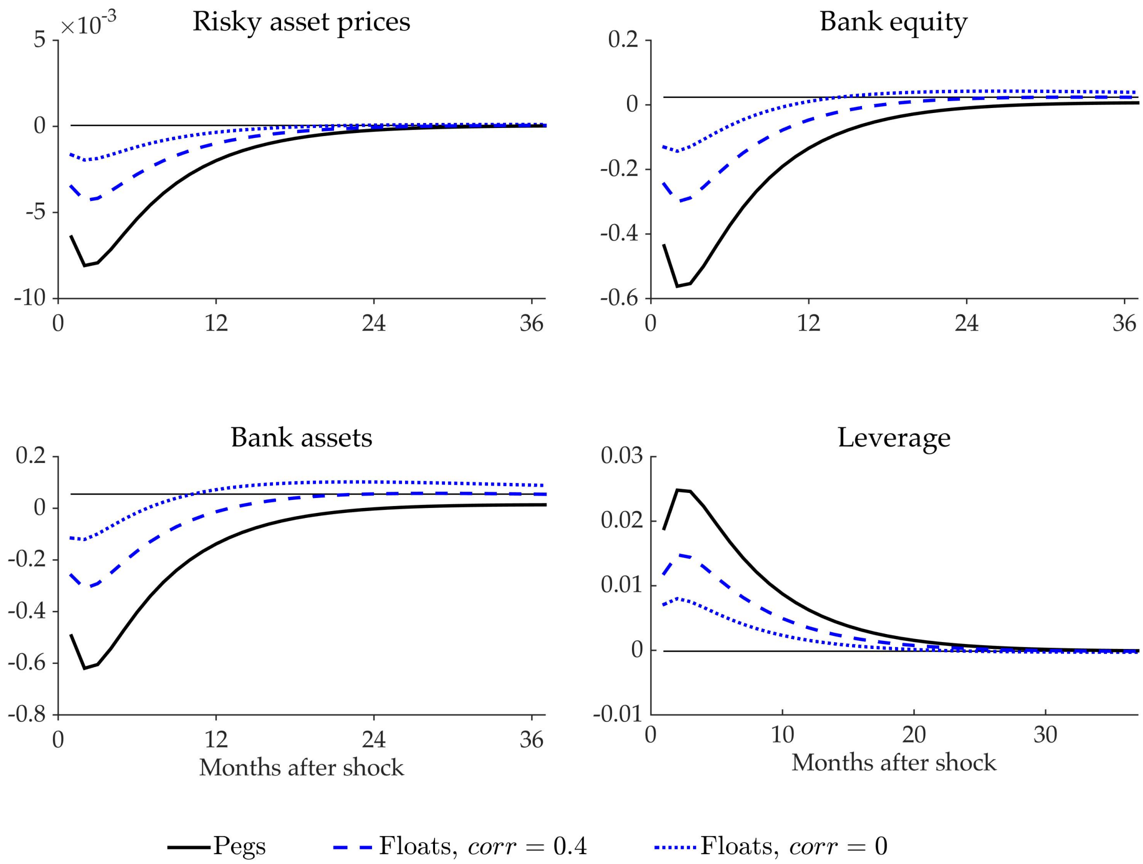
Notes: Solid black line – response of pegs; dashed blue line – response of floats with fundamental safe rate co-movement; dotted blue line – response of floats without fundamental safe rate co-movement.

To better understand the co-movement in risky rates figure 6 depicts various other impulse response functions that show the forces at work. First, the +1ppt policy rate hike in the U.S. leads to risky asset prices falling by between 5 and 10% (see Jordà *et al.* , 2017). This negatively impacts bank equity, and due to the VaR constraint, leads the U.S. and ROW banks to shed risky assets. Bank leverage, here defined as the ratio of total asset to equity, initially goes up as the banks' shrinking asset side eats into their equity. Thereafter, however, banks' balance sheets start to recover over a prolonged phase of deleveraging.

