

Stuart, Rebecca

Working Paper

Measuring stock market integration during the Gold Standard

IRENE Working Paper, No. 21-01

Provided in Cooperation with:

Institute of Economic Research (IRENE), University of Neuchâtel

Suggested Citation: Stuart, Rebecca (2020) : Measuring stock market integration during the Gold Standard, IRENE Working Paper, No. 21-01, University of Neuchâtel, Institute of Economic Research (IRENE), Neuchâtel

This Version is available at:

<https://hdl.handle.net/10419/238296>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

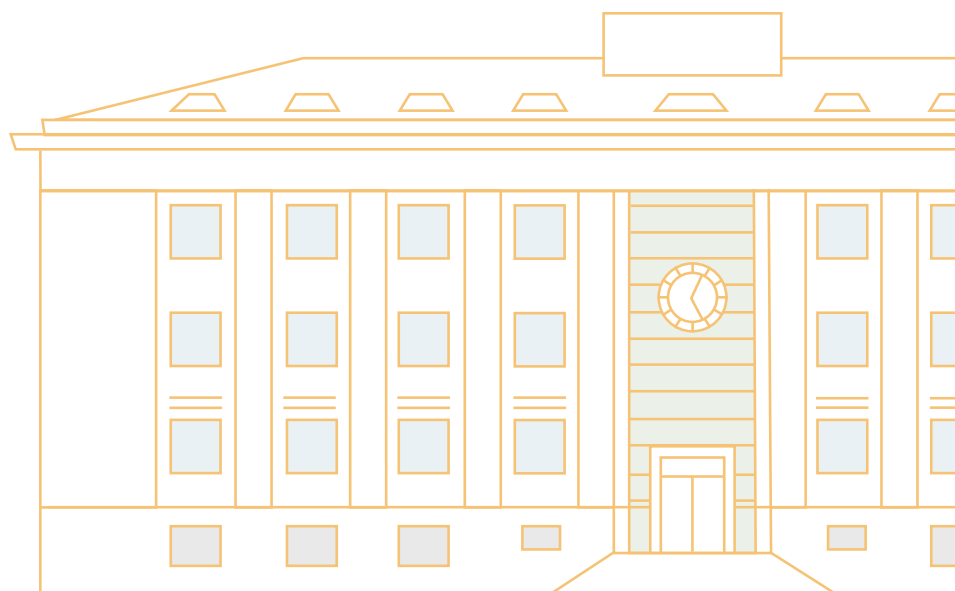
Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

IRENE Working Paper 21-01



Measuring stock market integration during the Gold Standard

Rebecca Stuart

Measuring stock market integration during the Gold Standard

Rebecca Stuart

University of Neuchâtel
and
Queen's University Belfast

January 5, 2021

Abstract

This paper uses a broad geographical sample to investigate stock market integration during the classical Gold Standard. It is novel in estimating 'global components' of stock market returns, using methods proposed by Volosovych (2011), Pukthuanthong and Roll (2009) and Ciccarelli and Mojon (2010). Contrary to the existing literature, all three measures suggest that integration increased during the first decades of the Gold Standard before levelling off thereafter. However, a comparison with more recent data suggests the level of integration was low compared to today. The results are robust to alternative formulations of the global component and alternative measures of returns.

Keywords: stock returns, principal components analysis, Gold Standard.

JEL Numbers: G1, N2.

I am grateful to David LeBris for providing French data, Marc DeLoof for providing Belgian data, Ronan Lyons for providing data from Grossman et al., (2014), Gareth Campbell for providing data from Campbell and Rogers (2015), Richard Grossman for assistance with his UK data and Adrian Pagan and Paula Drew for assistance in obtaining the Australian data. I would like to thank Daniel Kaufmann, John Turner, Richard Grossman, Stefan Gerlach, Morgan Kelly and participants at seminars in Queen's University Belfast and the Graduate Institute, Geneva, the EHES congress 2018 and the FRESH conference 2017 for helpful comments.

Contact information: email: rebecca.j.stuart@gmail.com, website: <https://www.rebeccastuart.net/>, address: Université de Neuchâtel, Institut de recherches économiques, Rue A.-L. Breguet 2, CH-2000, Neuchâtel.

1. Introduction

This paper aims to provide a robust picture of the pattern of stock market integration during the Classical Gold Standard, by using a broader sample than previously studied, and by employing several measures of integration not previously used in the literature. Obstfeld and Taylor (2005) point to the role of the Gold Standard in driving a convergence in interest rates across countries and increases in capital flows, with the result that from between 1870 to the First World War ‘the first age of globalization sprang forth’ (Obstfeld and Taylor (2005, p. 25)). Several studies have investigated different aspects of integration during this period: for instance, Canjels et al., (2006) considered integration in terms of the efficiency of international arbitrage, Volosovych (2011) studied the integration of sovereign bond markets, and Quinn (2003) studied the openness of the capital account.

As noted by Bekaert and Mehli (2019), recent studies have challenged the view that financial globalization was largely driven by debt and foreign direct investment. Indeed, cross-border equity flows were non-negligible during this period. For instance, Sylla et al., (2006) note that at the turn of the 19th century almost half of US securities were owned by foreigners.¹ The development in communications technologies and their role in driving co-movements has also been studied.² Hoag (2006) uses an event study analysis on one security with a dual listing on the London and New York exchanges from the time that the transatlantic telegraph cable became operational in July 1866 to show that the information lag decreased from 10 days to zero. Michie (1987) notes that in 1860 the daily range of prices of the same asset listed on both the London and New York stock exchanges

¹ See also Esteves (2006) and (2011) for discussions in relation to the UK, Germany and France.

² Moreover, Triner and Wandschneider (2005), argue that the behaviour of markets during the Brazilian financial crisis of 1890/91 is a precedent for the contagious financial crises that emerging markets faced at the end of the 20th century.

overlapped just 8.5 per cent of the time, but by 1870, prices overlapped 73.6 per cent of the time.³

Unsurprisingly, there are several studies which attempt to measure stock market integration during this period. Campbell and Rogers (2015) focus on the r-squared from a regression of two indices on each other, arguing that this indicates how much of the movement one index is ‘explained’ by the other. Stuart (2017 and 2018) uses a multivariate GARCH framework to study the co-movements of the US, UK and Irish stock markets during the late-19th and early 20th centuries.⁴ These studies generally find that the markets studied exhibit some level of co-movement or integration.

However, these studies say little about the level of integration generally. The multi-country studies that exist, however, tend to focus on long time series of data which end in more recent times, and do not discuss in detail the evolution of integration during the Gold Standard (Goetzmann et al., (2005), Quinn and Voth (2008), Bastidon et al., (2018), Bekaert and Mehli (2019)). Moreover, the evidence they provide gives differing views of the development of integration during the Gold Standard.

Two of these studies (Goetzmann et al., (2005), Quinn and Voth (2008)) use rolling correlations to understand co-movement. However, the rolling correlation method used in two of these studies has drawbacks as a measure of integration. As noted by Volosovych (2011), very often the observed differences in correlations result from the changes in statistical properties of a sample rather than from actual economic links. For instance, the sample correlation is not robust when there are

³ Michie (1987) uses data on railway stocks in 1860, and data on sovereign bonds in 1870.

⁴ There have been many studies of individual stock markets also. See for instance, Grossman (2002), Grossman (2014), Michie (2001) Smith (1929) on the UK, Hautcoeur and Riva (2012) on France, Shiller (2005), Smith (1929), Michie (1987) and Cowles (1939) on the US, Thomas (1986) on Ireland, Chlepner (1930) and Annaert, Buelens and Deloof (2012) on Belgium, and Kearns and Pagan (1993) on Australia.

outliers or the distribution is fat-tailed (Wilcox (2005), Huber and Ronchetti (2009)), while drawing conclusions about integration may be biased by conditional heteroskedasticity in the market returns (Boyer et al., (1999)). In addition, if financial markets are affected by a global shock in a similar fashion, the correlation across countries might be high even without substantial integration. Finally, Pukthunathong and Roll (2009) argue that two markets are fully integrated if they are entirely driven by two factors. However, if each market has a different weighting on each factor, the correlation between markets may be low even though the two markets are driven by the same factors.

A third study, Bastidon et al., (2018), uses a network analysis to understand financial globalization over the period since 1885. The fourth long run study, (Bekaert and Mehli (2019)) uses a factor model to consider the pattern of integration, also since 1885. Specifically, these models estimate a global factor and examine how individual series co-move with it. Several studies have used a broadly similar methodology on more recent data, including Bekaert and Harvey (1995), Aydemir (2004), Chambet and Gibson (2008), Brooks and DelNegro (2004) and Eiling and Gerard (2007).

In this paper, I apply an alternative methodology for measuring integration: extracting a 'global component' of stock price returns. I then estimate how the individual returns series co-move with the global component in order to obtain a measure of integration. A question that arises is whether this measure captures integration or common shocks which drive co-movements. As noted in Bordo et al., (2001), even if greater comovement is driven by common global shocks, the fact that such shocks propagate across countries and these shocks are frequent may be interpreted as evidence of market integration too. However, having obtained estimates of the level of integration, I go on to consider in more detail the role of common shocks in driving them.

