Federal Reserve Bank of Dallas
Globalization and Monetary Policy Institute
Working Paper No. 148
http://www.dallasfed.org/assets/documents/institute/wpapers/2013/0148.pdf

Large Global Volatility Shocks, Equity Markets and Globalisation: 1885-2011*

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June 2013

Abstract

I estimate the transmission of large global volatility shocks in international equity markets from the earlier (pre-1914) to the modern era of globalisation. To that end, I identify 43 such shocks over the period 1885-2011, defined as significant increases in unanticipated volatility in US equity markets, which I relate to well-known historical events. My estimates suggest that the response of global equity markets to these shocks in a panel of 16 countries is both statistically significant and large economically. On average, global equity market valuations correct by about 20% in the month when a shock occurs. There is substantial heterogeneity in responses both across countries and time, however, which can be partly explained by differences in global trade integration. I find no evidence that other potential theoretical determinants, such as output composition, country fundamentals or global policy responses matter, by contrast. These results shed light on a neglected aspect of globalisation, which creates opportunities but also heightens the exposure of economies to acute surges in global uncertainty and risk aversion.

JEL codes: F30, F31, N20

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I. Introduction

One of the most distinctive features of the financial crisis that engulfed the global economy after the collapse of Lehman Brothers in Autumn 2008 is to have pushed global uncertainty and risk aversion to historic levels. To paraphrase Chairman Bernanke, himself quoting a former US Secretary of Defence, the period after Lehman's bankruptcy was one of "profound uncertainty" associated with just too many "unknown unknowns" (Bernanke, 2010). In the month following the collapse of Lehman Brothers, the VIX –an index of implied volatility on a hypothetical at-the-money option on the S&P 500 commonly used as a yardstick of market uncertainty and risk aversion– reached an all-time-high, at over 80% per annum.

A particular trait of this acute surge in global uncertainty and risk aversion is that it had been initially restricted to a very small segment of US financial markets, the sub-prime mortgage market. But it rapidly spread to virtually all economies with overwhelming intensity, prompting large corrections in asset valuations, notably in the equity markets.

What is especially intriguing, however, is that one could not have taken for granted that such developments would necessarily have had massive repercussions on a global scale. Some historical precedents suggest that the opposite could have well occurred. US stock market volatility by the time of October 1929's Black Monday surged even higher than after the collapse of Lehman Brothers, for instance.[1] But the international equity market response was then muted at best. In October 1929, global equity markets outside the US corrected by a mere 5% on average. In October 2008, in the wake of Lehman's collapse, the correction of global equity markets was five times larger, at about 25%. What can possibly explain such a strikingly large difference? And more generally, how are large global stock market volatility shocks transmitted across countries and time?

Part of the explanation is that the world economy was far more globalised in 2008 than in 1929. Trade openness in advanced economies –defined as the sum of exports and imports scaled by GDP– was twice higher in 2009 than in 1929 (i.e. 80% vs. 40%), to take just one metric. This paper's aim is to show the importance of globalisation in transmitting large global volatility shocks across equity markets, as indicators of acute surges in global uncertainty and risk aversion.

Since we consider global equity markets, one strand of literature to which the paper clearly relates is that on international financial spillovers. The large body of research on volatility spillovers and contagion dates back at least to Engle, Ito and Lin

[1] See Figure 1 as well as sections II and IV for more details on the comparison between these two large stock market volatility shocks.

(1990) or Masulis, Hamao and Ng (1990). Countless papers have been written to propose quantitative measures of contagion (see e.g. Forbes and Rigobon, 2002; Bekaert, Harvey and Ng, 2005; and Forbes, 2012, for recent influential contributions, as well as Dungey et al., 2004, for a survey), or theories to explain it (see e.g. Allen and Gale, 2000, or Karolyi, 2003, for a survey).

My paper focuses on one specific angle of the issue. It does not consider stock market volatility shocks in general, but only those of really *historic* proportions, as in Bloom (2009). To motivate his theoretical model about how uncertainty affects agents' decisions, Bloom estimates the impact of 16 really major US stock market volatility shocks between 1962 and 2008 on US real macroeconomic variables, These shocks include e.g. the Cuban missile crisis of 1962; the assassination of President Kennedy in 1963; the 1973 oil-price shock or the 9/11 terrorist attack.