To get an impression of how much of the float's response is due to exchange rate valuation effects on intermediary balance sheets as described by Bruno and Shin (2015) I recalculate all impulse responses for the case in which the home bank perfectly hedges its foreign currency exposure, i.e. the value of its foreign currency denominated liabilities equals the value of its foreign currency denominated assets. In particular I replace the banks' first order conditions with respect to the non-local liability with the hedging equation $b_t^f = q_t^f b_t^f$. Figure 8 in the appendix shows that in this case the exchange rate valuation effect slightly increases the float's response. Figure 9 shows the same exercise for the case where both, the home and foreign banks, avoid currency mismatch. In this

risky rate response relative to the safe rate response. Second, the difference in the bad scenario returns of the home and foreign risky assets also plays a role. It is the second effect that explains the initial overlap in the peg's and float's risky rate responses. Bad scenario risky returns among pegs tend to increase initially, as the peg's asset prices fall closer to their low realization.

Figure 6: *Pegs' and floats' response to a foreign +1ppt rate shock*



Notes: Solid black line – response of pegs; dashed blue line – response of floats.

case the float's response increases by around 0.3 ppts. The proposed channel thus bites independently of exchange rate valuation effects and also generates important spillover effects when banks avoid currency mismatch.

In sum, given the co-movement in safe rates, the calibrated 2-region banking model generates around two thirds of the observed peak response of floats to U.S. monetary policy. Without the co-movement in safe rates, the proposed international risk-taking channel can account for around one third of the observed peak response of floats' risky rates.

5. Conclusion

Extensive risk premium spillovers have rendered floating exchange rates relatively ineffective at decoupling local risky rates from their global counterparts. In this sense my results do support claims that the macroeconomic policy trilemma is morphing into a dilemma, according to which floating exchange rates have become increasingly impotent in countering international financial spillovers. However, this is a new phenomenon. Early in the 20th century floating exchange rates were still effective at insulating local risky rates from foreign ones.

I rationalize the increasing ineffectiveness of floating exchange rates with the growing importance of global banks as marginal investors in global asset markets. If financial globalization is based on leverage-constrained banks, mark-to-market of asset prices synchronizes risk-taking across borders, even among floats. Introducing an open economy model with financial intermediaries that manage an international portfolio of risky assets, I show that this international risk-taking channel can account for about 30% of the spillovers of U.S. monetary policy into the risky rates of floats.

The finding that floating exchange rates have become ineffective at decoupling local risky rates does not necessarily imply that floating exchange rates are not worth having. After all, a floating exchange rate provides economic policymakers with one more degree of freedom for achieving their policy goals. However, my findings suggest that the world economy has become a considerably more demanding environment for policymakers to operate in. The rise of financial spillovers can drive a wedge between conventional targets of monetary policy, such as output and employment gaps, and other policy goals, such as financial stability targets. This divergence in policy targets worsens the trade-offs involved in the application of existing policy instruments. Policymakers may find themselves in need of additions to their policy toolkit.

My findings are speak to current debates about how to robustify open economies against financial shocks from abroad (Passari and Rey, 2015; Rey, 2013). The finding that floating exchange rates were effective at decoupling risky rates in the early 20th century shows that risk premium spillovers are not an inevitable consequence of financial globalization. Hence, the implementation of capital controls – de facto financial deglobalization – is not the only way in which monetary authorities can reassert their control over local interest rates. Instead, my findings suggest that institutional reform, aimed at lightening the interaction between leverage-constraints and mark-to-market accounting, can help to reconcile capital mobility with monetary autonomy. In this regard, the institutions that underpinned financial globalization at the beginning of the 20th century are worth another look.

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A1. Non-linear model equations

This section displays the complete set of non-linear model equations used in the simulations. $t+1$ variables indicate expected values. Foreign F region variables are denoted with a star superscript (*). The home and foreign banks maximize the expected discounted utility stream of their shareholders subject to three constraints. First, the equity laws of motion

$$k_t = k_{t-1} + \Pi_t - c_t + y \tag{1}$$

$$k_t^\star = k_{t-1}^\star + \Pi_t^\star - c_t^\star + y^\star. \tag{2}$$

Second, the balance sheet identities

$$k_t + d_t^h + d_t^f e_t = q_t^h b_t^h - q_t^f b_t^f e_t \tag{3}$$

$$k_t^\star + d_t^{f\star} + d_t^{h\star}/e_t = q_t^f b_t^{f\star} + q_t^h b_t^{h\star}/e_t. \tag{4}$$

