Dilemma or Trilemma?
Global Financial Cycles and Exchange Rate Regimes, 1870-2013*

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Abstract
Is the trilemma in reality a dilemma, because the global financial cycle overwhelsms the insulation provided by flexible exchange rates when international financial integration is high, as Rey (2013) argues? In this paper, we study global financial cycles in credit, house and equity markets in the long-run, relying on annual data for 17 advanced economies from 1870 to today. Introducing novel wavelet analysis to the study of financial cycles, we demonstrate that the global financial cycle has become stronger over time and that financial center countries lead the global cycle. While floating exchange rate regimes bring independence with respect to short-term interest rates, we find no evidence for decoupling from slow moving credit and house prices cycles, supporting the dilemma hypothesis.

Keywords: financial cycles, trilemma, asset prices, wavelet analysis.


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1 Introduction

The so-called macroeconomic *trilemma* or *impossible trinity* is a central tenet of international economics. A key implication of the theorem is that under conditions of capital mobility, floating exchange rates provide monetary policy autonomy. The trade-offs implicit in the trilemma and the time-varying policy responses to these trade-offs go a long way towards explaining the evolution of the global financial system in the past 150 years (Obstfeld and Taylor, 2004). The expectation of maintaining policy autonomy in times of mobile capital was an important underlying driver of the move towards floating exchange rates since the 1970s. Many empirical studies have broadly confirmed that the constraints imposed by the trilemma matter in practice (e.g. Obstfeld, Shambaugh, and Taylor, 2005). Or as Klein and Shambaugh (2013) put it recently: “Governments face the policy trilemma – the rest is commentary.”

However, the trilemma orthodoxy has recently been challenged and an alternative view has gained considerable momentum. Rey (2013) argues that in times of high capital mobility floating exchange rates do provide much less autonomy than commonly thought. This is because when global financial integration is high, widespread co-movement in credit growth and asset prices — a global financial cycle — compromises the insulation provided by independent monetary policy. In this alternative view, the global financial cycle reflects financing conditions in the world’s financial centers for internationally operating financial intermediaries. This leads to strong co-movement of financial variables even when countries have, on paper, an independent monetary policy. Put differently, funding conditions in the main economies, not local interest rate policies effectively determine domestic financial conditions. In this view the trilemma is in fact a dilemma.
Countries can decouple from the global financial cycle only through managing the capital account or macroprudential policies.

In this paper, we turn to macroeconomic history to shed new empirical light on these important issues. The trilemma and its policy implications have been studied extensively in economic history, but financial cycles have not. This is partly due to the fact that long-run data for credit growth (Schularick and Taylor, 2012), house prices (Knoll, Schularick, and Steger, 2014) and equity prices (newly revised in this paper) have only recently become available. We rely on these new long-run datasets to address the dilemma-trilemma question.

This article relates to the existing literature in several ways. First, we add a long-run cross-country perspective to the financial cycle literature, which has been pioneered by Claessens et al. (2011), Drehmann et al. (2012) as well as Aikman et al. (2015). Second, several authors have highlighted the increase in global financial synchronization over the past two decades (e.g. Bruno and Shin, 2013; Obstfeld, 2014). Cerutti, Claessens, and Ratnovski (2014) for example note that, from the 1990s onwards the international correlation of credit growth has increased. Our paper confirms these findings from a long-run perspective. The strong positive co-movement among financial cycles since the 1970s stands in sharp contrast with the asymmetry in international credit and asset price cycles during the first era of financial globalization, in the 19th century.

Yet most importantly, this article contributes to the debate about the effectiveness of floating exchange rates and the monetary policy autonomy they entail in achieving some degree of independence from global financial cycles in times of high levels of international financial integration. As mentioned above, Rey (2013) and Miranda-Agrippino and Rey (2014) have forcefully argued
that a global financial cycle, driven by global risk perceptions and financing conditions in the
world’s financial centers, binds together international financial conditions, regardless of exchange
rate regimes and the degree of monetary policy autonomy. Our analysis is generally supportive
of their ideas, but provides some more nuance. We will replicate the important findings of the
trilemma literature and show that floating exchange rates and an independent monetary policy go
along with some degree of independence from global interest rates and equity prices. However, we
will also show that there is very little evidence that floating exchange rate countries can decouple
from medium-term global cycles in credit aggregates and house price cycles.

The structure of the paper follows the three big questions we address: We first ask if the
international co-movement of financial cycles has increased over time, i.e., has the global financial
cycle become stronger in recent decades? Second, we study if financial center countries like the
U.S. today (and the U.K. in earlier times) lead the global financial cycle. We then turn to the
questions posed by the dilemma challenge: Do global financial cycles, originating from financial
centers, affect countries with flexible exchange rates to the same degree as fixed exchange rate
economies? Does independent monetary policy allow countries to decouple from global financial
cycles. The short answers to these questions will be: “yes, yes, and no”.

Methodologically, our study relies on novel wavelet methods. Wavelets have several important
advantages over more traditional correlation methods. First, they allows us to study the co-
movement relations of international financial cycles for cycles of different lengths. Equity prices
for example exhibit important short-run cycles, as well as decades-long bear and bull markets.
While one may co-move closely with its international counterparts, the other may not. As
financial systems have gone through profound changes over the past 140 years, there could also be substantial time-variations in the co-movement of financial cycles. Wavelets enable us to capture such potential time variations and allow us to show that, for instance, the length of house price-cycles has increased over the past decades. A final advantage of wavelet analysis is its lead/lag-robustness. Not all co-movement patterns can be expected to be contemporaneous. Credit and house prices might react with a considerable lag to what happens in important financial centers. We will provide more detail about the method in the following section.

2 Data and Method

In this section we briefly introduce our dataset, discuss the important issue of exchange rate regime classification and provide a primer on the main methodological innovation of this paper, i.e., the use of wavelet analysis to identify cyclical co-movement across frequencies that is lead/lag-robust. For the time being, data availability largely determines the choice of financial variables that we use to detect cyclical co-movements. In particular with respect to credit extension, we rely on credit volumes as no long-run data for credit spreads or lending rates are yet available.

2.1 Data

Our dataset comprises annual data from 1870 to 2013, for 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 50% of world GDP throughout the period we are looking at.

Financial cycles are often associated with the ebb and flow in credit aggregates, house prices
and equity prices, as Claessens et al. (2011), Drehmann et al. (2012) as well as Aikman et al. (2015) argue. To analyze their international co-movement since 1870 we build on data collections that have recently become available. Our credit and equity price series initially come from Jordà, Schularick, and Taylor (2014). The credit series cover loans of all monetary financial institutions — including savings banks, postal banks, credit unions, mortgage associations and building associations — to the non-financial private sector. The data has subsequently been extended and updated to cover 17 countries from 1870 to 2013. All other economic variables, including interest rates and consumer price indices used for deflation, also come from the most recent vintage of the Jorda-Schularick-Taylor macrohistory dataset.