This paper takes a different perspective from that in Bloom (2009), which is its first specific contribution. I aim to add a global financial dimension to the issue by examining spillovers across equity markets of historically large global stock market volatility shocks. This is in the spirit of Boutchkova et al. (2012) who examined how local and global political risks affect industry equity return volatility and found that global political uncertainty is reflected in the return volatility of trade-dependent domestic industries, suggesting that trade brings in foreign political risk.[2] Moreover, in looking exclusively at tail shocks, i.e. those of historic proportions, I explicitly take a longer view than Bloom (2009), going back to 1885. My sample embraces what economic historians sometimes call the "first era" (pre-1914) of globalisation (see e.g. O'Rourke and Williamson, 2001) up to the modern globalisation era. Such a long perspective is insightful because very large global shocks in equity markets occurred relatively infrequently, which implies that one has to go sufficiently back in time to identify a sufficient number of shocks to draw reliable inference.

Alongside the literature on international financial spillovers, another strand of research to which my paper is related is that on global market integration. A large array of studies have shown evidence the global equity market co-movements tended to increase as the global economy had become increasingly integrated, notwithstanding significant time-variations (see e.g. Bekaert and Harvey, 1995, 1997, 2000; Ng, 2000; Fratzscher, 2002; Bekaert, Harvey and Ng, 2005; Bekaert, Hodrick and Zhang, 2009; Baele and Inghelbrecht, 2009). Globalisation is characterised by long-run historical cycles, however. This includes a significant progress up to 1914; a massive retrenchment in the interwar period; a substantial revival after 1945; and, with the onset of the global

[2] Another related paper (albeit with a more domestic perspective) is Bittlingmayer (1998), who shows that that the dramatic political events that affected Germany between 1914 and 1924 (which marked clear exogenous political shocks) led to a significant increase in stock market volatility and, ultimately, output decline. There is also a theoretical literature looking at disaster shocks in an open economy (see e.g. Farhi and Gabaix, 2011).

financial crisis of 2007-09, some have openly discussed risks of "de-globalisation" (e.g. Van Bergeijk, 2010). The focus of the extant literature on global market integration on post-1970 data, when globalisation was always trending upwards, creates a possible bias. It tilts estimation results towards finding increasing global market integration in the data. The much longer perspective taken in this paper hence enables to gauge the impact of globalisation's progress and retrenchment on global equity markets in a more comprehensive manner, which is the second of its specific contributions. In so doing, I provide price-based measures of global financial market integration over a full century, which might also help address limitations of quantity-based or regulation-based measures (see e.g. Prasad, Rogoff, Wei and Kose, 2007; Kose, Prasad, Rogoff and Wei, 2009).

To estimate the transmission of large global stock market volatility shocks in international equity markets from the earlier (pre-1914) to the modern era of globalisation, my empirical framework makes use of a two-factor (global and regional) model with country-time-varying loadings. This approach draws from the class of models developed in Bekaert and Harvey (1995), Bekaert, Harvey and Ng (2005), Bekaert, Hodrick and Zhang (2009) and Bekaert, Ehrmann, Fratzscher and Mehl (2011). I use this model to estimate the international transmission of 43 large global stock market volatility shocks which I can identify over the period January 1885-October 2011.

More specifically, the shocks are defined as months when unanticipated volatility in US stock markets was exceptionally high in statistical terms, as in Bloom (2009). The proximate source of the shocks is identified using narratives of relevant articles from the *New York Times*' online archives, which provide information on the date of the shock, the event reported to be at its origin, its nature and its location. The new extensive dataset presented in this paper on tail volatility events in equity markets over such an extended period is the third of its specific contributions.

A nice feature of my paper's methodology is that it allows for a clean identification of a set of exogenously large global stock market volatility shocks, along with their explicit reported source (nature and location). In terms of nature, I have both economic and non-economic shocks (terrorist attacks, wars, political shocks). In terms of location, I can distinguish between shocks originating in the US and shocks originating outside the US, but common to all equity markets. Non-economic shocks are arguably exogenous in the purest sense, but since virtually all of my economic shocks originate from the US, they are also exogenous to equity markets outside the US.

To anticipate on the paper's main results, my estimates suggest that the response of global equity markets to these shocks in a panel of 16 countries is both statistically significant and large economically. On average, global equity market valuations correct by about 20% in the month when a shock occurs. There is substantial heterogeneity in responses both across countries and time, however, which can be partly explained by differences in global trade integration. I find no evidence that other potential theoretical determinants, such as output composition, country fundamentals or global policy responses matter, by contrast. These results shed light on a neglected aspect of globalisation, which creates opportunities but also increases the exposure of economies to acute surges in global uncertainty and risk aversion.