Third, the VaR constraints

$$VaR_{t+1} \leq k_t \tag{5}$$

$$VaR_{t+1}^\star \leq k_t^\star. \tag{6}$$

The home and foreign banks' value at risk (VaR) is defined as their low profit-realization state, where profits are defined as

$$\begin{aligned}\Pi_t = {} & \hat{q}_t^h b_{t-1}^h + \hat{q}_t^f b_{t-1}^f e_t - i_{t-1}^h d_{t-1}^h - i_{t-1}^f d_{t-1}^f e_t - k_{t-1} \\ & - \frac{\tau}{2}\left(d_{t-1}^f - o_d^f\right)^2 - \frac{\tau}{2}\left(b_{t-1}^f - o_b^f\right)^2\end{aligned} \tag{7}$$

$$\begin{aligned}\Pi_t^\star = {} & \hat{q}_t^f b_{t-1}^{f\star} + \hat{q}_t^h b_{t-1}^{h\star}/e_t - i_{t-1}^f d_{t-1}^{f\star} - i_{t-1}^h d_{t-1}^{h\star}/e_t - k_{t-1}^\star \\ & - \frac{\tau}{2}\left(d_{t-1}^{h\star} - o_d^h\right)^2 - \frac{\tau}{2}\left(b_{t-1}^{h\star} - o_b^h\right)^2\end{aligned} \tag{8}$$

Accordingly, the home and foreign banks' VaR is defined as

$$\begin{aligned}VaR_{t+1} = {} & \hat{q}^{h,low} b_t^h + \hat{q}^{f,low} b_t^f e_{t+1} - i_t^h d_t^h - i_t^f d_t^f e_{t+1} - k_t \\ & - \frac{\tau}{2}\left(d_t^f - o_d^f\right)^2 - \frac{\tau}{2}\left(b_t^f - o_b^f\right)^2\end{aligned} \tag{9}$$

$$VaR^{\star}_{t+1} = \hat{q}^{f,low} b^{f\star}_t + \hat{q}^{h,low} b^{h\star}_t / e_{t+1} - i^f_t d^{f\star}_t - i^h_t d^{h\star}_t / e_{t+1} - k^{\star}_t - \frac{\tau}{2}\left(d^{h\star}_t - o^h_d\right)^2 - \frac{\tau}{2}\left(b^{h\star}_t - o^h_b\right)^2 \quad (10)$$

The home bank's first order conditions with respect to consumption (c), the safe home and foreign liabilities, the risky home and foreign assets and bank equity (k) are:

$$c_t^{-\sigma} = \mu_t \quad (11)$$

$$\alpha_t = i^h_t(\beta\mu_{t+1} + \lambda_t) \quad (12)$$

$$\alpha_t = i^f_t \frac{e_{t+1}}{e_t}(\beta\mu_{t+1} + \lambda_t) + \tau(d^f_t - o^f_d)(\beta\mu_{t+1} + \lambda_t)/e_t \quad (13)$$

$$D^h_{t+1}(q^h_{t+1} + c^h)\beta\mu_{t+1} - \alpha_t q^h_t + D^{h,low}(q^{h,low} + c^h)\lambda_t = 0 \quad (14)$$

$$\beta\mu_{t+1} D^f_{t+1}(q^f_{t+1} + c^f)e_{t+1} - \tau(b^f_t - o^f_b)\beta\mu_{t+1} - \alpha_t q^f_t e_t + D^{f,low}(q^{f,low} + c^f)e_{t+1}\lambda_t - \tau(b^f_t - o^f_b)\lambda_t = 0 \quad (15)$$

$$\alpha_t = \beta\mu_{t+1} + \mu_t \quad (16)$$

Analoguously the first order conditions of the foreign bank read:

$$c_t^{\star-\sigma} = \mu^{\star}_t \quad (17)$$

$$\alpha^{\star}_t = i^{f\star}_t(\beta^{\star}\mu^{\star}_{t+1} + \lambda^{\star}_t) \quad (18)$$

$$\alpha^{\star}_t = i^h_t \frac{e_t}{e_{t+1}}(\beta\mu^{\star}_{t+1} + \lambda^{\star}_t) + \tau(d^h_t - o^h_d)(\beta\mu^{\star}_{t+1} + \lambda^{\star}_t)e_t \quad (19)$$

$$D^f_{t+1}(q^f_{t+1} + c^f)\beta\mu^{\star}_{t+1} - \alpha^{\star}_t q^f_t + D^{f,low}(q^{f,low} + c^f)\lambda^{\star}_t = 0 \quad (20)$$