Since the global component is not known, I estimate it in three different ways. In the first instance, I employ the methodology of Volosovych (2011), who uses the proportion of variance explained by the first principal component of sovereign bond yields over the period 1875-2009 to measure integration.⁵ Principal components are essentially a weighted average of the underlying series, where the weights are the eigenvectors of the variance-covariance matrix of the underlying series. The weights are therefore calculated from the data to which they are applied.

The second methodology which I apply is proposed by Pukthuanthong and Roll (2009) (hereafter referred to as PR). They calculate 'out-of-sample' principal components which use a lagged variance-covariance matrix to calculate weightings and applies these to current data. Integration is then measured as the average of the r-squared from rolling regressions of the individual stock market returns series on the global component.⁶ PR apply their methodology to recent data on a large number of series which are available on a daily frequency. It is an empirical question whether the methodology will capture integration well in the smaller sample of eight exchanges on which data are available during the Gold Standard.

Finally, I borrow from the literature on inflation co-movements to consider a second methodology for capturing the global component. Specifically, I draw on Ciccarelli and Mojon (2010) (hereafter CM), who show that the cross-sectional mean of national inflation rates captures well the global component of inflation. They show that the cross-sectional mean moves closely with a single factor computed using factor analysis and is simpler to calculate. Using the sample cross-sectional mean equally weights all exchanges. In this sense this measure is

⁵ Mauro et al., (2002) also find that the first principal component explains a large proportion of variation of sovereign bond spreads for a group of emerging market countries from 1877 to 1913 and an even larger proportion in the 1990s

⁶ PR use the adjusted r-squared since they are also comparing models with a number of factors.

not fundamentally different from the principal components-based measures, although the weighting is not determined by either current or lagged data.⁷

The first contribution of this paper is to apply these methodologies to measure stock market integration during the Gold Standard. This is, to my knowledge, the first paper to do so for this period.

The second contribution of this paper is to consider a broader geographical scope for stock market integration during the Gold Standard than previous studies. There are monthly data on eight stock exchanges in my sample,⁸ representing Australia, Belgium, Germany, France, Ireland, Russia, the UK and the US.⁹ In contrast, existing studies generally use much smaller geographical samples for the time period under review in this study, adding additional markets as data becomes available. For instance, although the sample size increases over time, Goetzmann et al., (2005) use data for the period under review for five exchanges, all of which are included in this study.¹⁰ Similarly, for much of their 19th century sample period, Bekaert and Mehli (2019) and Bastidon et al., (2018) have data on four exchanges.¹¹ In their study of stock market volatility and monetary policy, Eichengreen and Tong (2003) use data on four exchanges for much of the sample period used in this study.¹² Although the sample is not explicitly stated in the published paper, Quinn and Voth (2008) indicate that they use a similar dataset to Eichengreen and Tong (2003), and it may be assumed that it is not substantially larger.

⁷ Since the weighting is not determined by the data, the mean is also less sensitive to data imperfections, such as outliers.

⁸ Annual data is likely more widely available. See Dimson et al (2002) for the use of annual data.

⁹ Ireland was not an independent country during this sample period, however, the exchange in Dublin operated separately from London.

¹⁰ See Table 1 in Goetzmann et al. (2005). The exchanges are: Australia, Belgium, France, US and UK.

¹¹ See Figure 2 in Bastidon et al., (2018), and Appendix A in Bekaert and Mehli (2019).

¹² See Table 1 in Eichengreen and Tong (2003). The exchanges are Australia, France, US and UK.

In contrast to these studies, this paper uses a balanced panel of stock markets, which improves the interpretability of the results. As an example, consider the integration of two markets measured in each of two years using the average pairwise correlation. The integration between these two markets is 0.20 in the first and second year. However, in the second year, data are available on a third market with a pairwise correlation of 0.30 with each of the other markets. Now measured integration – the average pairwise correlation – increases from the first to the second year, but this is only because of the addition of the third market to the sample. In contrast, when a balanced panel is used, we know for sure that changes in measured integration do not simply reflect the addition of a market that is more or less integrated than the existing sample.

There are four main findings. First, all three measures of integration used here produce similar results in terms of the pattern of integration over the period. This is similar to CM's finding that relatively simple measures can capture the global component of a set of series well. Second, contrary to the existing literature on stock market integration, I find that integration increased from the start of the sample to the end of the 19th century, but levelled off thereafter. This suggests that although the Gold Standard was a period marked by increased integration, the increase was not uniform across the period. Third, the level of integration during the Gold Standard was substantially below what it is in a sample of more recent data (1985-2020). Thus, in terms of stock market integration, in contrast to findings in relation to other financial markets, it appears that the level of integration during the Gold Standard was not comparable with the recent past. Fourth and finally, the results are robust to alternative formulations of the global component and other measures of stock prices in the markets under review.

The paper is structured as follows: The next section discusses the data and some descriptive statistics. Section 3 explains the estimation methods for capturing the global component in detail, presents the resulting measures of integration, and

discusses the nature of the integration captured by these measures. Section 4 considers several comparisons: with the existing literature, with more recent data, with an alternative formulation of each of the three global components and with alternative Gold Standard-era stock price data. Section 5 concludes.

2. The data

2.1 Data sources

Monthly data from eight stock exchanges are collected for the period 1879-1914. To the author's knowledge, this is the broadest geographical sample of monthly data that are available for the entire sample period. The log-differences of indices are used to calculate returns. This is the same procedure as used in Jorion and Goetzmann (1999) and Eichengreen and Tong (2003). In this case, market-capitalisation weighted series are used where possible. For the most part, the preference in this paper is to use indices that are as similarly constructed as possible. Moreover, preference is given to series that represent capital gains, or price changes exclusive of dividends.

Moreover, the preference is for the broadest possible sectoral coverage in the indices. However, sometimes a decision was made to use a narrower index either because of lack of availability of a broader index (Australia) or because of the superior quality of construction of the index (France). Using a narrower index is likely to lower the correlation between indices and bias any econometric analysis towards finding insignificant results. However, it is interesting to note that Campbell and Rogers (2015) find little role for firm size and industry in explaining co-movements in UK and US equities over the period 1825 to 1925.

Australian data are from Lamberton (1958) and are for the industrial and commercial listings on the Sydney Exchange. Belgian data are from Annaert, Buelens and de Ceuster (2012) and are market-capitalisation weighted, nominal

returns without dividends for each month. French data are available from Le Bris and Hautcoeur (2010) and are also a market-capitalisation weighted index, in this instance of the top 40 stocks rated by market capitalization on French exchanges each year. The German data are taken from the NBER macrohistory database and are composed of two separate series spliced together. These series are described as: an unweighted index of representative stocks for the period 1871-1889 and a weighted index of a larger number of stocks for the period 1890-1913. Irish data are from Grossman et al., (2014), and are a market-capitalisation weighted capital gains series. Russian data are calculated by the author using data from the Yale International Centre for Finance's St Petersburg Stock Exchange Project. The index is an unweighted price series. Data for the UK are from Campbell et al., (2019) and are a market-capitalisation weighted series of capital gains. For the US, the data are the Common Stock Price Index compiled by the Cowles Commission obtained through the St Louis Federal Reserve Economic Data (FRED) website. These data are, in general, arithmetic averages of the highest and lowest prices of the month weighted by the number of shares outstanding at the end of the month.¹³

Differences in index compilation is common in both historical and more recent studies.¹⁴ Indeed PR note that while they have a mixture of weightings in the indices they use, sometimes differences in the construction of indices are unavoidable. Moreover, the presence of cross-listings may tend to raise the correlation between indices. To the extent possible, series that capture domestic firms are used, however, this is not possible in all cases. For this reason, in Section 4.4 I also consider alternative available measures of some of the markets.

2.2 Descriptive statistics

¹³ For more information, see Moore (1961, p.24). This series is widely used in the literature, see for instance, Shiller (2005).

¹⁴ For instance, Bekaert and Mehli (2019) discuss how their data are not uniform in construction.

Average returns for each market are presented in Table 1 both for the full sample and for three sub-samples, 1879-1890, 1891-1902 and 1903-1913. Across the full sample, average monthly returns are highest in Germany and the US, and lowest in France, Ireland and the UK. Indeed, returns in the UK market are marginally negative over the sample period. In terms of the sub-samples, average returns are generally highest in the first sub-sample. The Belgian, German, French, Russian and UK markets all record negative average returns for the middle sub-period, while the Belgian, Australian and Russian markets rise particularly strongly in the final subperiod.

Variances are also presented in Table 1. US returns exhibit the highest variance over the full sample; followed by the Russian and German indices. The Australian, Irish and UK returns have the lowest variance. Looking across subperiods, the Russian and US returns exhibit a high and generally increasing volatility through time. In contrast, the Australian and German returns exhibit a general decline in volatility over the subsamples.