The rest of the paper is structured as follows. Section II explains the methodology to identify the set of large global stock market volatility shocks. Section III describes the empirical framework and the data. Section IV reviews the empirical results. Section V concludes and draws implications for research and policy.

II. Identification of large global stock market volatility shocks

My measure of large global stock market volatility shocks borrows directly from that proposed by Bloom (2009). Equity market volatility is the "canonical measure" used by practitioners to proxy for uncertainty in financial markets (Bloom, 2009, p. 623), although it obviously may reflect both uncertainty (i.e. the quantity of risk) and risk aversion (i.e. preferences towards risk) at the same time (see e.g. Bekaert, Hoerova and Scheicher, 2009; Bekaert, Hoerova and Lo Duca, 2011).

In addition, Bloom (2009) together with Bloom, Bond, and Van Reenen (2007) showed that equity return volatility is significantly correlated with alternative uncertainty proxies at the micro level. These proxies include real sales growth volatility, the cross-sectional spread of industry productivity growth, (pre-tax) profit growth or financial analysts' forecasts. Equity return volatility is also significantly correlated with other uncertainty proxies at the macro level, such as the degree of disagreement among professional forecasters about their GDP forecasts.

I strive to follow Bloom's methodology to identify major stock market volatility shocks in a comparable way. The identification focuses on the US equity market to ensure that shocks are exogenous for other countries, in line with the dominant weight of the US in the global economy throughout the sample. In so doing, I extend Bloom's sample almost threefold, from 1962-2008 to 1885-2011.

I first create a US equity market volatility series over 1885-2011. As in Bloom (2009), I take implied volatility from 1986 onwards (i.e. the "VXO" index published by the Chicago Board of Options Exchange, an index of implied volatility on a hypothetical at-the-money option on the S&P 100).[3] As the VXO index is not available prior to 1986, I again follow Bloom (2009) in using realised volatility beforehand, which is calculated

[3] Bloom (2009) uses the VXO rather than the new VIX series which is based on the S&P 500 but is available only since 1990. The VXO's tracking error relative to the VIX is negligible over the period when they overlap.

as the monthly standard deviation of daily S&P 500 index returns (available from *Global Financial Data*), normalised to the same mean and variance as those of the VXO index over the period 1986-2011. It is important to note that using instead *realised* volatility throughout has no bearing on the results. It is basically the same events that are identified, ultimately (see Figure A4 in the appendix). The reason is that implied and realised volatility (albeit being very different economic concepts, arguably) are highly correlated (with a correlation of 0.89 over 1987-2011), i.e. they surge at the same time and end up picking the same events.

I then create a dummy variable that takes a value of 1 if unanticipated equity market volatility is significantly high, i.e. in excess of 1.65 standard deviations above the Hodrick-Prescott detrended mean of the volatility series (with λ = 129,600).[4] These are the major stock market volatility shocks. Some of the shocks occur during one month only, but many others last several months. To avoid counting the same shock twice, I consider only the first month in which unanticipated volatility was significantly high (with a 6-month exclusion window). Overall, I can identify 43 major stock market volatility shocks, which are reported in Table 1. As I also want to take into account the magnitude of the shocks in the estimation, I scale the 0/1 dummy by unanticipated stock market volatility divided by its standard deviation. The resulting series is then expressed in terms of units of standard deviation of unanticipated volatility (where 1 standard deviation roughly equals a 6.5% monthly equity price change), which I will refer to as "σ units".

To gauge what the sources of those shocks are, I resort to narratives found in newspapers' articles published at the time when they occurred. Since we are looking at a very long sample that spans over a 125 years, I use the archives of the *New York Times* available online.[5] For each event, I create a database of relevant articles containing information on the date of the shock, the event reported to be at its origin, its nature and location (the database is available from the author upon request).