$$\beta\mu^{\star}_{t+1} D^h_{t+1}(q^h_{t+1} + c^h)/e_{t+1} - \tau(b^h_t - o^h_b)\beta\mu^{\star}_{t+1} - \alpha^{\star}_t q^h_t / e_t + D^{h,low}(q^{h,low} + c^h)/e_{t+1}\lambda^{\star}_t - \tau(b^h_t - o^h_b)\lambda^{\star}_t = 0 \quad (21)$$

$$\alpha^{\star}_t = \beta\mu^{\star}_{t+1} + \mu^{\star}_t \quad (22)$$

Market clearing for the home and foreign risky bonds is characterized by

$$b_t^{h,\star} + b_t^h = b_S{}^h + \frac{1}{\psi}\, q_t^h \tag{23}$$

$$b_t^f + b_t^{f,\star} = b_S{}^f + \frac{1}{\psi}\, q_t^f, \tag{24}$$

where ψ is the inverse demand elasticity for the risky assets.
The model is closed through the foreign exchange market equation

$$\begin{aligned} e_t = 1 + \frac{1}{\Phi}\, \Big(& d_t^{h,\star} + e_t\, b_t^f\, q_t^f - d_t^f\, e_t - e_t\, D_t^f\, \left(c^f + q_t^f\right)\, b_{t-1}^f + \\ & e_t\, i_{t-1}^f\, d_{t-1}^f - q_t^h\, b_t^{h,\star} + D_t^h\, \left(c^h + q_t^h\right)\, b_{t-1}^{h,\star} - i_{t-1}^h\, d_{t-1}^{h,\star} \Big), \end{aligned} \tag{25}$$

and exogenous processes for the safe rates and default shocks:

$$i_t^h = \left(1 - \chi^i\right)\, i^h + i_{t-1}^h\, \chi^i + \epsilon_t^{h,i} \tag{26}$$

$$i_t^f = \left(1 - \chi^i\right)\, i^f + i_{t-1}^f\, \chi^i + \epsilon_t^{f,i} \tag{27}$$

$$D_t^h = \left(1 - \chi^D\right)\, D^h + \chi^D\, D_{t-1}^h + \epsilon_t^{h,D} \tag{28}$$

$$D_t^f = \left(1 - \chi^D\right)\, D^f + \chi^D\, D_{t-1}^f + \epsilon_t^{f,D}. \tag{29}$$

Finally, several auxiliary equations have been made use of, such as total bank assets:

$$A_t = e_t\, b_t^f\, q_t^f + q_t^h\, b_t^h \tag{30}$$

$$A_t^\star = \frac{q_t^h\, b_t^{h,\star}}{e_t} + q_t^f\, b_t^{f,\star} \tag{31}$$

Bank leverage is here defined as the ratio of total assets to equity:

$$l_t = \frac{A_t}{k_t} \tag{32}$$

$$l_t^\star = \frac{A_t^\star}{k_t^\star} \tag{33}$$

The risky rate analyzed is the expected total return on the risky asset:

$$r_t^h = \frac{D_t^h(q_{t+1}^h + c^h)}{q_t^h} \tag{34}$$

$$r_t^f = \frac{D_t^f(q_{t+1}^f + c^f)}{q_t^f} \tag{35}$$

A2. Additional results

Table 9: *Risk premiums calculated with base country safe rates*

	Safe rates		*Risk premia*		
	Δi^{ST}	Δi^{LT}	$\Delta\rho^{\text{Mort}}$	$\Delta\rho^{\text{Bank}}$	$\Delta\rho^{\text{Corp}}$
β_1	0.013**	0.038**	0.358***	0.763***	0.571***
	(0.006)	(0.017)	(0.092)	(0.037)	(0.104)
N	271204	15252	7763	8104	1514
R^2	0.04	0.23	0.33	0.44	0.17

Notes: Driscoll-Kraay standard errors in parentheses (accounting for 3 lags of autocorrelation). All specifications include country-pair fixed effects. Periods: Pre-1914 (1874-1913), Interwar (1919-1938), Bretton Woods (1950-1972), Post-Bretton Woods (1973-2007). Sample excludes WW1 (1914-1918) and WW2 (1939-1945) periods, as well as outliers, defined as absolute interest rate movements in excess of 50 ppts. Standard errors in parentheses.