2.3 Correlations

The upper panel of Table 2 presents pairwise correlation coefficients for the returns. The highest correlation coefficients are between the UK and Belgian, Irish and US returns, and the Belgian and German returns, all of which are above 0.3. The average pairwise correlation coefficient for the returns is reported in the bottom panel of Table 2. Across the full sample, the UK and German returns have the highest average correlation at 0.22 and 0.21, respectively. Perhaps unsurprisingly given their geographical remove, the lowest average correlations are exhibited by the Australian and Russian indices. Since the data are at a monthly frequency, it is possible that there is a lag in the arrival of information to these more remote exchanges. However, taking the example of correlations of these two series with that in the UK, there is no pattern of increasing allowing for lags in information transfer of 1 to 12 months. As such, there appears to be no

systematic increase in correlations from allowing for lags. As such, I do not include any lag for information transfer in the analysis below.

One question that arises is whether the correlations changed over time. The lower panel of Table 2 also includes average pairwise correlations across subsamples. The average correlations rose between the first and last subperiods in most instances. A Jennrich (1970) test for equality of correlation matrices in the first and final sub-sample periods rejects the null hypothesis of equality (p-value = 0.000). The implication that the variance-covariance matrix changed over time suggests that the integration of the stock markets is indeed time-varying.

3. The global component and integration during the Gold Standard

3.1 Capturing a global component

In this Section I consider the global component of stock market returns. Throughout, recognizing that the variance-covariance matrix is changing through time, the estimations are carried out based on a rolling 3-year window. In what follows, I center the results from these windows, and thus report the results for the window 1882M1-1884M12 in 1883.

The global component is not observed, and the estimated level of integration therefore depends to some extent on how well measured it is. As a result, I use three methods in order to ensure that the methodology is not driving the results. First, drawing on Volosovych (2011), I use the first principal component. Principal components are calculated by obtaining the eigenvectors and eigenvalues of the variance-covariance matrix. The eigenvectors are sorted by decreasing eigenvalues to obtain the weightings. These weightings are then multiplied by the

underlying series – in this case, the returns series. As a result, eight principal components are obtained.¹⁵

The first principal component is the series obtained by multiplying the eigenvector associated with the largest eigenvalue by the underlying series and is therefore the component that captures the most variance. Figure 1 shows the average proportion of the variance accounted for by each principal components over the sample period. Although it rises somewhat over the sample period, the first principal component generally accounts for between approximately 22 and 40 per cent of the variance. This is considerably lower than the proportion of variance accounted for by the first principal component in Volosovych's (2011) study of sovereign bond yields. There, the first principal component accounted for between approximately 80 per cent of the variation in bond yields during the sample period under review in this study.

The second method is based on PR who calculate 'out-of-sample' principal components using daily data over the period 1973-2007. They use one-year windows, applying weightings (eigenvectors) from the 1973 covariance matrix to the returns of the same countries during 1974. This process is repeated, so that the weightings from 1974 are applied to returns from 1975, and so on until and so on until the 2006 weightings are applied to the 2007 returns, producing 34 calendar years with out-of-sample principal components.

In my sample, the data are available at a monthly, instead of daily, frequency, and a one-year window would result in the variance-covariance matrix being calculated using just 12 observations. I therefore use a three-year window, increasing the sample size to 36. This means that the weightings (eigenvectors)

¹⁵ To conduct principal component analysis, the returns series must be stationary. To test that, I use an Elliott-Lothman-Stock test. Here, the lag length is selected for the test using the Hannan-Quinn criterion. The test rejects the null of a unit root for all eight series at the 1% level. This result is robust to whether a trend is included or excluded from the test.

computed from the three-year period 1879M1-1881M12 variance-covariance matrix are applied to the returns of 1882M1-1884M12. The window is then rolled forward one year, and the process repeated. Thus, in total, there are 26 windows.

In contrast to Volosovych (2011), PR use the first 10 principal components when measuring integration. Selecting the principal components to consider ‘global components’ is somewhat arbitrary. PR’s first 10 components account for approximately 90 per cent of the variation in their returns series. Figure 1 shows that while the first principal component accounts for approximately 30 per cent of the variance of the series, the equivalent for the second principal component is between 15 and 25 per cent of the variance, while the remaining components account for markedly less of the variance.¹⁶ Indeed, to capture a similar proportion of the variance as PR do, six or seven of the eight principal components would have to be used. This raises the danger of overfitting. I therefore first consider the first out-of-sample component a ‘global component’, before adding the second and third components to the analysis.

Volosovych (2011) uses data on 15 sovereign bond markets in his study, while PR primarily use data from 17 indices in the calculation of their out-of-sample principal components. Thus, both studies have almost twice the number of series compared to this study. With a smaller cross-sectional sample it is possible that large outliers might have an outsize impact on the measure of the global component.

As a result, an alternative measure of the global return is also considered. This measure is drawn from the literature on inflation co-movements, specifically CM. In their study of inflation in the 22 countries over the period 1960 to 2008, they consider several measures of ‘global inflation’: including model-based measures

¹⁶ Although Figure 1 shows standard, rather than out-of-sample, principal components, the shares of variance accounted for by the cross-country average of the out-of-sample principal components are similar, and therefore in the interests of brevity they are not shown here.

and the cross-sectional mean. They find that these two methods yield almost identical results and, since the mean is simpler to calculate and interpret, they argue that this is a good measure of a global component of inflation.

3.2 Global components as a weighted average

While these three methodologies may at first appear quite different, all involve taking an average of the series under review. Thus:

$$(1) \quad r_t^g = \sum_{i=1}^n (w_{i,t} \times r_{i,t})$$

Where r_t^g is the global return at time t , $r_{i,t}$ is the return on exchange i , and $w_{i,t}$ is the weighting on exchange i , where the weights sum to one, $\sum_{i=1}^n w_{i,t} = 1$.

In the case of principal components, the weightings, $w_{i,t}$, are the eigenvectors of the variance-covariance matrix. In traditional principal component analysis used by Volosovych (2011), these weightings are applied to the data underlying the variance-covariance matrix from which they are calculated. PR's innovation is to apply the weights to the returns in the subsequent window, thus creating an 'out-of-sample' series which avoids the weights being based on recent movements in the data and thus 'building in' co-movement.

In the third methodology, the cross-sectional mean, the weightings, $w_{i,t}$, are set to be $1/n$ and are therefore chosen entirely independently of the data. CM find that this simple approach to capturing a global component (in inflation data) works well compared to more complicated methodologies. Thus, in their underlying calculation, these methods are similar, although the weightings used are different.

3.3 The pattern of integration during the Gold Standard

Once each global component is estimated, integration is calculated as in PR.¹⁷ Simply, the r-squared is stored from a regression of the global component on the return on each exchange. That is:

$$(2) \quad r_{i,t} = \alpha + \beta \times r_t^g + e_t$$

A separate regression is run for each of the eight stock price series in each three-year window. The mean of the r-squareds at each point in time is stored.¹⁸ The results using the three measures of integration are presented in Figure 2 (solid lines).

The first measure of integration is the first principal component. The average of the mean of the r-squareds from the regression in equation (2) at each point in time are presented in Figure 2. Two points are of note. First, following an initial decline, the average r-squared increases through to the end of the 19th century. Thus, the first part of the classical Gold Standard era was one during which markets became more integrated. Second, after reaching a maximum level around the turn of the century, the level of integration declined, or at best levelled out.

Turning to the out-of-sample principal components, the average of the r-squareds from equation (2) using the first out-of-sample principal component is also presented in Figure 2.¹⁹ The pattern is very similar to that when the standard calculation of the first principal is used. If anything, the increase in integration through the first part of the sample period is more marked. The average r-squared

¹⁷ Volosovych (2011) uses the proportion of variance accounted for by the first principal component as an index of integration. However, for the purposes of comparison with the level of integration captured by the other estimated global components, here I use the average r-squared from the regression of the first principal component on the return on each exchange.

¹⁸ This approach is also similar to that of Goetzmann et al., (2005), in that, once they obtain their individual measures of integration for the each exchange (in their case, pairwise correlations rather than r-squareds), they then calculate overall integration as the mean of the individual measures at each point in time.

¹⁹ The results are missing for the first three years of the sample period due to the use of lagged variance-covariance matrix in the calculation of the out-of-sample principal components.

increases in two phases, one from approximately 1885 to the early 1890s and the second from 1895 onwards.

Since PR use several principal components in their analysis, I next include both the first and second out-of-sample principal components in equation (2) to test whether this affects the measured integration. The average adjusted r-squared from this model is included in Figure 3. For comparison, Figure 3 also includes the adjusted r-squared from the model with just the first out-of-sample component included. Overall, the estimated level of integration rises when the second out-of-sample principal component is added, however, the pattern of integration over the period remains remarkably unchanged. The same is true when the third out-of-sample principal component is added to the model (Figure 3).

Finally, I consider the level of integration when using CM's alternative measure of global returns – the cross-sectional mean. This is calculated and regressed on the individual returns series as per equation (2) and, as above, the average r-squared at each point in time is used to measure integration (Figure 2). Again, the pattern of integration is remarkably similar: following a decline at the start of the sample period, the level of integration generally rises in two distinct periods over the remainder to the 19th century. Thereafter, integration levels out, and declines for periods, particularly around 1910.