A nice feature of the methodology is that it allows for a clean identification of a set of exogenous major stock market volatility shocks, along with their explicit reported source (nature and location). In terms of nature, the shocks are classified into economic shocks (including on oil prices) and non-economic shocks (terrorist attacks, wars, political events). In terms of location, they are classified into shocks originating in the US and shocks originating outside the US, but common to all equity markets (such as the Russian revolution of 1917 or the invasion of France by Germany in 1940 at the onset of World War II). Arguably, the shocks which are exogenous in the purest sense are the non-economic ones. But since virtually all of my economic shocks originate from the US,

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[4] Note that the mean can be neglected empirically as it is virtually nil.
[5] See http://query.nytimes.com/search/query?srchst=p#top.

they are exogenous to equity markets outside the US.[6] Figure 2 plots the 43 large global stock market volatility shocks which I could identify (in addition, Figure A3 in the appendix also plots the equity market volatility series, i.e. the raw undetrended series, its HP trend and unanticipated volatility, i.e. the detrended series, over time).

To what extent can these shocks be interpreted economically? Undoubtedly, they are observable measures of tail volatility events that are potentially relevant globally. However, it is unclear as to whether they reflect acute surges in uncertainty or in risk aversion, i.e. in the amount of risk or attitudes towards risk, or even a combination of both. Recent studies (Bekaert, Hoerova and Scheicher, 2009; Bekaert, Hoerova and Lo Duca, 2011) have proposed methodologies that aim at disentangling risk aversion from uncertainty. They use implied volatility measures or expectations survey data that are not available for the largest part of my sample, unfortunately. However, those studies found on post-1990 data that both risk aversion and uncertainty are positively correlated and that they also tend to surge at the same time (see Bekaert, Hoerova and Lo Duca, 2011, p. 29). This suggests that my shocks are likely to reflect a combination of uncertainty and risk aversion, i.e. of market environments when both are simultaneously exceptionally high. Insofar as the purpose of my paper is solely to study how these observable shocks are transmitted across equity markets, I do not take a stance on their ultimate economic interpretation and refer to them throughout as "large global stock market volatility shocks", which may reflect acute surges in both global uncertainty and risk aversion.

III. Empirical framework

Simple factor model

The starting point of my empirical framework draws from the class of models developed in Bekaert and Harvey (1995), Bekaert, Harvey and Ng (2005) as well as in Bekaert, Hodrick and Zhang (2009).

It consists of a two-factor model with country-time-varying loadings that looks as follows:

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta_{i,t}^{glo}\ F_t^{glo,\setminus i} + \beta_{i,t}^{reg}\ F_t^{reg,\setminus i} + \mathbf{D_t} + \varepsilon_{i,t} \qquad (1)$$

with

[6] One exception is the European sovereign debt crisis of September 2011.

$$\beta_{i,t}^{glo} = b_0^{glo} + b_1^{glo} X_{i,\tau-1}^{glo}$$
$$\beta_{i,t}^{reg} = b_0^{reg} + b_1^{reg} X_{i,\tau-1}^{reg} \quad (2)$$

where $R_{i,t}$ is the excess return of country *i* in month *t* (the equity return less the 10-year long term bond yield in monthly units[7]); $E_{t-1}[R_{i,t}]$ is the expected excess return, measured as a country specific constant α_i; F^{glo} is the global stock market excess return; F^{reg} is the regional stock market excess return; and $\mathbf{D}_t$ are time effects that control for other potential common factors.

This general model allows for country-time-varying beta exposures to global and regional factors, and can capture full or partial global market integration or regional integration as well as changes in the intensity of integration through international trade linkages. From an asset pricing theory perspective, if $\beta^{reg} = 0$, Eq. (1)-(2) become a world CAPM model with the global factor as benchmark; and if $\beta^{glo} = 0$, Eq. (1)-(2) become a regional CAPM model, with the regional factor as benchmark.

I take as the global factor F^{glo} the first principal component of the 16 country-level excess returns, excluding the returns of country *i* itself (to avoid adding up spurious correlations between the right hand side and left hand side of Eq. (1)). The first principal component is a good summary measure of the variability of the equity market returns across countries, capturing typically 40% of their variance. Note that I choose to resort to principal component analysis rather than market capitalisation-weighting because data on market capitalisations are not available for my full sample of countries over 125 years, and in the absence of obvious alternatives.[8] In one of the robustness checks, I will also take the US market return as an alternative to the global market return.

As regards the regional factor F^{reg} , I split my sample into three regions: Europe (Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, UK); Northern America (US, Canada) and Asia-Pacific (Australia, Japan). Europe's regional factor is calculated as the first principal component of the 13 European country excess returns, excluding the returns of country *i* itself. Since there are only two countries in the Northern America and Asia-Pacific regions, I take the US (Canada) as the regional factor for Canada (the US), as well as Australia (Japan) as the regional factor for Japan (Australia).