The house price data come from Knoll, Schularick, and Steger (2014). They typically cover the same house type across time, and reflect prices of existing houses, rather than new ones. Within-country geographical coverage can vary (particularly for the earlier years), but generally the series were constructed on the basis of the indices with the broadest geographical coverage available. We have updated the house price series through to 2013, and extended their country coverage to include Italy, Portugal and Spain.

Equity price data rely on the series collected by Schularick and Taylor (2012), but they have been substantially extended and updated for this paper by chain-linking historical stock price indices. Where more than one index was available, we used the index with a broader firm and sectoral coverage. The equity price data now covers 17 countries from 1870 to 2013 with very few gaps.

In our analysis, we work with transformations of the raw data: we first deflated all series with
their respective long-run CPI series (also from Jordà, Schularick, and Taylor (2014)) and linearly detrended the logged series. The credit, house price and equity price series contain missing values, which are concentrated at the beginning of our sample and around the two World Wars. To deal with these, we linearly intra- and extrapolate the deflated and logged series, before linear detrending. We then normalize all detrended series to a mean of 0 and standard deviation of 1 for each country. The resulting series thus convey only information on the deviation from a country-specific trend.

As part of the robustness checks we also ensured that our results do not critically depend on the country selection, or the treatment of missing values: First, we replicate all analyses on a subset of countries unaffected by intrapolation and extrapolation. Second, we replicate our study with post-World War 2 data, which is not affected by missing values (see figures A1, A2 and A3 in the appendix).

2.2 Exchange rate regime and capital controls

The classification of exchange rate regime has long been recognized as an important issue in the empirical trilemma literature (Klein and Shambaugh, 2013). The choices we made are the following: Our peg dummy takes the value of 1 if a country was on the gold standard before 1940. We rely on the indicator variable by Obstfeld and Taylor (2003). After World War 2, we rely on the coarse exchange rate regime classification scheme of Ilzetzki, Reinhart, and Rogoff (2008). Our peg dummy is 1 for de facto pegs, whose exchange rate stays within a +/- 2% band, and 0 otherwise. Yet after World War 2, the distinction between peg and float becomes less clear-cut, as the trilemma gets “cornered” by crawling pegs and managed floats (Klein and Shambaugh, 2013).
As a robustness check we therefore also compare free floats, as defined by Ilzetzki, Reinhart, and Rogoff (2008), with pegs.

With respect to the selection of the base country against which other countries peg, we follow Obstfeld, Shambaugh, and Taylor (2005). Before World War 1, the U.K. is generally the base country, with a few exceptions. For the Netherlands, Norway, Italy and the U.K. itself, Germany is considered the base country (see Morys, 2010). In the interwar period the U.S. is considered to be the base country up to 1932. Thereafter France takes over from 1933-1935. But there are various exceptions. For the Sterling block countries, the U.K. continues to be the base country after 1931. In the Bretton Woods era, the U.S. are the base country until 1960. From 1960 on we use the base indicator by Shambaugh (2004), which we extended up to 2013.

We follow Obstfeld, Shambaugh, and Taylor (2005) with respect to our capital control dummy. Before 1914, there are no capital controls. From 1920 to 1939, we rely on Eichengreen and Irwin (2010) for the construction of the variable. During the Bretton Woods era capital controls are assumed to be in place for all countries. From 1973 on we rely on the index of capital account openness by Chinn and Ito (2008). The index is a continuous variable which we code as 1, for values above its mean, and zero below.

2.3 Wavelet analysis

To address the core research question of this paper, we turn to wavelet analysis. Wavelets are wave functions, which can be used to “read” the cyclical properties of a time series. Wavelets can be stretched or compressed to scan for oscillations of various frequencies. They can be furthermore shifted back and forth in time.
In our context, these specific properties of wavelets are important for a number of reasons: First, the degree of synchronization of financial variables may depend on the frequency looked at. Equity prices for instance exhibit important short-run variation, as well as decades-long bear and bull markets (see Shiller, 1981; Barsky and Long, 1990; Geanakoplos, Magill, and Quinzii, 2004). It might be the case that only the latter are internationally synchronized, while the former are not, or vice versa. Wavelet-based methods reveal such frequency-dependent co-movement patterns.

Second, financial cycles may change their frequency over time. This is clearly evident in house price cycles. While in the 1960s and 1970s a typical cycle lasted 4-8 years, its length has since increased to 20 years. Such changes in cycle length are hard to accommodate in conventional correlation analyses. Correlation coefficients, calculated on the basis of band-pass filtered time series, run the risk of loosing sight of the cycle if it “migrates out” of the prespecified filter bands towards lower frequencies. Specifying very broad filter bands on the other hand risks confounding the low correlation house prices exhibit at standard business cycle frequencies, with the extremely high international correlation they exhibit at lower frequencies. Wavelet-analyses yield time-as well as frequency-specific results.

Finally, financial cycles do not always co-move contemporaneously. In particular house price- and credit-cycles may exhibit considerable cross-country time lags. In the extreme case this can result in conventional correlation coefficients indicating zero correlation for two time series that actually exhibit identical cycles, although at a lag. For instance, this would be the case if a 4-year US-credit cycle led a 4-year U.K.-credit cycle by 1 year. Complex valued wavelets can capture such lead/lag-structures. The following paragraphs provide a short introduction to the wavelet-based
measures we use in the subsequent investigation. For more details we refer the reader to the technical appendix of this paper.

2.3.1 Wavelet transformation

Wavelets are time-localized wave functions $\psi_{\tau,s}$, which are shifted across time by translation parameter $\tau$ and are stretched or compressed by scaling parameter $s$:

$$\psi_{\tau,s}(t) = \frac{1}{\sqrt{s}} \psi \left( t - \frac{\tau}{s} \right).$$ (1)

By convoluting a time series $x(t)$ and a wavelet, i.e. by integrating their product, the wavelet can "read off" the cyclical properties from the time series. By stretching and compressing the wavelet and convoluting it with the time series we can discover at which frequencies the time series oscillates. By shifting the wavelet back and forth in time this information is rendered time-specific. All this information – when a time series varies at which frequencies – is stored in the continuous wavelet transform (CWT):

$$W_x(\tau,s) = \int_{-\infty}^{\infty} x(t) \psi^*_{\tau,s}(t)dt,$$ (2)

where $^*$ denotes the complex conjugate.