Overall, it seems that all three measures of the global component yield a similar story of the path of integration. Since the global component is not observed, the measure of integration partially depends on how good these estimates are. Therefore, the finding that all three measures provide a similar story about the pattern of integration is reassuring. This finding also fits well with CM's analysis that simple measures of the global component work well.

3.4 Considering the nature of 'integration' during the Gold Standard

In this section, the nature of integration during the Gold Standard is considered in more detail. In a first step, the principal component methods are exploited to better understand segmentation in the market. Specifically, I consider the factor loadings of the first principal component. If the first principal component does not load positively onto many of the series, this would indicate segmentation: sub-groups of markets are moving together. Figure 4 shows the number of series on which the first principal component loads negatively at each point in time. The first point to note is that is relatively rare for more than one country to have a negative loading at the same time. This suggests there isn't segmentation in which sub-groups of countries are co-moving, but the sub-groups are moving in different ways.

The second point to note is that less than a third of the time (30 per cent), the first principal component loads positively onto all eight series, implying that all series move in the same direction with the global component. However, 45 per cent of the time, the first principal component loads negatively onto just one series, suggesting an idiosyncratic shock to that market, rather than groups of markets moving together²⁰. Similar analysis carried out on recent data (since 1985) shows that almost 100 per cent of the time the first principal component loads positively on all series.²¹ Thus, the nature of shocks has changed: many of the shocks during the Gold Standard were not so much 'global' as specific to one or two countries.

Moreover, a closer examination of the periods of negative loadings on more than one series suggests that these cluster around well-known panics and depressions, such as the depression in the early- to mid-1880s (which included the panic of 1883), and panics in 1893 and 1907. To test this more formally, the measures of integration are regressed on a measure of financial crises (a wider range of

²⁰ Indeed, in just one year does the first principal component load negatively on four series.

²¹ For details on the more recent data used, see Section 4.2.

variables were considered but proved insignificant and are not included here for brevity²²). The measure of financial crisis is based on the chronology of Bordo et al., (2001), and is a dummy variable that captures the years of banking, currency and twin crises.²³ Following Volosovych (2011), the fraction of countries experiencing a financial crisis in each year is used in the regression.²⁴

Interestingly, financial crises are significant when the first principal component and cross-sectional mean methodologies are used (p-values = 0.01 and 0.05, respectively), but not when the out-of-sample principal component method is used (p-value = 0.50). The sign on the financial crisis variable is negative in the regressions, suggesting that financial crises tend to reduce integration. This is in line with more frequently negative factor loadings during times of financial crisis and the observation that shocks tended to be less ‘global’ and more idiosyncratic during this time (Figure 5).²⁵

4. Some comparisons

4.1 Comparison with the existing literature

Although remarkably consistent across all three estimates of the global component, the pattern of integration here is somewhat different to that in the existing literature. For instance, Goetzmann et al., (2005) calculate pairwise correlations in stock price movements over the period 1875-2000 in a rolling 5-year

²² Volosovych (2011) provides a list of variables which might reasonably be correlated with the measure of integration. Alongside financial crises, these include trade openness, CPI inflation, government surplus, currency peg, capital controls, economic disasters and hyperinflations. Data on these were obtained from the Bordo et al., (2001) and the Jorda, Schularick and Taylor databases. There is little or no movement in the final four of these variables during the sample under review here, while the coefficients on trade openness, CPI inflation and government surplus had insignificant and/or counterintuitive signs.

²³ The data were accessed here: <https://sites.google.com/site/michaelbordo/home3>

²⁴ Following Volosovych (2011), a time trend is included and Newey West standard errors are calculated.

²⁵ It is also in line with the (insignificant) results for the case of bond yields in Volosovych (2011).

window. For the Gold Standard period, they find a decline in integration at the start of the Gold Standard period which reaches a trough in the 1880s.²⁶ There is then a generally increasing trend in integration until just before 1910, and a levelling out thereafter. Quinn and Voth (2008) employ a similar methodology, but with a four-year rolling window, to analyse the period from 1893 to the early 2000s and find a wave-like pattern of integration during the Gold Standard: an initial decline to a negative correlation in the late 1890s is followed by a sharp rise to an average correlation in the early-1900s, and then an almost continuous decline thereafter to 1913.²⁷ Bekaert and Mehli (2019) study the period 1885 to 2014. They estimate several measures of integration, but generally find an initial decline in integration followed by levelling out up to the first years of the 20th century, follow by a rising trend for the remainder of the Gold Standard period to 1913.²⁸ Overall, the pattern of stock market integration during the Gold Standard remains an open question.

Since the existing literature primarily uses rolling correlations, to ensure that the different pattern of integration does not relate to the methodology alone, I calculate pairwise correlations for every series on the same rolling 3-year window as used in the earlier analysis, resulting in 28 correlation coefficients in each of the 33 windows. The average of these 28 correlation coefficients is calculated and presented in Figure 2 (read off the right-hand axis). Overall, the pattern is very similar to the three baseline measures of integration. The rolling correlation shows a marked decline at the beginning of the sample period, similar to that of the cross-sectional mean measure of integration. Thereafter, the average correlation increases somewhat before levelling off towards the end of the sample, although there is a marked decline in integration in the early 1890s.

²⁶ See Goetzmann et al., (2005), Figure 3: Average Correlation of Capital Appreciation Returns for all Available Markets, p. 45.

²⁷ See Quinn and Voth (2008), Figure 1: Stock Market Correlations over the Long Run, p. 537.

²⁸ See Bekaert and Mehli (2019), Figure 1: Global betas, p. 234.

Overall, the levelling out in integration through the early 1900s captured in this study is not evident in the pre-existing literature. Thus, it appears that the wider sample employed here results in a different understanding of how integration progressed during the Gold Standard. Moreover, all three measures of integration calculated here tell a similar story and are corroborated by the rolling correlations.

4.2 Comparison with recent integration

Whether the level of integration during the Gold Standard was high or low is difficult to judge in isolation. In this section I consider the absolute level of integration during the Gold Standard by comparing the results obtained above with more modern data. Before proceeding, it is important to note that the global component may reflect not just integration but also common shocks. The analysis here implicitly assumes that these shocks are the same today as they were during the gold standard. If this were not the case, the comparison is difficult to interpret.

Interestingly, the literature is not uniform in its findings in relation to the level of integration during the Gold Standard compared to today. For instance, Baldwin and Martin (1999) present a number of measures of capital mobility and financial market integration and argue that capital mobility was perhaps higher during the classical gold standard than in recent decades. Bordo and Murshid (2006) draw the same conclusion. On the other hand, Volosovych (2011) and Bekaert and Mehli (2019) find that integration exhibited a ‘J-shaped’ or ‘swoosh’ trend whereby integration at the end of the 20th century was higher than in the late-19th century periods, with a decline in integration in between. Bastidon et al., (2018) argue that financial market integration exceeded that of the late 19th century only in the last 10 years.

For this analysis I collect data from the OECD for the period 1985 to 2020 (the same length as the sample for the Gold Standard above), and the log differences of

the indices are again used in the analysis.²⁹ Russian data is not available prior to 1997 and is therefore excluded from this analysis.³⁰

The average r-squareds from the three methodologies are presented in Figure 5. There are three points to note. First, the three methodologies produce extremely similar measures of integration in the current period. The first principal component often loads evenly onto all series.³¹ This points again to CM's observation that relatively simple measures can capture the global component well.

Second, the level of integration is significantly higher in more recent times than it was during the Gold Standard across all measures. Specifically, the r-squareds from the out-of-sample principal components are approximately twice as large in the recent data compared to during the Gold Standard.³² Turning to the cross-sectional mean, the average r-squared using this measure is also significantly higher in the modern data – the minimum average r-squared for the recent data is 0.56, whereas the maximum average r-squared during the Gold Standard is 0.38.

The third point to note relates to the change in integration over the Gold Standard. In relative terms, the increase in integration during the Gold Standard was much larger: broadly speaking, the average r-squared at least doubled from over the period of the Gold Standard, whereas in the more recent period it increased by two thirds. Thus it appears that the relative change in integration over the Gold Standard was larger than in recent times.

²⁹ The sample here begins in May 1985, when Belgian data become available.

³⁰ This is the case on multiple platforms: including Bloomberg, Datastream and the OECD. The stock market in St Petersburg was closed following the revolution in 1917, and it was not until 1990 that Soviet citizens were permitted to buy stocks, bonds and other securities. See: <https://www.nytimes.com/1990/11/14/business/stock-exchange-in-moscow.html>

³¹ For example, the eigenvalues for the 3-year window midway through our sample period are as follows: 0.36 (Australia), 0.37 (Belgium), 0.39 (Germany), 0.40 (France), 0.35 (Ireland), 0.38 (UK) and 0.39 (US).