Table 10: *Good quality data*

	Safe rates		*Risky rates*		
	Δi^{ST}	Δi^{LT}	Δr^{Mort}	Δr^{Bank}	Δr^{Corp}
β_1	0.10**	0.59***	0.27***	0.38***	0.47***
	(0.05)	(0.04)	(0.07)	(0.07)	(0.11)
β_2 $(float)$	-0.09*	-0.57***	-0.21***	-0.07	0.05
	(0.05)	(0.05)	(0.07)	(0.08)	(0.11)
DCP	-88%	-96%	-79%	-19%	11%
	(7.87)	(3.15)	(15.20)	(18.55)	(25.88)
N	15257	5854	3997	2430	1067
R^2	0.42	0.31	0.32	0.28	0.40

Notes: The sample excludes Afghanistan, Angola, Benin, Burkina Faso, Burundi, Cambodia, Cape Verde, Central African Republic, Chad, Comoros, Democratic Republic of Congo, Cte dIvoire, Djibouti, El Salvador, Eritrea, Ethiopia, Fiji, The Gambia, Grenada, Guinea-Bissau, Haiti, Lao Peoples Democratic Republic, Liberia, Libya, Mali, Mauritania, Mozambique, Myanmar, Niger, Nigeria, Rwanda, Sierra Leone, Swaziland, Syria, Timor-Leste, Togo, Uganda, Yemen and Zambia. Driscoll-Kraay standard errors in parentheses (accounting for 3 lags of autocorrelation). All specifications include country-pair-period fixed effects. Periods: Pre-1914 (1874-1913), Interwar (1919-1938), Bretton Woods (1950-1972), Post-Bretton Woods (1973-2007). Sample excludes WW1 (1914-1918) and WW2 (1939-1945) periods, as well as outliers, defined as absolute interest rate movements in excess of 50 ppts. Standard errors in parentheses. Sample excludes outliers, defined as absolute interest rate movements in excess of 50 ppts. Independent variables: Δr_j same rate as dependent variable. Standard errors in parentheses.

Table 11: *Advanced economies*

	Safe rates		*Risky rates*		
	Δi^{ST}	Δi^{LT}	Δr^{Mort}	Δr^{Bank}	Δr^{Corp}
β_1	0.22***	0.60***	0.24***	0.34***	0.48***
	(0.06)	(0.05)	(0.07)	(0.09)	(0.11)
β_2 $(float)$	-0.12***	-0.56***	-0.03	-0.00	0.07
	(0.04)	(0.07)	(0.08)	(0.08)	(0.11)
DCP	-57%	-94%	-11%	-1%	15%
	(8.34)	(6.75)	(30.38)	(24.51)	(26.51)
N	6461	5130	3437	1901	1021
R^2	0.22	0.29	0.28	0.28	0.42

Notes: The advanced economies subsample consists of Australia, Austria, Belgium, Canada, Cyprus, the Czech Republic, Denkmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Iceland, Ireland, Israel, Italy, Japan, Lithuania, Latvia, Luxembourg, Macao, Malta, the Netherlands, New Zealand, Norway, Puerto Rico, Portugal, Singapore, San Marino, the Slovak Republic, Slovenia, South Korea, Spain, Sweden, Switzerland, Taiwan, the U.K. and the U.S.A.. *DCP* – decoupling power of floating exchange rates. Driscoll-Kraay standard errors in parentheses (accounting for 3 lags of autocorrelation). All specifications include country-pair fixed effects. Periods: Post-Bretton Woods (1973-2008, excludes zero lower bound period among advaced economies). Sample excludes outliers, defined as absolute interest rate movements in excess of 50 ppts. Standard errors in parentheses.

Table 12: *Emerging markets*

	Safe rates		*Risky rates*	
	Δi^{ST}	Δi^{LT}	Δr^{Mort}	Δr^{Bank}
β_1	0.11**	0.27*	0.08	0.09
	(0.05)	(0.15)	(0.19)	(0.23)
β_2 $(float)$	-0.10**	-0.17	-0.07	-0.05
	(0.05)	(0.10)	(0.18)	(0.23)
DCP	-97%	-63%	-90%	-53%
	(10.04)	(5.93)	(24.60)	(127.72)
N	10552	970	748	667
R^2	0.32	0.76	0.29	0.28

Notes: The emerging markets subsample consists of the full sample (see table 16) excluding the advanced country-sample (see table 11) and the low data quality sample (see table 10). DCP – decoupling power of floating exchange rates. Driscoll-Kraay standard errors in parentheses (accounting for 3 lags of autocorrelation). All specifications include country-pair fixed effects. Periods: Post-Bretton Woods (1973-2015). Sample excludes outliers, defined as absolute interest rate movements in excess of 50 ppts. Standard errors in parentheses.