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[7] Note that I could not use T-bill rates as proxy for the risk-free rate due to limited data availability for many countries of my century-long sample.

[8] For instance, GDP weighting could be feasible as long-time series are available, but it is not really an attractive option. GDP is unlikely to be a reasonable proxy of equity market capitalisation. The use of market vs. bank financing is likely to have been indeed very heterogeneous across both countries and time in my sample, with countries of similar economic weights (such as the UK, France or Germany) having yet very different traditions in terms of financing structure.

As is customary in the literature, in order to obtain an intuitive interpretation of the loading estimates and avert multicollinearity, the regional factor is orthogonalised with respect to the global factor by regressing the former on the latter over the full sample and then using the residuals as the regional factor (as in e.g. Bekaert, Harvey and Ng, 2005, or Bekaert, Hodrick and Zhang, 2009). In other words, we have: $F^{reg} \perp F^{glo}$. In estimating Eq. (1)-(2), I report standard errors that are robust to heteroskedasticity and clustered heterogeneity.

Clearly, stock markets are affected by non-linearities, with market returns being everywhere near the tails of any potential ex-ante distribution at times of crises or large volatility periods. I am not trying with this framework to explain such non-linear effects at all, however. Just as in Bekaert, Harvey and Ng (2005), Bekaert, Hodrick and Zhang (2009) and Bekaert, Ehrmann, Fratzscher and Mehl (2011), my benchmark partial equilibrium model linking asset returns to factors is linear indeed, but it is a reduced-form factor model, in which non-linearities are accounted for through the return factors.

The reduced form nature of the model implies that I stop short of trying to explain why the factor returns jumped or were extremely negative/positive. But I can use this model to investigate the response of different countries to the (extreme) movements in these returns, especially when large global stock market volatility shocks occurred. In fact, the model does a pretty good job at explaining co-movements between global equity markets and the shocks, appearing to get their first-order effects correctly (i.e. it explains over 50% of return variation when the shocks occur, as it will be shown in section IV below).

Decomposition model

Of course, the global and regional factors are potentially affected by the 43 large global stock market volatility shocks themselves. To assess specifically the impact of these shocks on global equity markets –as well as their determinants, which may or may not be different from those shaping global and regional market interdependence– we need to decompose global equity return co-movements into a part driven purely by the factors and another one driven by the large global stock market volatility shocks specifically.

To that end, I draw on the model proposed in Bekaert, Ehrmann, Fratzscher and Mehl (2011) to disentangle "normal" interdependence from contagion in global equity return co-movements and modify Eq. (1)-(2) to the form

$$R_{i,t} = E_{t-1}[R_{i,t}] + \beta_{i,t}^{glo}\ F_t^{glo,\backslash i,\perp} + \beta_{i,t}^{reg}\ F_t^{reg,\backslash i,\perp} + \gamma_{i,t} u_t + \mathbf{D_t} + \varepsilon_{i,t} \qquad (1')$$

where we now have a third country-time-varying loading

$$\gamma_{i,t} = g_0 + \mathbf{g}_1'\mathbf{Z}_{\mathbf{i,\tau-1}} \tag{2'}$$

and where I have also added variable u_t, i.e. the large global stock market volatility shocks defined in section 1.

Insofar as the large global stock market volatility shocks are exogenous (being either common or US shocks), it is economically sensible to orthogonalise the factors with respect to the latter to achieve my decomposition of global equity market return co-movements. The global factor is orthogonalised with respect to the large global stock market volatility shocks by regressing the former on the latter over the full sample and then using the residuals as the global market factor. The regional factor is orthogonalised with respect to both the large global stock market volatility shocks and the global factor by regressing the former on the latter two over the full sample and then using the residuals as the regional factor. In sum, we have $F^{glo} \perp u$ and $F^{reg} \perp u, F^{glo}$. The factor orthogonalisation estimates are reported in Table A1 of the Appendix. In estimating (1)-(2)-(2') I again report standard errors that are robust to heteroskedasticity and clustered heterogeneity.