³² The first principal component accounts for approximately 60 per cent of variance at the start of the sample, and rises through most of the period, reaching approximately 90 percent in the mid-2010s. There is a small decline thereafter.

Nonetheless, despite this period being considered the first era of globalisation of capital markets, and the rapid relative increase in integration over the period, stock markets appear to have been significantly less integrated during the Gold Standard than they are today. However, this result is similar to the findings of Bekaert and Mehli (2019) (and Volosovych (2011) for sovereign bond markets) whereby financial market integration by the end of the 20th century was higher than in earlier periods.

4.3 Comparison with global component calculated separately for each country

If one market's return is heavily weighted in the principal components then the level of integration will naturally be higher for this index. Therefore, PR (2009) propose that separate principal components be calculated excluding each index in each window. For instance, if we are measuring the level of integration of the US market, the principal component is calculated using the variance-covariance matrix and returns of the other seven markets only.

I next employ this method for all three measures of the global component. A separate global component is calculated for each market, denoted, $r_{i,t}^g$, with the effect that equation (2) is now written:

$$(3) \quad r_{i,t} = \alpha + \beta \times r_{i,t}^g + e_t$$

The average r-squareds for all three methodologies are also presented in Figure 2 (dashed lines). Compared to the average r-squared calculated using r_t^g , it is notable that while the overall level of integration is much lower, the pattern of integration does not change. Indeed, the correlation between the average r-squareds using this measure of the first principal component, and the baseline estimate of the first principal component, is 0.98. The equivalent coefficients using this and the baseline measures of the first out-of-sample principal component and the cross-sectional mean are 0.96 and 0.98 respectively.

Overall, it appears that estimating the global component in this manner does not have a significant impact on the overall pattern of integration, although it does markedly affect the absolute level of measured integration.

4.4 Comparison using alternative measures of the stock prices

To check that the baseline results are not driven by the specific measure of stock prices chosen, in this section I test alternative measures which are available for the various stock markets, and compare the average r-squareds from the resulting regressions. I use the baseline calculation of the global component, r_g , and thus estimate equation (2) in this exercise. For brevity, I report the correlation of the resulting average r-squareds with those obtained using the baseline series as above in Table 3. As an example, Figure 6 shows the various measures of integration obtained using these alternative series and the first principal component method.

In the first instance, I consider different weightings on the Irish series. This is because both price weighted and unweighted series³³ are available using the same underlying dataset as the baseline, market-capitalisation weighted series. The analysis is re-run, substituting in the two alternative series in turn. There is little impact on the overall story: Figure 6 indicates a slightly less dramatic decline at the start of the sample period, resulting in a somewhat less marked increase in integration thereafter, however the general trend remains. Moreover, the correlation between the new measure of integration and the baseline measure is never less than 0.91 (Table 3).

The analysis above provided some sense of the effect of including one differently weighted series. However, unweighted indices are available for Belgium, France and Ireland. Here, all series are based on the same underlying data as the

³³ The price-weighted series is from Stuart (2017), the other series is from Grossman et al., (2014).

unweighted series used in the baseline specification.³⁴ When all three of these series are substituted into the analysis, the overall story is unchanged although the mid-sample peak in integration occurs marginally later than in the baseline (Figure 6), although the correlation coefficient between the average r-squareds is lower for the principal component based measures (approx. 0.65) than the cross-sectional mean measure (0.82) (Table 3).

Price-weighted data are available for the UK and US as well as Ireland. I re-run the analysis substituting in these series. It is important to note that these series differ from those used in the baseline specification in more ways than the weighting: the UK data are calculated by Campbell and Rogers (2015), while the US data are from Goetzmann et al., (2005) and is a capital appreciation index. These additional differences will tend to reduce the correlation. Figure 6 shows that the general trend remains the same, although the profile is somewhat flatter in the first half of the sample period than for the other indices. The correlation coefficients decline to between 0.64 and 0.72 (Table 3).

Weighting is not the only way in which series can differ. Some series include a narrower set of firms than others. For instance, the French index here is a blue chip index. To understand what the effect of this might be, I use the blue chip index calculated by Campbell, et al., (2019). The results are presented in Table 3 and Figure 6. The correlation coefficients are in the region of 0.97 and above, and the overall pattern of integration is generally unchanged.

Finally, cross-listings are likely to cause co-movement between indices. In the baseline specification, I have used indices focused on the domestic market where possible. However, Campbell et al., (2019) also provide a broad index of all listings on the London market. In the first instance, I include this in the model as before. Although the peak in the mid-sample correlation occurs marginally earlier

³⁴ These series are obtained from the same sources as the data above and outlined in Section 3.1.

(Figure 6), the correlations are always in excess of 0.90 (Table 3). Next, I look at the loading of the first principal component on the UK series when the broader and baseline (narrower) indices are used (Figure 7). The evolution of the factor loadings through the 3-year windows is similar: as might be expected the broader series generally has a marginally higher factor loading, but this is relatively constant throughout the sample period. There is a period in the late 1880s when the factor loading turns negative for both series and it takes a little longer for the broad index to regain positive loadings. However, overall, the mean difference between the two series is less than 0.03. This analysis suggests that cross-listings are not significantly altering the main findings.

Overall, therefore, it seems that the choice of weighting and the general composition of the index does not have a significant impact on the broad pattern of integration during the Gold Standard.

5. Conclusions

This paper examines the integration of eight stock markets during the classical Gold Standard, using monthly data on indices in Australia, Belgium, France, Germany, Ireland, Russia, the UK and the US. To my knowledge, it is the most comprehensive comparative study of the behaviour of stock return integration during this period. Moreover, it is the first to do so using methodologies to capture 'global components' of stock returns rather than rolling correlations or a factor model. First, I estimated the global component using two principal component-based measures. The first draws on Volosovych (2011) and is the first principal component. The second is 'out-of-sample' principal components proposed by PR. Since the relatively small sample size during the Gold Standard may make this measure difficult to implement, I also calculated the cross-sectional mean as per CM.

Overall, it appears that all three measures of integration calculated here produce similar results in terms of the pattern of integration. This is similar to CM's finding that relatively simple measures can capture the global component of a set of series well. Moreover, this concordance between measures adds credibility to the pattern of integration observed during the period.

The pattern indicates that integration increased markedly from the start of the sample to the end of the 19th century. Compared to the existing literature, the findings here suggest that the level of integration levelled off or declined somewhat towards the end of the period. Thus, the Gold Standard was a period during which integration increased, although this process was not uniform over the period. Overall, it appears that the wider sample employed here results in a different understanding of how integration progressed during the Gold Standard.

However, the level of integration during the Gold Standard was substantially below that in more recent data. Thus, despite this period being considered the first era of globalisation of capital markets, and findings elsewhere of integration in financial markets of about the same level in the 1990s or 2000s as during the Gold Standard, stock markets appear to have been significantly less integrated during the Gold Standard than they are today.

Finally, I show that the result is robust to an alternative formulation of the global component in which a separate global component is measured excluding each country in turn, and to alternative measures of stock prices in the markets under review. In particular, it seems that excluding a country from the measure of the global component lowers the overall level of integration without affecting the pattern. Moreover, it seems that the choice of weighting does not have a significant impact on the general development of integration during the Gold Standard.

References

- Annaert, J., F. Buelens and M.J.K. De Ceuster, (2012), 'New Belgian Stock Market Returns: 1832-1914', *Explorations in Economic History*, 49, 189-204.
- Annaert, J., F. Buelens and M. Deloof, (2012), 'Long run stock returns: Evidence from Belgium 1838-2010', *Cliometrica*, 9(1), 77-95.
- Aydemir, C., (2004), 'Why are international equity market correlations low?' Unpublished Working Paper, Carnegie Mellon University.
- Baldwin, Richard and Philippe Martin, (1999), 'Two waves of globalisation: superficial similarities, fundamental differences', NBER Working Papers Series, Working Paper 6904, January.
- Bastidon, C., M. Bordo, A. Parent and M. Weidenmier, (2018), 'Stock Market Integration Since 1885: A Network Perspective', Paper presented at the 2018 WEHC, mimeo.
- Bekaert, G. and C. R. Harvey, (1995), 'Time-varying world market integration', *The Journal of Finance*, 50(2), 403-444.
- Bekaert, G. and A. Mehli, (2019), 'On the global financial market integration 'swoosh' and the trilemma', *Journal of International Money and Finance*, 94, 227-245.
- Bordo, M., B. Eichengreen, D. Klingebiel, M. S. Martinez-Peria and A. K. Rose, (2001), 'Is the Crisis Problem Growing More Severe?', *Economic Policy*, 16(32), 53-82.
- Bordo, M. and A. P. Murshid, (2006), 'Globalization and changing patterns in the international transmission of shocks in financial markets', *Journal of International Money and Finance*, 25(4), 655-674.
- Boyer, B.H., M.S. Gibson and M. Loretan, (1999), 'Pitfalls in Tests for Changes in Correlations', International Finance Discussion Paper No. 597R, Federal Reserve Board, Washington DC.
- Brooks, R. and M. Del Negro, (2004), 'A latent factor model with global, country, and industry shocks for international stock returns', Federal Reserve Bank of Atlanta Working Paper 2002-23b.
- Campbell, G., R. Grossman and J. Turner, (2019), 'Before the cult of equity: New monthly indices of the British share market, 1829-1929', CEPR Discussion Papers, DP13717.
- Campbell, G. and M. Rogers, (2015), 'Integration between the London and New York Stock Exchanges, 1825-1925', working paper.
- Canjels, E., G. Prakesh-Canjels and A. M. Taylor, (2004), 'Measuring Market Integration: Foreign Exchange Arbitrage and the Gold Standard, 1879-1913', *Review of Economics and Statistics*, 86(4), 868-882.