Table 13: *Post-1973 results for pre-1914 sample*

	Safe rates		Risky rates		
	Δi^{ST}	Δi^{LT}	Δr^{Mort}	Δr^{Bank}	Δr^{Corp}
β_1	0.48***	0.81***	0.25	0.32**	0.75***
	(0.10)	(0.05)	(0.22)	(0.15)	(0.11)
β_2 $(float)$	-0.15	-0.33***	0.12	0.10	-0.15
	(0.09)	(0.08)	(0.16)	(0.10)	(0.10)
DCP	-31%	-41%	49%	31%	-20%
	(14.96)	(8.39)	(106.89)	(46.19)	(11.52)
N	618	601	594	594	249
R^2	0.26	0.48	0.37	0.31	0.48

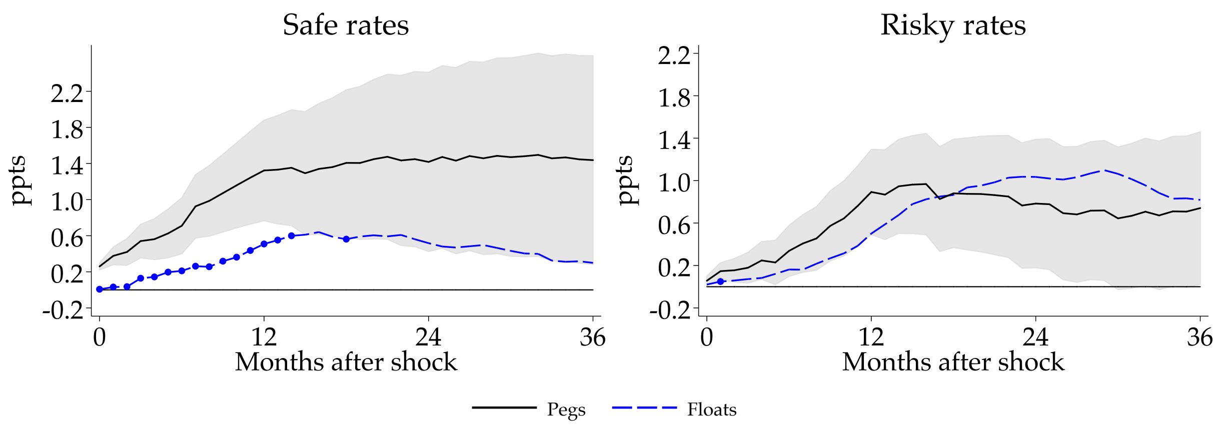
Notes: The countries from the pre-1914 sample are Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, U.K. and the U.S.. DCP – decoupling power of floating exchange rates. Driscoll-Kraay standard errors in parentheses (accounting for 3 lags of autocorrelation). All specifications include country-pair fixed effects. Sample period: Post-Bretton Woods (1973-2007). Sample excludes outliers, defined as absolute interest rate movements in excess of 50 ppts. Standard errors in parentheses.

Table 14: *2-year changes*

	Safe rates		Risky rates		
	Δi^{ST}	Δi^{LT}	Δr^{Mort}	Δr^{Bank}	Δr^{Corp}
β_1	0.18***	0.62***	0.44***	0.36***	0.51***
	(0.05)	(0.04)	(0.08)	(0.09)	(0.09)
β_2 $(float)$	-0.17***	-0.26***	-0.24***	-0.02	-0.03
	(0.04)	(0.10)	(0.07)	(0.07)	(0.10)
DCP	-91%	-41%	-55%	-6%	-5%
	(5.07)	(15.09)	(15.15)	(18.90)	(18.24)
N	14347	5080	3361	1990	952
R^2	0.37	0.48	0.36	0.34	0.45