Instruments

Cross-country differences in the intensity of global or regional market integration and changes over time in this intensity, i.e. the beta loadings of Eq. (2), are captured through standard international trade linkage "instruments" (as in e.g. Bekaert, Harvey and Ng, 2005, or Baele and Inghelbrecht, 2009).[9] These include a constant, as well as the trade openness ratio X^{glo} (the sum of exports and imports scaled by GDP) and the share of regional trade X^{reg} (the sum of regional exports and imports scaled by total trade). As these variables are available at the annual frequency, they are lagged by one year to avoid endogeneiety (i.e. we have in Eq. (2): $\tau - 1 = t - 12$).

The reaction of global equity markets to large global stock market volatility shocks, captured in the gamma loadings of Eq. (2'), can also vary across countries and time through international linkages. One hypothesis is that large global stock market volatility shocks hit hardest those economies that are highly interdependent through trade and financial linkages. Several researchers have stressed the increased vulnerability to crises that comes with financial and economic integration (see Mendoza and Quadrini,

[9] I do not mean to suggest that these "instruments" are "exogenous" in the strict sense of econometric identification. In the asset pricing literature, this term is simply used for variables that are not returns and are pre-determined (in a temporal sense) and used to model time-variation in factor exposures, prices of risk, etc. The terminology goes back to the GMM literature where such instruments could be used to multiply orthogonality conditions arising from rational expectations models to obtain over-identified unconditional moment conditions (for more recent references see Adrian and Franzoni (2009), Baele and Inghelbrecht (2009) or Bekaert, Ehrmann, Fratzscher and Mehl (2011)).

2010, for a theoretical analysis). In particular, the trade channel has often been associated with international spillovers and contagion (see Kaminsky and Reinhart, 2000; Forbes, 2004 and 2012; Baele and Inghelbrecht, 2009; Bekaert et al. 2011). The financial channel is arguably also important, but poor data availability for my 125 year-sample makes it far more difficult to measure.[10] I therefore focus here on trade linkages and use the share of bilateral trade with the US (i.e. a measure of direct exposure to large global stock market volatility shocks originating from the US) and the trade openness ratio (i.e. a measure of direct exposure to large global stock market volatility shocks originating from outside the US) as instruments for the gamma loadings.

But there are several other theoretical channels and potential instruments to consider, in addition, which I also include in vector **Z** of Eq. (2').

One instrument pertains to output composition, namely the share of durables in the economy, which aims to capture the importance of non-convexities in labour and capital adjustment costs. Bloom (2009)'s recent theoretical contribution suggests that non-convexities are a key determinant indeed of firms' decisions at times of high uncertainty. As he puts it, firms only hire or invest when conditions are sufficiently good and fire or disinvest only when they are sufficiently bad. When uncertainty is higher, they wait and do nothing. This is particularly the case in the durable goods sector, since these are the goods "we can wait to replace" (Bloom, 2011). The share of durable goods in the economy might therefore be a good proxy of the share of economic activity particularly prone to be affected by large global stock market volatility shocks, due to non-convex labour and capital adjustment costs.

Another set of instruments pertains to country's fundamentals. Interdependence between economies may arguably unfold not only through real and financial linkages, but also through the relative soundness of domestic fundamentals. This is the so-called "wake-up call" hypothesis, which states that a shock initially restricted to one country provides new information that may prompt investors to reassess the vulnerability of other countries, which then spreads the shock across borders (Goldstein, 1998; Masson, 1999; Goldstein, Kaminsky and Reinhart, 2000; Forbes, 2012).[11] Under this hypothesis, domestic fundamentals are likely to play a dominant role in the international transmission

[10] It has been observed that international trade and financial linkages are tightly linked, however, so that the former captures partly the latter, at least to some extent. Commercial transactions are a source of intelligence useful for informing foreign investment decisions (Antras and Caballero, 2007); and the existence of trade links may make foreign investments more secure insofar as strategic default is deterred by the threat of commercial retaliation (Rose and Spiegel, 2004). In line with this, Aviat and Coeurdacier (2007), Lane and Milesi-Ferreti (2008a) and (2008b), Coeurdacier and Martin (2009), Forbes (2010) and Coeurdacier and Rey (2011) report evidence that trade in goods is an important determinant of international financial investments.

[11] Goldstein (1998) coined the phrase "wake-up call" in the wake of the Asian financial crisis, arguing that the Thai currency crisis of 1997 had prompted international investors to recognise that the so-called "Asian miracle" of the time was rather an "Asian mirage", which ultimately led to a reassessment of all other countries in the region.

of a shock. I therefore consider a large array of country-specific macro fundamentals in the estimations, including domestic growth, inflation, public debt, trade balance and banking crises.