Ciccarelli, M. and B. Mojon, (2010), 'Global Inflation', *The Review of Economics and Statistics*, 92(3), 524-535.

Chambet, A. and R. Gibson, (2008), 'Financial integration, economic instability, and trade structure in emerging markets', *Journal of International Money and Finance*, 27(4), 654-675.

Chlepner, B.S., (1930), Le Marché Financier Belge Depuis 100 Ans, Librairies Falk, Brussels.

Cowles, A. the 3rd, and Associates, (1939), Common Stock Indices, Cowles Commission for Research in Economics, Principa Press, Inc, Bloomington Indiana, Second edition.

Dimson, E., P. Marsh, M. Staunton, (2002), Triumph of the Optimists: 101 Years of Global Investment Returns, Princeton University Press, New Jersey.

Eichengreen, B. and H. Tong, (2003), 'Stock Market Volatility and Monetary Policy: What the Historical Record Shows', in Reserve Bank of Australia 2003 Conference: Asset Prices and Monetary Policy, ed. Anthony Richards and Tim Robinson, 108-42. Sidney, AU: Reserve Bank of Australia.

Eiling, E. and B. Gerard (2007), 'Dispersion, equity returns correlations and market integration', unpublished Working Paper, University of Toronto.

Esteves, R., (2006), 'Between Imperialism and Capitalism. European Capital Exports Before 1914', mimeo., University of Oxford.

Esteves, R., (2011), 'The Belle Epoque of international finance. French capital exports, 1880-1914', Economics Series Working Papers 534, University of .Oxford.

Goetzmann, William N., Lingfeng Li and K. Geert Rouwenhorst, (2005), 'Long-Term Global Market Correlations', *The Journal of Business*, 78(1), 1-38.

Grossman, Richard S., (2002), 'New Indices of British Equity Prices, 1870-1913', *The Journal of Economic History*, 62 (1), 121-146.

Grossman, Richard S., (2014), 'Bloody Foreigners! Overseas Equity on the London Stock Exchange, 1869-1928', Wesleyan Economic Working Paper No. 2014-001, January.

Grossman, Richard S., Ronan C. Lyons, Kevin Hjortshøj O'Rourke and Madeleine A. Ursu, (2014), 'A monthly stock exchange for Ireland, 1864-1930', *European Review of Economic History*, 18(3), 248-276.

Hautcoeur, P-C. and A. Riva, (2012), 'The Paris financial market in the nineteenth century: complementarities and competition in microstructures', *Economic History Review*, 65(4), 1326-1353.

Hoag, C., (2006), "The Atlantic telegraph cable and capital market information flows", *The Journal of Economic History*, 66(2), 342-353, June.

- Huber, P.J. and E.M. Ronchetti, (2009), Robust Statistics, Wiley Series in Probability and Statistics, second ed. John Wiley & Sons, New York.
- Jorion, P. and W. Goetzmann, (1999), 'Global Stock Markets in the Twentieth Century', *Journal of Finance*, LIV, 953-980.
- Lamberton, D. McL., (1958), 'Security Prices and Yields 1875-1955', Pamphlet, Sydney Stock Exchange Research and Statistical Bureau, Sydney.
- Le Bris, D. and P. Hautcoeur, (2010), 'A Challenge to Triumphant Optimists? A Blue Chips Index for the Paris Stock-Exchange (1854-2007)', *Financial History Review*, 17(2), 141-183.
- Le Bris, D., (2013), 'Why did French Savers buy Foreign Assets before 1914? A Decomposition of the Benefits from Diversification', *Louvain Economic Review*, 79(3), 71-89.
- Mauro, P., Sussman, N., Yafeh, Y., (2002), 'Emerging market spreads: then versus now', *Quarterly Journal of Economics*, 117, 695-733.
- Michie, R., (1987), The London and New York Stock Exchanges 1850-1914, Unwin Hyman Ltd, London.
- Michie, R., (2001), The London Stock Exchange: A History, Oxford University Press, Oxford.
- Neal, L., (1987), 'The integration and efficiency of the London and Amsterdam Stock Markets in the Eighteenth Century', *Journal of Economic History*, 47(1), 97-115.
- Obstfeld, Maurice and Alan M. Taylor, (2005), Global Capital Markets: Integration, Crisis, and Growth, Cambridge University Press, Cambridge.
- Pukthuanthong, Kuntara and Richard Roll, (2009), 'Global market integration: An alternative measure and its application', *Journal of Financial Economics*, 94(2), 214-232.
- Quinn, D. P., (2003), 'Capital Account Liberalization and Financial Globalization, 1890- 1999: A Synoptic View', *International Journal of Finance and Economics*, 8(3), 189-204.
- Quinn, D. P. and H-J. Voth, (2008), A Century of Global Market Correlations, *American Economic Review: Papers & Proceedings*, 98(2), 535-540.
- Shiller, R. J., (2005), Irrational Exuberance, Princeton University Press, Broadway Books, 2nd edition.
- Smith, C.F., (1929), 'The Early History of the London Stock Exchange', *American Economic Review*, 19(2), 206-216, June.
- Smith, K.C. and G. F. Horne, (1934), 'An Index Number of Securities 1867-1914', London and Cambridge Economic Service Special Memorandum 37.
- Stuart, Rebecca, (2017), 'Co-movements in stock market returns, Ireland and London, 1869-1929', *Financial History Review*, 2017, 24(2), 167-184.

- Stuart, Rebecca, (2018), 'The co-movement of the Irish, UK and US stock markets, 1869-1925', *Essays in Economic and Business History*, 36(1), 23-46.
- Sylla, Richard, Jack W. Wilson and Robert E. Wright, (2006), 'Integration of Trans-Atlantic capital markets, 1790-1845', *Review of Finance*, 10(4), 613-644.
- Thomas, W. A., (1986), The Stock Exchanges of Ireland, Francis Cairns Publications, Liverpool.
- Triner, G. D. and K. Wandschneider, (2005), 'The Baring Crisis and the Brazilian Encilhamento, 1889-1891: An Early Example of Contagion Among Emerging Capital Markets', *Financial History Review*, 12(2), 199-225.
- Volosovych, V., (2011), 'Measuring financial market integration over the long run: Is there a U-shape?', *Journal of International Money and Finance*, 30(7), 1535-1561.
- Wilcox, R.R., (2005), *Introduction to Robust Estimation and Hypothesis Testing*, Academic Press, San Diego.

Table 1: Descriptive statistics, 1879-1914

	AU	BE	DE	FR	IE	RU	UK	US
Average return								
Full sample	0.139	0.101	0.210	0.053	0.014	0.155	-0.003	0.203
1879-1890	0.311	0.100	0.499	0.123	0.050	0.090	0.136	0.200
1891-1902	0.024	-0.048	-0.001	-0.045	0.110	-0.021	-0.019	0.391
1902-1913	0.210	0.264	0.118	0.083	-0.130	0.289	-0.066	0.000
Variances								
Full sample	1.424	3.356	5.485	2.743	0.970	7.994	1.175	1.424
1879-1890	2.061	4.553	8.431	4.885	1.324	1.557	1.247	2.061
1891-1902	1.283	2.383	3.753	1.817	0.816	7.853	1.089	1.283
1902-1913	0.449	3.060	2.159	1.400	0.721	15.374	0.990	0.449

Table 2: Correlation coefficients, 1879-1914

Full sample	Australia	Belgium	Germany	France	Ireland	Russia	UK	US
Australia	1.000							
Belgium	-0.003	1.000						
Germany	0.049	0.380	1.000					
French	0.064	0.091	0.226	1.000				
Ireland	0.029	0.145	0.069	-0.030	1.000			
Russia	0.001	0.171	0.133	0.013	0.090	1.000		
UK	0.060	0.267	0.324	0.069	0.401	0.085	1.000	
US	-0.031	0.214	0.267	0.075	0.134	0.071	0.334	1.000
Average pairwise correlations								
Full sample	0.024	0.181	0.207	0.073	0.120	0.081	0.220	0.152
1879-1890	0.033	0.121	0.215	0.048	0.072	0.088	0.214	0.139
1891-1902	0.001	0.188	0.215	0.080	0.180	0.074	0.205	0.107
1902-1913	-0.012	0.288	0.265	0.109	0.140	0.135	0.239	0.256

Note: average correlation calculated as the average of pairwise correlation coefficients, such as those reported in the upper panel of the table.