Based on two such time- and frequency-dependent CWTs, for either the credit-, house price- or equity price-series of two countries $i$ and $j$, we can obtain a time- and frequency-dependent
covariance measure, the *cross-wavelet transform*\(^1\):

\[ W_{x_i,x_j}(\tau,s) = W_{x_i}(\tau,s)W_{x_j}^*(\tau,s). \] (3)

On the basis of two CWTs (equation 2) and their cross-wavelet transform (equation 3), it is possible to obtain a time- and frequency-dependent correlation measure, the *wavelet coherency*. It is defined similar to the conventional correlation coefficient:

\[ \rho_{x_i,x_j}(\tau,s) = \frac{|S(W_{x_i,x_j}(\tau,s))|}{\sqrt{S(|W_{x_i}(\tau,s)|^2)S(|W_{x_j}(\tau,s)|^2)}}, \] (4)

where \( S \) is a smoothing operator, and \(|\cdot|\) denote the modulus. As opposed to conventional correlation coefficients wavelet coherency ranges only from 0 to 1, where a values of 0 indicates no correlation and a value of 1 indicates perfect correlation. The wavelet coherency allows us to see how the financial cycles of two countries co-move – when, and at whether the co-movement takes place among short-cycles or medium-term cycles. Note that wavelet coherency does not indicate whether the correlation is positive or negative. We can determine which is the case, by looking at the *phase difference*

\[ \phi_{x_i,x_j}(\tau,s) = \text{Arctan} \left( \frac{\mathcal{I}(W_{x_i,x_j}(\tau,s))}{\mathcal{R}(W_{x_i,x_j}(\tau,s))} \right), \] (5)

where \( \mathcal{I}(W_{x_i,x_j}(\tau,s)) \) and \( \mathcal{R}(W_{x_i,x_j}(\tau,s)) \) denote the imaginary and real part of the complex cross-wavelet transform respectively. The phase difference indicates by how much two cycles lead or lag each other, and through this whether they are positively or negatively correlated. Intuitively,

\(^1\)Actually we calculate the bias-corrected cross-wavelet transform (Veleda, Montagne, and Araujo, 2012), such as not to bias our results towards high co-movement at low frequencies.
as a complex number the wavelet coherency at any time \( t \) and scale \( s \) can be imagined as vector in the complex plane. The angle between the real axis and this vector represents how far a series has progressed in its cycle: \( 0^\circ \) indicate the cycle’s beginning, \( 180^\circ \) indicate the series is half through its cycle, and the cycle comes to completion at \( 360^\circ \). In this sense the imaginary part of the wavelet coherency retains information on \textit{when} which series is at which point in its cycle. The definition of the phase difference – also the \textit{phase angle} – then follows from basic trigonometry in the complex plane.

The phase difference ranges from \(-\pi\) to \(\pi\). Generally, an absolute phase difference of less than \(\frac{\pi}{2}\) is taken to indicate a positive correlation, while an absolute phase difference above \(\frac{\pi}{2}\) indicates a negative correlation.\(^2\)

2.4 Application

In our investigation of the co-movement of international financial cycles in section 3, we aggregate the wavelet coherency measures of all country pairs \( i, j \) into the \textit{wavelet cohesion} measure

\[
\text{coh}(\tau, s) = \frac{1}{N} \sum_{i<j} \rho_{x_i, x_j}(\tau, s),
\]

where \( x_i \) and \( x_j \) are either the credit-, house price- or equity price-series of countries \( i \) and \( j \), and \( N \) is the number of country-pairs.

To determine whether important financial centers (the U.K. in the 19th century, and the U.S.

\(^2\)More precisely, for absolute values of \( \phi_{x_i, x_j}(\tau, s) \) below \(\frac{\pi}{2}\) the two time series are \textit{in phase} (positively correlated), with \( x_j \) leading \( x_i \) for \( \phi_{x_i, x_j}(\tau, s) \in (-\frac{\pi}{2}, 0) \), and \( x_j \) lagging \( x_i \) for \( \phi_{x_i, x_j}(\tau, s) \in (0, \frac{\pi}{2}) \). For absolute values of \( \phi_{x_i, x_j}(\tau, s) \) above \(\frac{\pi}{2}\) the two time series are \textit{out of phase} (negatively correlated), with \( x_j \) leading \( x_i \) for \( \phi_{x_i, x_j}(\tau, s) \in (-\pi, -\frac{\pi}{2}) \), and \( x_j \) lagging \( x_i \) for \( \phi_{x_i, x_j}(\tau, s) \in (\frac{\pi}{2}, \pi) \).
today) lead international financial cycles we turn to the phase difference. In section 4 we calculate
the phase differences for credit-, house price- and equity price-cycles of the financial center \( f_c \)
with respect to all other countries \( j \). Analogously to the cohesion measure, we then aggregate the
country-pair phase differences \( \phi_{x_{f_c},x_j}(\tau,s) \) into an average

\[
\Phi(\tau,s) = \frac{1}{N_{f_c}} \sum_{f_c \neq j} \phi_{x_{f_c},x_j}(\tau,s),
\]

where \( x_{f_c} \) indicates the financial center’s time series, while \( x_j \) (\( j = 1, \ldots, J \)) indicate all other
countries’ time series (including the U.S. when the U.K.’s lead with respect to the rest of the world
is checked, and vice versa). \( N_{f_c} \) is the corresponding total of country-pairs.

Finally, to analyze how much insulation floating exchange rates provide from global financial
cycles, we calculate the cohesion measure (6) for the different exchange rate regimes. We do not
only match pegs with their base country, but we also match two pegs when they share the same
base country. Similarly, two pegs are counted as non-pegged to one another, if they are pegged
to different base countries, and if these base countries are not pegged to one another. In order
to focus squarely on the difference between peg and non-peg we drop the time dimension and
calculate the time-averaged cohesion for pegs and floats separately,

\[
coh(s) = \frac{1}{T} \sum_{\tau} \left( \frac{\sum_{i<j} e_{i,j}(\tau) \rho_{x_i,x_j}(\tau,s)}{\sum_{i<j} e_{i,j}(\tau)} \right),
\]

where \( T \) stands for the total number of years averaged over, and \( e_{i,j}(\tau) \) is the time-specific peg
status between countries \( i \) and \( j \). On the basis of this measure we can see whether financial cycles
co-move differently among pegs and floats, at any frequencies. Using this time-averaged cohesion
measure we can test whether the co-movement of floating and fixed exchange rate economies is significantly different across different cycle frequencies.