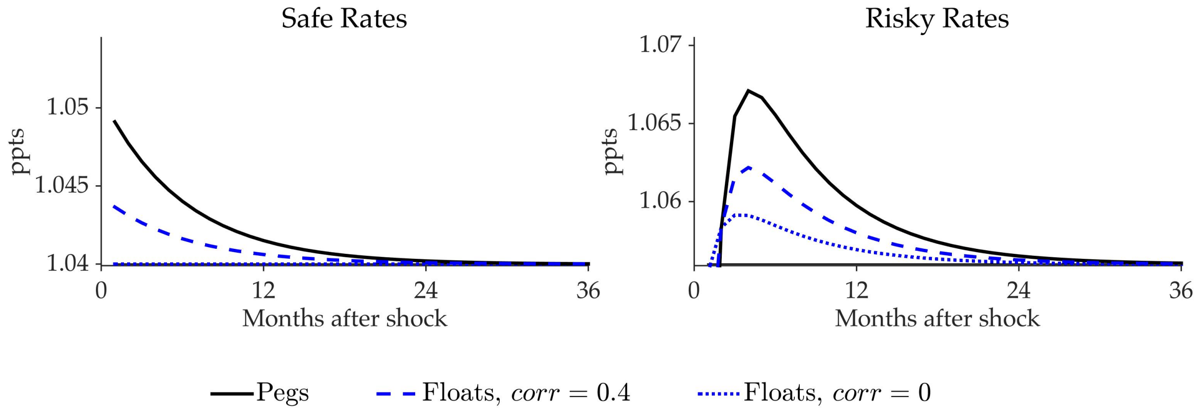
Notes: Regressions are based on 2-year interest rate changes. *DCP* – decoupling power of floating exchange rates. Driscoll-Kraay standard errors in parentheses (accounting for 3 lags of autocorrelation). All specifications include country-pair fixed effects. Periods: Pre-1914 (1874-1913), Interwar (1925-1938), Bretton Woods (1950-1969), Post-Bretton Woods (1974-2015). Sample excludes WW1 (1914-1918) and WW2 (1939-1945) periods, as well as outliers, defined as absolute interest rate movements in excess of 50 ppts. Standard errors in parentheses.

Figure 7: *Advanced economies, post-1973*



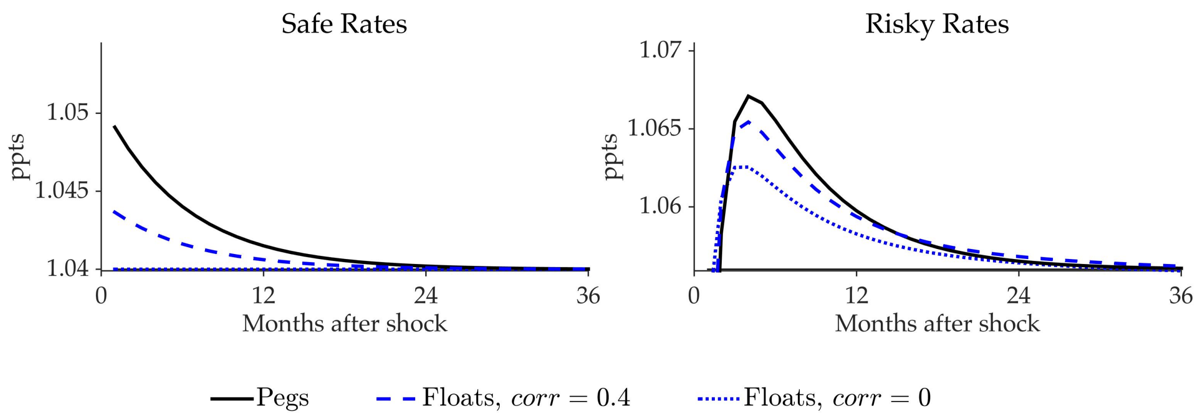
Notes: The advanced economies subsample consists of Australia, Austria, Bahrain, Bahamas, Belgium, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Latvia, Lithuania, Luxembourg, Macau, Malta, Netherlands, New Zealand, Norway, Portugal, Puerto Rico, Qatar, San Marino, Singapore, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Taiwan, U.K. and the U.S.. Solid black line – response of pegs; dashed blue line – response of floats; Blue circles indicate the rejection of the null hypothesis that the peg response equals the float response at the 90% significance level, according to a two-sided Wald test. Confidence bands calculated on the basis of Driscoll-Kraay standard errors (accounting for 36 monthly lags of autocorrelation). All specifications include country fixed effects. Post-Bretton Woods sample: 1973:1 to 2010:12.