Table 3: Correlation of average r-squareds, baseline and alternative stock price series.

	Correlation with results using baseline series		
	Measure of integration		
Alternative price series used	1 st principal component	Out-of-sample-principal components	Cross-sectional mean
Price-weighted: Ireland	0.911	0.959	0.961
Unweighted: Ireland	0.910	0.954	0.971
Unweighted: Belgium, France, Ireland	0.640	0.661	0.816
Price weighted: Ireland, UK, US	0.643	0.724	0.646
Blue chip: UK	0.974	0.982	0.982
Broad index: UK	0.907	0.939	0.854

Figure 1: Average proportion of variance accounted for by each principal component, 1883-1912

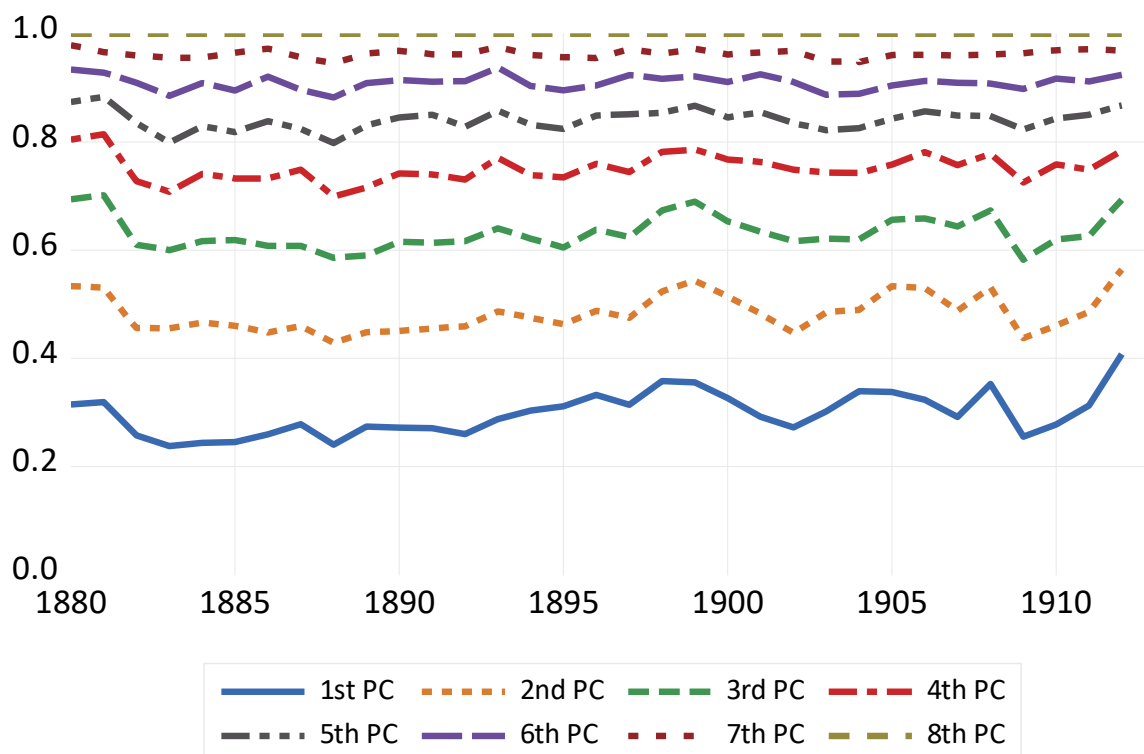


Figure 2: Measures of integration, 1880-1912

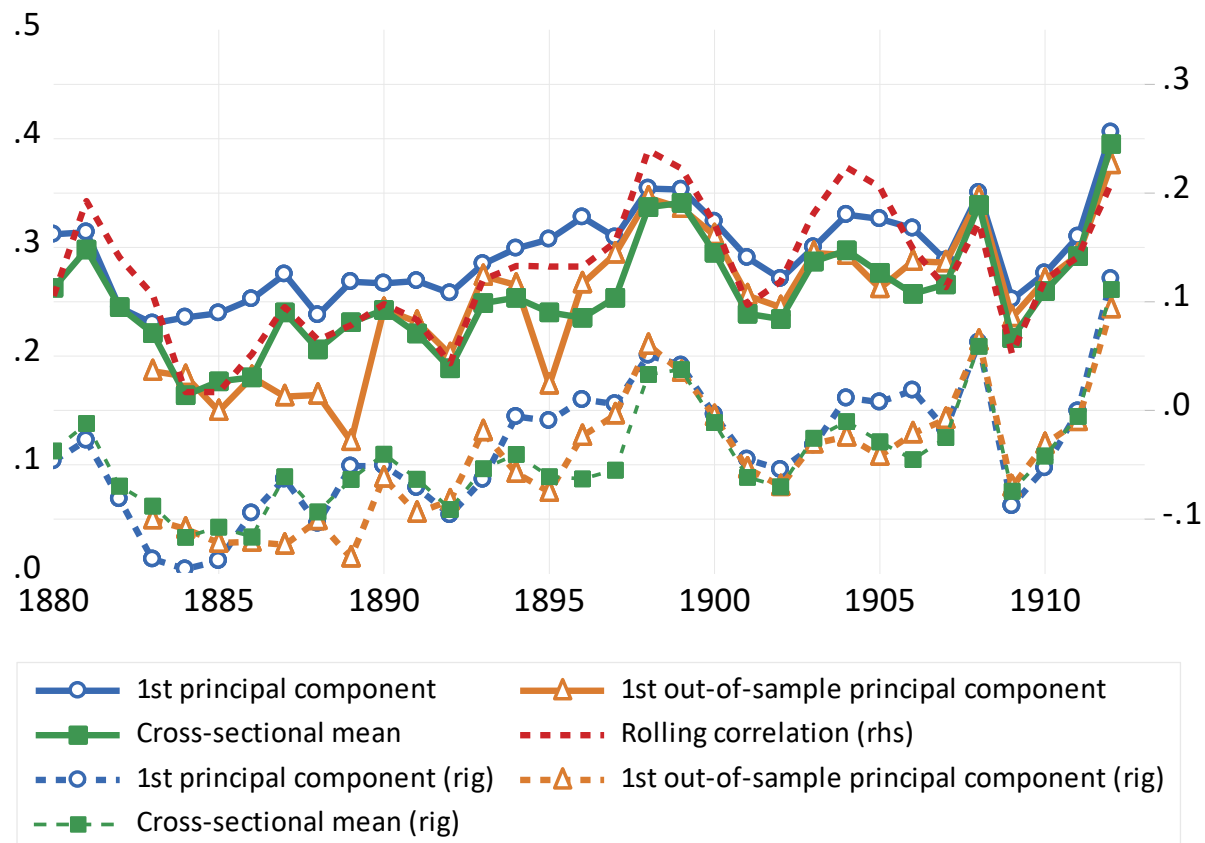


Figure 3: Average adjusted r-squared, including 1st, 2nd and 3rd out-of-sample principal components

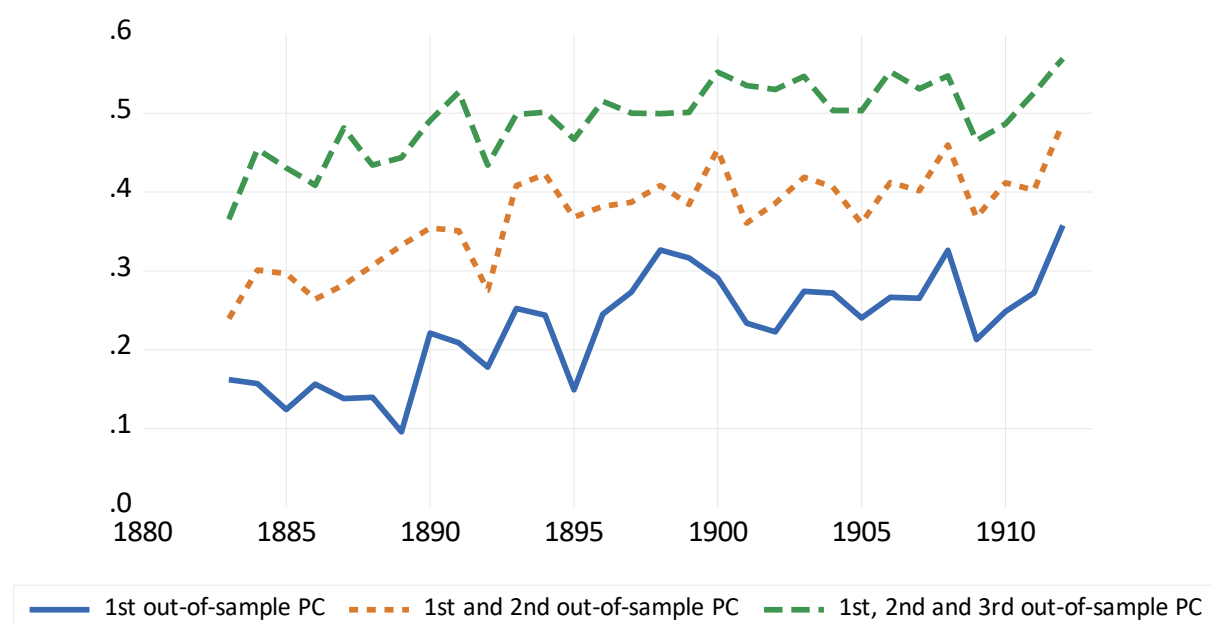


Figure 4: Number of series on which first principal component loads negatively, 1880-1913