3 How do financial cycles co-move internationally?

Theory makes no clear prediction if one should expect positive or negative international co-movement of financial variables. A basic international RBC framework suggests a negative co-movement as a domestic TFP shock increases the marginal product of capital at home leading to a temporary expansion there. At the same time the foreign country contracts as world interest rates are pushed up by home’s increased financing demand (Backus, Kehoe, and Kydland, 1992; Kollmann, 1996; Mendoza, Quadrini, and Ríos-Rull, 2009).

In contrast, international macro-models featuring bank intermediation can generate positive co-movement in international financial cycles. Kollmann, Enders, and Müller (2011), for instance, present a model in which negative co-movement inherent in international RBC models is supplemented by the synchronizing forces of a global bank. Responding to a credit loss in one country, the global bank increases the loan-deposit spread in both countries to replenish its capital and thereby induces an internationally synchronized contraction. Van Wincoop (2011) provides an overview of international general equilibrium models with a banking sector that generate positive international co-movement on the basis of the transmission of asymmetric shocks. Other than transmission mechanisms, correlated international shocks can also be responsible for financial cycle co-movement: Bacchetta and van Wincoop (2013) for example explain globally synchronized co-movement.

\[^3^{Clearly, the relation between capital flows in general (studied in most international macro-models) and bank lending and asset prices (our data) is not unambiguous, international macro-models nevertheless provide a helpful starting point to think about the international co-movement of financial cycles.\]
contractions by self-fulfilling global risk shifts. Empirically, the global nature of risk perception, and consequentially asset pricing has been underlined by Miranda-Agrippino and Rey (2014). Empirical analysis has therefore an important role to play for guiding future theoretical work. This is what we turn to next.

Figure 1 shows the wavelet cohesion for international credit-cycles in the time-period plane. A period refers to the number of years a cycle needs to return to its initial value. The degree of cohesion is color-coded, with dark areas indicating high cohesion, and light areas low cohesion. If financial cycles are out of phase (i.e. negatively correlated), this is indicated by white minus signs. Cohesion values which differ at the 5% significance level from the cohesion of two independent AR(1) processes are encircled by thick black and white confidence bands. The black-transparent areas at the left- and right end of the figure indicate the cone of influence, within which results are affected by border-effects and thus have to be interpreted cautiously. For ease of exposition, we will occasionally refer to the 2-8 year period-band as the "short-cycle range", and the 9-32 year period-band as the "medium-cycle range".

Figure 1 shows that before 1900, short- and medium-term credit-cycles tended to be negatively correlated with one another (as is indicated by the white minus sings and confidence bands). When credit boomed in some countries, it tended to be sluggish in others. Other areas of significant credit-cohesion can be found in the medium-term cycle range around World War 1 and

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4The negative co-movement results for the 19th century are generally less often significant, than the positive co-movement results of today’s financial globalization. Partly this is due to the linear extrapolations we undertake at the beginning of our sample. More fundamentally however, while all countries’ cycles can co-move positively with one another, it is never possible that all countries’ cycles co-move negatively at the same time. As the deck is thus in principle stacked against finding negative co-movement the consistently negative cohesion we find for the 19th century, although often insignificant, is thus all the more noteworthy.
Figure 1: Global Credit Cohesion

Notes: High cohesion (dark). Low cohesion (light). Black and white lines indicate 95% confidence bands (500 Monte-Carlo simulations; AR(1) background spectrum). Black confidence bands surround areas of average in-phase cohesion (positive correlation). White bands surround areas of average out-of-phase cohesion (negative correlation). White minus signs indicate average out-of-phase cohesion. Black-transparent areas indicate the cone of influence in which results are affected by border-effects. Dashed lines separate the Prewar-, the Interwar-, the Bretton Woods- and the Post-Bretton Woods periods.

2. In both cases credit collapsed and subsequently recovered across many countries. Abstracting from the wars however, the most notable accumulation of significant credit-cohesion can be found after 1970 — international credit-cycles today are more synchronized than ever before.

The big picture for house prices looks very similar to the credit cohesion measure (see figure 2). Prior to World War 1 house prices tended to be inversely related to one another. The first notable area of significant positive cohesion is again located in the medium-term cycle range around World War 1. The Bretton Woods era from 1945 to 1973 does not exhibit significant international co-movement in house prices. If anything, house prices tend to be negatively correlated. Since 1973 international cohesion in house prices has been on the rise. Moreover, the period at which house price cycles co-move has lengthened, from 4-8 years in the 1970s to above 16 years since the 2000s.
The cohesion-results for equity prices share similarities with credit- and house prices, but there are some substantial differences. In the 19th century equity price-cycles are characterized by negative co-movement. However, there are occasional outbursts of positive co-movement in the short-cycle range, such as during the “Gründerkrach” in the early 1870s, or around the global crisis of 1907. At very low frequencies (period > 20 years) an area of high positive cohesion emerges shortly after 1900 and retains its significance throughout most of the 20th century. This high cohesion area is associated with decades-long bear and bull markets, explanations for which range from animal spirits, over variations in expected returns, to demographics (see Shiller, 1981; Barsky and Long, 1990; Geanakoplos, Magill, and Quinzii, 2004). Figure 2 shows that the alternation between these major bear and bull markets has been highly synchronized across countries.

The short-cycle range is characterized by significant cohesion around the Great Depression
Figure 3: Global Equity Price Cohesion

Notes: High cohesion (dark). Low cohesion (light). Black and white lines indicate 95% confidence bands (500 Monte-Carlo simulations; AR(1) background spectrum). Black confidence bands surround areas of average in-phase cohesion (positive correlation). White bands surround areas of average out-of-phase cohesion (negative correlation). White minus signs indicate average out-of-phase cohesion. Black-transparent areas indicate the cone of influence in which results are affected by border-effects. Dashed lines separate the Prewar-, the Interwar-, the Bretton Woods- and the Post-Bretton Woods periods.

and a number of other occasions. High cohesion in the 1950s may reflect an increase in financial integration within regions (Europe, Scandinavia, North America as regional cohesion results suggest — not shown but available upon request). The cohesion among short-cycles in the early 1950s for instance may be associated with the abolishment of war-time exchange and capital controls by 1951 in the U.S. and Canada. For Europe, a similar process occurs somewhat later in the 1950s after several reintegration efforts had been undertaken (European Payments Union, 1950; Treaty of Rome, 1957). From the 1960s on the high cohesion-results for equity prices could be associated with an increase in financial integration between regions (Eurodollar market). Since the 1980s, medium-term equity price-cycles become highly integrated too and the extent of global equity price synchronization has reached an historically unprecedented level.