Figure 8: *Pegs' and floats' response to a foreign +1ppt U.S. policy rate shock, no exchange rate valuation effect in the home bank*



Notes: Solid black line – response of pegs; dashed blue line – response of floats with fundamental safe rate co-movement; dotted blue line – response of floats without fundamental safe rate co-movement.

Figure 9: *Pegs' and floats' response to a foreign +1ppt U.S. policy rate shock, no exchange rate valuation effect in the home and foreign bank*



Notes: Solid black line – response of pegs; dashed blue line – response of floats with fundamental safe rate co-movement; dotted blue line – response of floats without fundamental safe rate co-movement.

A3. Data

Table 15: *Annual pre-1945 sample*

Australia, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, UK, Italy, Japan, Netherlands, Norway, Portugal, Sweden, USA,

Table 16: *Annual post-1945 sample*

Afghanistan, Angola, Albania, Netherlands Antilles, United Arab Emirates, Argentina, Armenia, Antigua and Barbuda, Australia, Austria, Azerbaijan, Burundi, Belgium, Benin, Burkina Faso, Bangladesh, Bulgaria, Bahrain, Bahamas, Bosnia and Herzegovina, Belarus, Belize, Bolivia, Brazil, Barbados, Brunei Darussalam, Bhutan, Botswana, Central African Republic, Canada, Switzerland, Chile, China, Cote D'Ivoire, Cameroon, DR Congo, Congo, Colombia, Comoros, Cape Verde, Costa Rica, Cyprus, Czech Republic, Germany, Djibouti, Dominica, Denmark, Dominican Republic, Algeria, Egypt, Spain, Estonia, Ethiopia, Finland, Fiji, France, Micronesia, Gabon, UK, Georgia, Ghana, Guinea, Gambia, Guinea-Bissau, Equatorial Guinea, Greece, Grenada, Guatemala, Guyana, Hong Kong, Honduras, Croatia, Haiti, Hungary, Indonesia, India, Ireland, Iran, Iraq, Iceland, Israel, Italy, Jamaica, Jordan, Japan, Kazakhstan, Kenya, Kyrgyzstan, Saint Kitts and Nevis, Korea, Kuwait, Lao, Lebanon, Liberia, Libya, Saint Lucia, Sri Lanka, Lesotho, Lithuania, Luxembourg, Latvia, Morocco, Moldova, Madagaskar, Maldives, Mexico, Macedonia, Mali, Malta, Myanmar, Mongolia, Mozambique, Mauritania, Mauritius, Malawi, Malaysia, Namibia, Niger, Nigeria, Nicaragua, Netherlands, Norway, Nepal, New Zealand, Oman, Pakistan, Panama, Peru, Philippines, Papua New Guinea, Poland, Portugal, Paraguay, Qatar, Romania, Russia, Rwanda, Saudi Arabia, Senegal, Singapore, Solomon Islands, Sierra Leone, El Salvador, San Marino, Sao Tome and Principe, Suriname, Slovak Republic, Slovenia, Sweden, Swaziland, Seychelles, Chad, Togo, Thailand, Tajikistan, Tonga, Trinidad and Tobago, Tunisia, Turkey, Tanzania, Uganda, Ukraine, Uruguay, USA, Vanuatu, Saint Vincent and Grenadines, Venezuela, Vietnam, Samoa, Yemen, South Africa, Zambia, Zimbabwe,

Table 17: *Monthly pre-1914 sample*

Denmark, Spain, Japan, Portugal, Sweden,

Table 18: *Monthly post-1973 sample*

United Arab Emirates, Australia, Austria, Belgium, Bangladesh, Bulgaria, Bahrain, Bahamas, Brazil, Canada, Switzerland, Chile, China, Colombia, Czech Republic, Germany, Denmark, Ecuador, Egypt, Spain, Finland, France, UK, Greece, Hong Kong, Hungary, Indonesia, India, Ireland, Iceland, Israel, Italy, Jordan, Japan, Korea, Kuwait, Lebanon, Latvia, Macao, Mexico, Malta, Malaysia, Netherlands, Norway, New Zealand, Pakistan, Peru, Philippines, Poland, Puerto Rico, Portugal, Romania, Russia, Saudi Arabia, Singapore, San Marino, Slovak Republic, Slovenia, Sweden, Thailand, Turkey, Taiwan, Ukraine, Venezuela, Vietnam, South Africa,