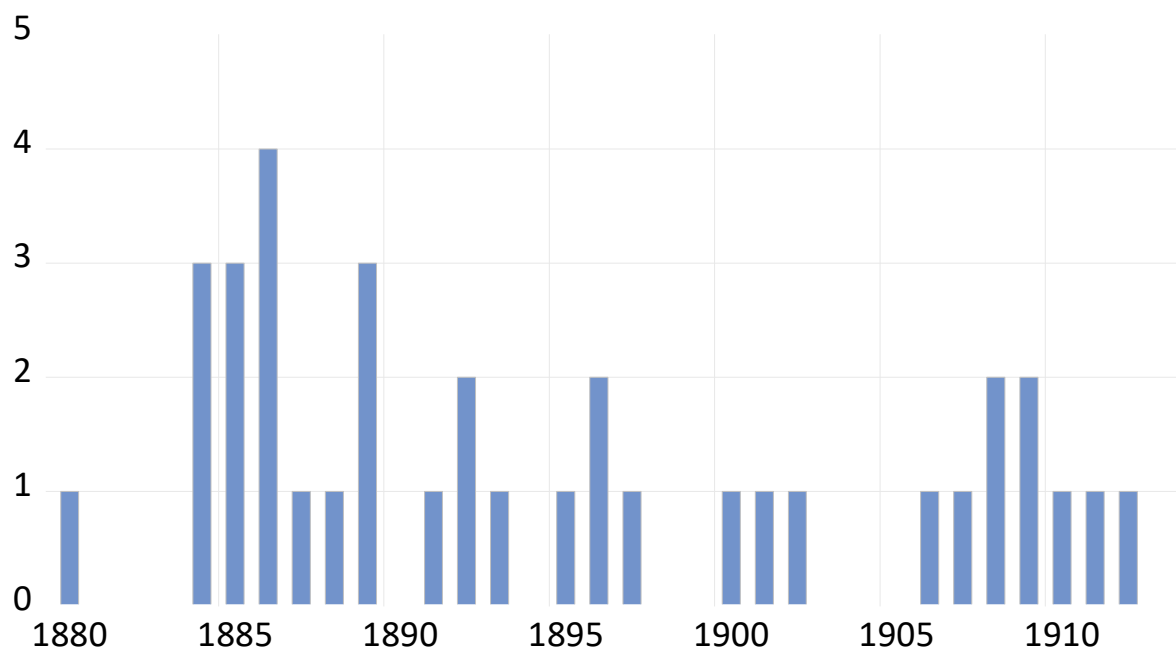


Figure 5: R-squared, 1985-2020, excluding Russia

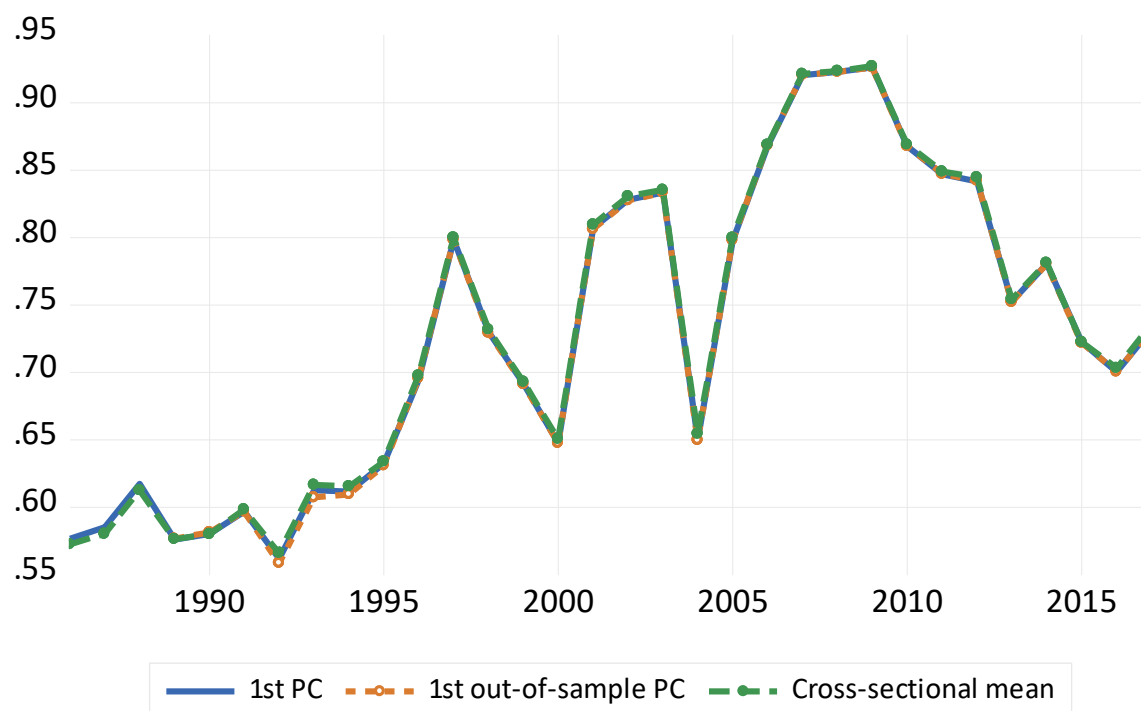


Figure 6: Alternative stock price series, integration measured with cross-sectional mean, 1880-1912

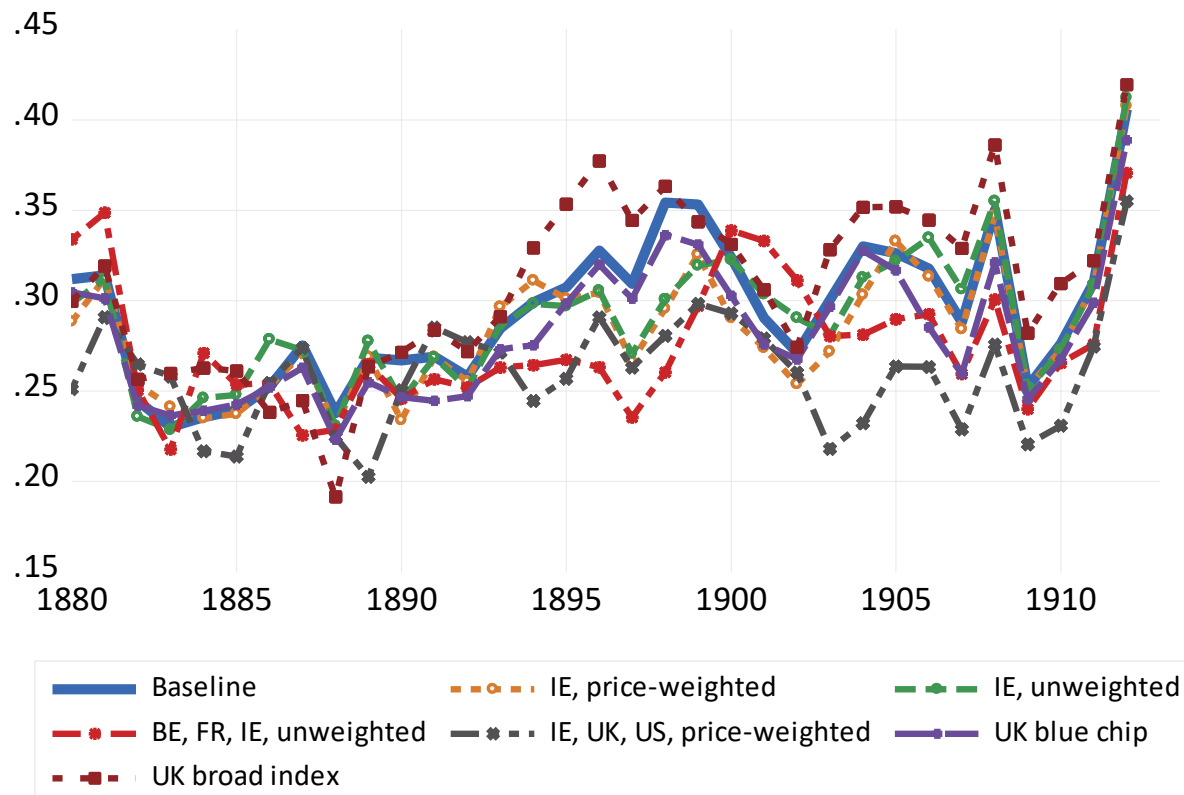


Figure 7: Factor loadings on UK returns using narrow (baseline) and broad index