Our findings can be summarized as follows: The most recent era of financial globalization, has
witnessed a large degree of positive financial cycle correlation across countries (also see Aikman, Haldane, and Nelson, 2014; Miranda-Agrippino and Rey, 2014). This stands in stark contrast to the first era of financial globalization, before 1914, when financial cycles tended to be negatively correlated (also see Ford, 1962; Fishlow, 1985). These results are robust to GDP-weighted aggregation of bilateral coherencies, retaining only series with even less interpolated values, and different wavelets (see the robustness section in the appendix to this paper). In general the various robustness check tend to strengthen the asymmetry-result for the 19th century.

4 Do financial centers lead international financial cycles?

What role do financial centers play in kick-starting global financial cycles? Does the US today lead the global financial cycle and did the U.K. do so in the first era of financial globalization? For instance, Miranda-Agrippino and Rey (2014) have shown that monetary policy in the U.S. affects credit growth and asset prices beyond American borders. Bruno and Shin (2013), for instance, propose a model in which global banks, with access to financial center money markets, transmit the financial center’s financing conditions to regional banks around the world; and Cetorelli and Goldberg (2012) presents econometric evidence on how global banks contribute to the international transmission of liquidity shocks through the lending conducted by their foreign affiliates. There are also other channels through which financial centers may lead global financial cycles. Financial center stock markets, for instance, may synchronize perceptions of asset price-risk of international investors (see Bacchetta and van Wincoop, 2013). Financial centers may also be leaders in financial regulatory reform, inducing a financial center-lead in low-frequency cycles.
Figure 4: Credit phase differences

Notes: Phase differences above 0 indicate a financial center-lead, phase differences below 0 a lag. For absolute phase differences below \( \frac{\pi}{2} \) the two time series are in phase (positively correlated). For absolute phase difference values above \( \frac{\pi}{2} \) the two time series are out of phase (negatively correlated). Dashed lines: 95% confidence intervals.

With these considerations in mind we now investigate whether the U.S. leads international financial cycles today, and whether the U.K. did so in the first era of financial globalization. Figures 4 to 6 display the corresponding phase differences (equation 7) averaged over the 2-32 year period-band for credit, housing markets and stock prices. Figure 4 thus displays the average phase differences, which the U.K. and the US financial cycles exhibit with respect to the rest of the world from 1880 to 2003. A phase difference above 0 indicates a lead of the financial center, while a phase difference below 0 indicates a lag.\(^5\)

The main result from the figures is that since the 1970s the U.S. have a clear lead in world

\(^5\)The figures leave out the first and last ten years of our sample due to border-effects. Interpretation of the results can be further aided by looking at the corresponding cohesion measures in the appendix. They indicate the exact timing and frequency of significant cycle co-movements that were led or lagged by the financial centers (see Ge, 2008).
Figure 5: House price phase differences

Notes: Phase differences above 0 indicate a financial center-lead, phase differences below 0 a lag. For absolute phase differences below $\frac{\pi}{2}$ the two time series are in phase (positively correlated). For absolute phase difference values above $\frac{\pi}{2}$ the two time series are out of phase (negatively correlated). Dashed lines: 95% confidence intervals.

credit cycles. The U.S. took over this role as the conductor of the international credit cycle around World War 1, but for the intermittent Bretton Woods era the lead is insignificant. If we turn back to the 19th century, the U.S. tended to lag the international credit cycles. The U.K. as the leading financial center of its time led the global credit cycles until World War 1. After World War 2, the U.K. temporarily regains a lead in the 1950s. However, a look at the corresponding cohesion maps (figure A7 in the appendix) also shows, that the 1950s did not exhibit much significant co-movement in world credit-cycles. Thus, while the U.K. may have had a tendency to lead international credit-cycles in the 1950s, these cycles were small in amplitude and in the degree of co-movement.

With respect to house prices, figure 5 indicates that, after World War 2, the U.S. did again have a
tendency to lead, again taking over from the U.K.. In the 19th century, the U.S. furthermore tended to lag international house price cycles. For house prices in the Bretton Woods era, occasionally, no confidence bands could be calculated. This happens when the individual country-pair phase differences are too uniformly dispersed between $-\pi$ and $\pi$; in other words: at the time, financial centers exhibited neither systematical leads nor lags on international house prices.

Figure 6 shows the results for equity prices. A similar picture emerges. As was the case for credit and house prices, financial centers tend to lead international equity price cycles. The U.S. took over the lead from the U.K. around World War 1 and has kept it ever since. In the 19th century, the U.S. tended to lag international equity prices – similar to our previous findings for credit aggregates and house prices.
In sum, there is substantial evidence that financial center countries lead global financial cycles in credit, house prices and equity markets. Today, the U.S. economy leads highly co-moving financial cycles. The U.K. did lead the 19th century’s cycle. These findings are again robust to GDP-weighted aggregation of bilateral phase differences, retaining only series with hardly any interpolated values, and the application of different wavelet bases (see the robustness section in the appendix).

5  Do financial cycles co-move less among floating exchange rate economies?

It is widely accepted that floating exchange rates allow monetary policy-makers to set domestic interest rates in pursuit of domestic policy goals (Fleming, 1962; Mundell, 1963). Important empirical studies have confirmed that interest rate co-movement is stronger among economies whose exchange rates are pegged (Shambaugh, 2004; Obstfeld, Shambaugh, and Taylor, 2005). Can this result be generalized to credit and asset prices? Or, put differently, how much insulation do floating exchange rates provide from global financial cycles?

Opinions on the topic differ. On the one hand Obstfeld (2014) stresses that although global financial cycles may complicate matters, flexible exchange rates are still worth having. Independent interest rate is nevertheless a powerful arrow in the quiver of policy makers. On the other hand, the Rey (2013) and Miranda-Agrippino and Rey (2014) argue that the efficacy of this independent interest rate pales in comparison to the force of global financial cycles. In this view, floating exchange rates would have to be complemented by capital controls and macroprudential policies.
in order to gain policy independence and true control of domestic financial conditions.

At the heart of the dilemma-trilemma debate stands the question if domestic monetary policy or global financial factors are more potent in affecting domestic credit growth and asset prices. This question can be tested empirically: If monetary policy autonomy is overwhelmed by global financial conditions, financial cycle co-movement should not systematically differ among pegs and floats. However, if monetary policy is powerful in shaping domestic financial conditions, credit- and asset prices should exhibit less co-movement with the global financial cycle. Our empirical strategy relies on this intuition: in essence, we will test whether financial cycles co-move significantly less among floating exchange rate economies than among fixed-exchange rate countries.

The range within which we expect our results to fall can be illustrated by two extreme cases: If there exists a reliable effect of interest rates on credit and asset prices, interest rate-independence in the trilemma logic should also translate into (more) credit- and asset price-independence. In this case, financial cycles should be less integrated among floats — the trilemma logic extends to financial cycles. If however the effect of interest rates on credit and asset prices is overwhelmed by global factors in times of high financial integration, then financial cycle co-movement should not differ substantially among pegs and floats and we would find the same degree of financial cycle co-movement among different exchange rate regimes.

To connect our results to the broader trilemma literature, table 1 shows how our wavelet cohesion measure compares to the regression coefficients reported in Obstfeld, Shambaugh, and Taylor (2005). The first column displays the coefficients Obstfeld, Shambaugh, and Taylor (2005)
Table 1: ST rates: regression coefficients vs wavelet cohesion

<table>
<thead>
<tr>
<th></th>
<th>OST 2005, Regression coefficients</th>
<th>Our sample, Regression coefficients</th>
<th>Cohesion (average), not lead-lag robust</th>
<th>Cohesion (average), lead-lag robust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pegs</td>
<td>0.43 (p-value) = 0.35 &lt; 0.01</td>
<td>0.35 (p-value) = 0.00 &lt; 0.01</td>
<td>0.39 (average) = 0.00</td>
<td>0.68 (average) = 0.02</td>
</tr>
<tr>
<td>Nonpegs</td>
<td>0.26 (p-value) = 0.00 &lt; 0.01</td>
<td>0.21 (p-value) = 0.00 &lt; 0.01</td>
<td>0.22 (average) = 0.00</td>
<td>0.64 (average) = 0.00</td>
</tr>
<tr>
<td>Difference</td>
<td>0.17 (p-value) = n/a</td>
<td>0.14 (p-value) = 0.01 &lt; 0.01</td>
<td>0.17 (average) = 0.00</td>
<td>0.04 (average) = 0.00</td>
</tr>
</tbody>
</table>


obtain by regressing the changes of the nominal short-term interest rate of the base country, $\Delta R_{it}^{base}$, on the corresponding variable in the home country, $\Delta R_{it}$,

$$\Delta R_{it} = \alpha + \beta \Delta R_{it}^{base} + u_{it},$$

(9)

for pegs and nonpegs separately.\(^6\) Similar to our baseline peg dummy, the pegs and floats here are separated according to the de facto behavior of their exchange rate, i.e., depending on whether it stays within a +/-2% band. Obstfeld, Shambaugh, and Taylor (2005) find that the $\beta$-regression coefficient for pegs ($\beta = 0.43$) is substantially higher than for nonpegs ($\beta = 0.26$). Floating clearly goes along with considerable less short-term interest rate co-movement with the base country.

\(^6\)Obstfeld, Shambaugh, and Taylor (2005) consider the co-movement between pegs and their base country only. As described in the text, we will base our main results on a slightly different setup. We do not only consider countries according to whether they float or peg with respect to their base country, instead we also consider two countries as pegs if they are pegged to the same base country. Similarly we consider two pegs as floating to one another if they are pegged to different base countries, and these base countries have floating exchange rates. However, we adhere to the approach of Obstfeld, Shambaugh, and Taylor (2005) for the remainder of table 1 to ensure comparability.
As the Obstfeld, Shambaugh, and Taylor (2005) results are based on a different dataset, our first task is to replicate these findings. Column two shows the results: the coefficients, as well as their difference, are of comparable magnitude. The next step is to test how wavelet cohesion compares to the regression coefficients. Column three presents the time- and period-average of a wavelet cohesion measure that is not lead-lag robust. The non lead-lag robust measure is obtained through retaining only the real part of the cross-wavelet transform (equation 3),

$$\rho_{x_i x_j}^{\text{real}}(\tau, s) = \frac{R(S(W_{x_i}x_j(\tau, s)))}{\sqrt{S(|W_{x_i}(\tau, s)|^2)S(|W_{x_j}(\tau, s)|^2)}}. \tag{10}$$

the resulting non-lead-lag robust cohesion measure ranges from -1 to 1, and it is equivalent to standard correlation coefficients (see Rua, 2010):

$$coh_{x_i x_j}^{\text{real}}(\tau, s) = \frac{1}{N} \sum_{i<j} \rho_{x_i x_j}^{\text{real}}(\tau, s). \tag{11}$$

Column three also shows that the results we obtain on the basis of this measure are very similar to the regression coefficients that are standard in the trilemma literature.

However, the results in column four change the picture. Here we present the time-and period-average of the lead-lag robust wavelet cohesion measure (equation 6). Cohesion levels are generally higher both for pegs and floaters. Importantly, the difference between pegs and nonpegs shrinks substantially. The explanation is the following: Floats may not follow changes in foreign interest rates within the year, but once co-movement at various leads and lags is taken into account, pegs and nonpegs behave in a more similar way. In the following, we will report the lead-lag robust measure, but the contemporaneous cohesion-results can also be interesting as a
reference point to the trilemma literature. They can be found in the appendix.

We can refine this analysis by looking at differences in the cyclical cohesion between pegs and non-pegs across different frequencies. We calculate period-specific wavelet cohesion measures according to equation 8. We now also turn from comparing only country-base pairs to comparing any two countries whose exchange rate is fixed or floats to one another. This allows us to consider a substantially broader set of country-pairs.\(^7\) Each subplot in figure 7 contains two lines — one indicating the cohesion of financial cycles among pegs (solid line), the other among non-pegs (dashed line). The gray confidence band represents the range which the dashed line has to leave in order to indicate a 5%-significant cohesion difference between pegs and floats. Put differently, for the trilemma hypothesis to prevail, one would expect these two lines to be apart far enough to reject the hypothesis that they are equal.

Our result do not bode well for the trilemma view of the world: for credit and house prices, financial cycles do not co-move significantly differently among pegs and nonpegs. For credit and house prices the cohesion levels range from 0.5 to 0.8. Generally co-movement is higher at lower frequencies. The dashed lines (floats) don’t lie consistently below the solid lines (pegs). For equity prices, cohesion levels are generally higher, ranging from 0.6 to 0.9. While the dashed line lies below the solid line more often, their difference is insignificant at all periods.

For short-term and long-term interest rates cohesion levels range from 0.6 to just above 0.8. For both interest rates, the dashed line (floats) lies consistently below the solid line. This confirms, with a novel statistical approach, that the trilemma holds for interest rates. As anticipated in table 1, the

\(^7\)It however turns out that it hardly matters which country-groupings we use; figure A17 in the appendix shows the equivalent to our baseline results (figure 7, but considering only the co-movement of economies with their base countries.
non-lead-lag robust cohesion measure for interest rates indicates an even larger contemporaneous independence among floats (figure A12). Floating exchange rates appear to entail a considerable degree of contemporaneous independence for fast moving variables – interest rates and equity prices. Yet we find no significant differences in slow moving credit aggregates and house prices between floaters and peggers.

Figure 7: Peg vs. Nonpeg Financial Cycles: Cohesion Differences

Notes: Solid line – pegs. Dashed line – nonpegs. Gray area – confidence band covering 95% of the 500 cohesion differences obtained through randomly repartitioning the exchange rate regime dummy. The 97.5 percentiles of the peg − float (float − peg) cohesion differences have been added (subtracted) to (from) the peg cohesion line (see technical appendix for more details).
We made the simple peg-nonpeg comparisons our baseline results. These findings are also confirmed by various checks. If we control for capital controls by considering only open pegs and floats (figure A13), the cohesion differences for equity prices and interest rates come out more pronounced. If we additionally separate free floats from target zone-regimes, crawling pegs and managed floats (see Klein and Shambaugh, 2013) the results hold up well (see figure A14). Perhaps surprisingly the long-term interest rate cohesion among floats now is no longer consistently lower than among pegs. Theoretically there are good reasons to expect the peg-float distinction to be less pronounced for long-term rates than for short-term rates: In the long-run expected exchange rate changes are more likely to cancel each other out and uncovered interest rate parity entails interest rate parity even for floats (Obstfeld, 2014). We are furthermore unsuccessful in significantly perturbing the baseline results through the use of only post-World War 2 data or using a GDP-weighted cohesion measure (see appendix to this paper).

The result that credit and house prices do not co-move less among floats than among pegs is clearly good news for the dilemma hypothesis. However, we also confirm a central tenet of the trilemma literature: short term interest rates under floating exchange rates co-move significantly less than in pegs, and equity prices tend to mirror the behavior of interest rates. For fast moving financial variables the trilemma appears to hold.

6 Conclusions

In this paper, we studied global financial cycles in credit markets as well as house and equity prices in the long-run, covering 17 advanced economies from 1870 to today. Introducing novel
wavelet analysis to the study of financial cycles, we find that the global financial cycle has become stronger over time and that financial center countries lead international financial cycles.

Is the trilemma in reality a dilemma as Rey (2013) argues? Do powerful financial spill-overs from global financial variables nullify the policy independence provided by floating exchange rates? We confirm the finding of previous studies that the trilemma hypothesis holds for short-term interest rates. Floating exchange rates bring independence for fast moving variables such as interest rates and equity prices. Yet we find no significant differences in slow moving credit aggregates and house prices between floating and fixed exchange rate countries. Credit and house prices do not co-move less among floats than among pegs. This gives credence to the dilemma hypothesis of Rey (2013).

The increasing global co-movement of financial variables documented in this paper indicates that for economic policy makers the world economy has become a considerably more demanding environment to operate in. As there seems to be no “divine coincidence” between monetary policy and financial cycle independence, policy makers may well find it harder to achieve their objectives without new instruments in their toolkit.

References


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Appendix

Figure A1: Linear Inter- and Extrapolation of Real Total Credit (logarithm)

Notes: Black points - original data. Blue Diamonds - imputed data.
Figure A2: Linear Inter- and Extrapolation of Real House Prices (logarithm)

Notes: Black points - original data. Blue Diamonds - imputed data.
Figure A3: Linear Inter- and Extrapolation of Real Equity Prices (logarithm)

Notes: Black points - original data. Blue Diamonds - imputed data.
Technical appendix

Frequency definition

The scale $s$ is translated into a frequency measure $\omega$ according to the energy frequency definition:

$$\omega^E = \frac{1}{||\Psi||^2} \int_{-\infty}^{\infty} \omega |\Psi(\omega)|^2 d\omega.$$  The cycle length is then simply the inverse of $\omega$, also called period.

For the morlet wavelet all three possible frequency definitions (energy frequency to peak frequency or central instantaneous frequency (see Lilly and Olhede, 2009, for details)) coincide. Thus the results reported in section 5 are not affected by frequency definition.

Wavelet choice

Many different wavelets exist. Much of the following analysis builds on the Generalized Morse Wavelet (GMW). The GMW has the advantage that its frequency- as well as time-localization are easily controlled by two parameters (see Lilly and Olhede, 2009; Aguiar-Conraria and Soares, 2014). This characteristic allows us to "zoom in" on the time-dimension and make more precise statements about the timing of a particular cycle-phenomenon. The GMW in the frequency domain is defined as:

$$\Psi_{\beta,\gamma}(\omega) = U(\omega) a_{\beta,\gamma} \omega^{\beta} e^{-\omega^\gamma}, \quad (12)$$

where $\Psi(\omega)$ is the Fourier transform of $\psi(t)$; $\omega$ is the frequency-, $t$ the time-index. $a_{\beta,\gamma}$ is a normalizing constant and $U(\omega)$ the unit step function. $\beta$ and $\gamma$ control the wavelet form. As economic historians we are particularly interested in the time dimension of our analysis. We thus use a baseline GMW with $\beta = 9$ and $\gamma = 1$, which allows us to make very precise statements about the timing of a particular cycle phenomenon, at the cost of less precision in the frequency
domain. We try to reflect this imprecision in the frequency domain by referring to broad frequency categories, such as short- and medium-cycles in the exposition of our results. We also apply different wavelet bases to ensure our results do not critically depend on prior wavelet choice.

Equation 8 abstracts from the time-dimension - time precision thus becomes irrelevant. Consequently it stands to reason to use a wavelet which puts more weight on precision in the frequency domain. We thus use the Morlet(6) wavelet for equation 8, which has a substantially higher frequency precision compared to our baseline GMW(9,1).

**Smoothing in equations 4 and 7**

Not smoothing the wavelet transforms results in an uninformative wavelet coherency measure, taking the value 1 throughout. The wavelet transforms are thus convoluted with a suitable window function. We use a Hamming window with a constant windowsize of three for time and scale smoothing (see Cazelles et al., 2007).

For the phase difference (equation 7) we use the same window function, but with a windowsize of 12 years, in order to concentrate on longer-run trends.

**Exchange rate regime-weighting in equation 8**

Before we use the exchange rate regime (ERR) dummy in equation 8, the dummy series is convoluted with a rectangular window function, with period-equivalent length (i.e. 8-year period – 8-year averaging of ERR-dummy). In this way the ERR-status is smoothed out over time in accordance with the length of the cycle under analysis. While the transition from peg to float occurs within one year, cycles bridge transitions in exchange rate regimes. The weighting strategy
ensures, that coherency values are adjusted for these exchange rate regime transitions – if half of the cycle extends into the next exchange rate regime, the corresponding coherency value is given only half the weight. This procedure undoubtedly blurs results around transition phases, but any analysis trying to link multi-year cycles with year-on-year changes in exchange rate regimes is bound to do so in one way or another: Correlation analyses of detrended variables feature cyclical components which aggregate information from before and after the transition; year-on-year growth rates, or first differences on the other hand put much weight on year-on-year movements, which does not go along well with the importance of medium-term cycles in credit and house prices.

**GDP-weighting equations 6, 7 and 8**

As a robustness check, we calculate GDP-weighted versions of equations 6, 7 and 8, to see whether our results are driven by economically smaller countries (data from Bolt and van Zanden, 2013):\(^8\)

\[
\operatorname{coh}(\tau, s) = \frac{\sum_{i<j} w_{ij}(\tau)\rho_{x_i,x_j}(\tau, s)}{\sum_{i<j} w_{ij}(\tau)}, \quad (13)
\]

\[
\Phi(\tau, s) = \sum_{f\neq j} \frac{w_{ij}(\tau)\phi_{x_{fc},x_j}(\tau, s)}{\sum_{f\neq j} w_{ij}(\tau)}, \quad (14)
\]

\[
\operatorname{coh}(s) = \frac{1}{T} \sum_{\tau} \left( \frac{\sum_{i<j} e_{ij}(\tau) w_{ij}(\tau)\rho_{x_i,x_j}(\tau, s)}{\sum_{i<j} e_{ij}(\tau) w_{ij}(\tau)} \right), \quad (15)
\]

where \(w_{ij}(\tau)\) is a time-specific weight attached to the wavelet coherency or phase difference of

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\(^8\)For what other plausible weighting variables come to mind, there usually does not exist sufficient long-run data. For instance the level of stock market capitalization for stock prices, or the value of the overall housing stock for house prices. However, unweighted results can be found in the appendix for comparison.
country-pair \( i, j \). Analogously to the exchange rate regime weighting in equation 8, the PPP-GDP series in equations 13, 14 and 15, are convoluted with a rectangular window function, with period-equivalent length (i.e. 8-year period – 8-year averaging of PPP-GDP). In this way the weighting corresponds to the length of the cycle under analysis.

**Frequency-aggregation of equation 7, in sections 4**

The period dimension in wavelet analysis is usually log-scaled, and the period grid, for which the wavelet statistics are calculated is usually made up of fractional powers of 2. When averaging over the period dimension there are thus far more grid points in the high frequency range than there are for lower frequencies; as a result a simple average would mostly reflect high frequency phase differences. For this reason we conduct a weighted averaging, to cancel out the grid effect.

**Confidence intervals**

To reflect the variation in the phase difference across different country-pairs, we calculate the 95% - confidence intervals for the mean direction (Zar et al., 1999; Berens, 2009, see). When the individual country-pair phase differences are too uniformly dispersed between \(-\pi\) and \(\pi\) no confidence bands are calculated.

The bootstrap confidence bands for the cohesion difference between floats and pegs in section 5 are calculated on the basis of random repartitions of the peg dummy along the lines suggested by Maris and Oostenveld (2007). Spells of 0s (floats) and 1s (pegs) are randomly restacked into a surrogate exchange rate regime dummy. On the basis of this surrogate dummy two more cohesion difference are calculated: \(coh_{peg} - coh_{float}\) and \(coh_{float} - coh_{peg}\). This procedure is repeated 500
times. We then add (subtract) the 97.5 percentiles of the 500 $\text{coh}_{\text{float}} - \text{coh}_{\text{peg}} (\text{coh}_{\text{peg}} - \text{coh}_{\text{float}})$ surrogate cohesion differences to (from) the original cohesion difference for pegs to obtain the confidence band.

**Cone of influence**

We calculate all cones of influence on the basis of a wavelet’s standard-deviation in time (see Aguiar-Conraria and Soares, 2014).
How do financial cycles co-move internationally?

The international co-movement results hold up in various robustness checks. They are virtually identical for the GDP-weighted cohesion measure (figure A4). The results also survives the application of a different wavelet basis (figure A5). Finally, if we use only time series with hardly any missing values one notable change occurs (figure A6): Medium-term house price-cycles since 2000 are no longer in-phase, but out-of-phase. After dropping the U.K. and US house price series, the remaining sample is almost exclusively European. We also try dropping the U.K. and the U.S. credit series, to see whether the same happens to credit-cohesion – it does. Thus, perhaps Interestingly, Europe, since the introduction of the common currency, exhibits the negative credit- and house price-cohesion last observed during the classical gold standard.

For credit we drop Belgium, France, Germany, the Netherlands and Spain (see figure A1). For house prices we drop Switzerland, the U.K. and the U.S. (see figure A2). For equity prices we drop the Netherlands, Switzerland and Spain (see figure A3).
Figure A4: GDP-weighted cohesion

(a) Credit

(b) House prices

(c) Equity prices
Figure A5: Cohesion with Morlet(6) wavelet

(a) Credit

(b) House prices

(c) Equity prices
Figure A6: Cohesion with fewer missing values

(a) Credit

(b) House prices

(c) Equity prices
Figure A7: Cohesion: UK vs RoW

(a) Credit

(b) House prices

(c) Equity prices
Figure A8: Cohesion: U.S. vs RoW

(a) Credit

(b) House prices

(c) Equity prices
Figure A9: GDP-weighted phase differences

(a) Credit

(b) House prices

(c) Equity prices
Figure A10: Phase differences with Morlet(6) wavelet

(a) Credit

(b) House prices

(c) Equity prices
Figure A11: Phase Differences: Other financial center-countries

(a) Credit

(b) House prices

(c) Equity prices
Figure A12: Peg vs. Nonpeg Financial Cycles: Cohesion differences (not lead-lag robust)
Figure A13: Cohesion difference: Open pegs vs. open nonpegs

Notes: Solid line – pegs. Dashed line – nonpegs. Gray area – confidence band containing 95% of the bootstrapped peg-nonpeg cohesion differences.
(a) Credit  (b) House Prices  (c) Equity Prices

(d) Short-Term Rates  (e) Long-Term Rates

Figure A14: Cohesion difference: Open pegs vs. open free floats

Notes: Solid line – pegs. Dashed line – nonpegs. Gray area – confidence band containing 95% of the bootstrapped peg-nonpeg cohesion differences.
Figure A15: Post-world war 2 cohesion difference: Peg vs. Nonpeg
Figure A16: GDP-weighted cohesion difference: Peg vs. Nonpeg
Figure A17: Cohesion difference: Peg vs. Nonpeg (only country-pairs with at least one base country)