A final set of instruments pertains to global policy responses. The literature on self-fulfilling currency crises with multiple equilibria (see e.g. Morris and Shin, 1998; Sarno and Taylor, 2001) stressed the key role played by official communication by policy makers to avert crises or mitigate their effect. In these models, although each market participant may individually believe that a country's fundamentals are sound, uncertainty about beliefs may yet precipitate a crisis. If it is uncertain that some may believe that fundamentals are unsound, a crisis will occur, even though everyone is individually convinced that fundamentals are sound. This suggests a crucial role for timely and effective announcements by policy makers to stabilise markets, as announcements can help coordinate market participants' beliefs by restoring transparency and common knowledge about fundamentals. In my setting, credible announcements by policy-makers may therefore help mitigate the international transmission of large global stock market volatility shocks and partly shelter economies from these shocks.

To test this channel of international transmission, I first examine global policy responses to large global stock market volatility shocks and focus on the communication by the Group of Seven key industrialised economies (G7) and the Group of Twenty key industrialised and emerging economies (G20). The G7 between 1975 and 2009 and the G20 since 2009 have been the prime fora for international economic policy coordination.[12] Both the G7 and G20 have issued statements or communiqués at times of rising uncertainties and/or severe financial and economic stress, oftentimes with an explicit view to sending a strong signal to market participants. For instance, recent research suggests that G7 communication has been instrumental in managing global exchange rate configurations (Fratzscher, 2009).

As an alternative to G7/G20 communication, I consider the impact of US monetary policy, using the change in the Fed's key policy rate as a metric, to test whether an easing in US monetary policy helps dampen the impact of global uncertainty and risk aversion shocks.[13] Finally, I also consider policy uncertainty measures, namely the indices constructed by Baker, Bloom and Davies (2012) for the US and Europe (which are available for a much shorter time period, however). A decline in policy uncertainty

[12] The G7 has arguably played a central role in various episodes, for instance following the Plaza Accord in 1985, the Louvre Accord in 1987 and other episodes in the 1990s and 2000s. Since the collapse of Lehman Brothers, the G20 has also played a more active role in an attempt to devise a response to the global economic and financial crisis.

[13] I use the Fed's discount rate from 1914 to 1950; the Fed fund market rate from 1951 to 1979 and the Fed fund target rate from 1980 to 2011, all sourced from *Global Financial Data*.

might also help dampen the impact of the shocks, to the extent that it may encourage private agents to resume spending on durable investment and consumption goods.[14]

As most of the instruments included in vector **Z** are available at the annual frequency, they are lagged by one year to avoid endogeneiety (i.e. we have in Eq. (2)-(2'): $\tau - 1 = t - 12$). In the case of policy-related variables (i.e. G7/G20 communication, policy uncertainty indices and US monetary policy), which are available at the monthly frequency, I use one month lags (i.e. we have in Eq. (2)-(2'): $\tau - 1 = t - 1$).

Data

The baseline sample period is January 1885 to October 2011, i.e. my sample starts when the US became the largest economy in the world and ends shortly after its sovereign debt was downgraded by one rating agency for the first time in history. The sample contains up to 1,521 monthly observations for 17 (including the US) countries (with some observations missing for some countries), namely: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States. The US is included in the baseline sample, but excluded from the estimation in the robustness checks (as we will show hereafter the results are essentially not affected by the (excl)inclusion of the US in the estimation).

All data on financial asset prices are taken from *Global Financial Data* (GFD) and are sampled at the monthly frequency. With some 130 years of monthly data, it will come as no surprise that GFD's data may be drawn from several primary sources, including within countries, which implies that they may not be fully harmonised. In the absence of a straightforward alternative for a large set of countries over a century long time period, it is the "major source" (Barro and Ursúa, 2011, p. 6) for financial asset prices, however. Moreover, to the extent that my focus is on tail events, i.e. really large shocks, we can be reasonably confident that their effects should be visible from most primary data sources.

The raw data on equity market indices are in nominal and local currency terms. They are available since 1885 for four countries (Australia, Germany, the UK and the US); since 1914 at least for another eight countries; and no later than 1922 for the remaining countries. I take the government bond yield in nominal and local currency

[14] Baker, Bloom and Davies build an index of US policy-related economic uncertainty since 1985 from components that measure three aspects: (i) the frequency of references to economic uncertainty and policy in a set of 10 leading US newspapers; (ii) the number of US federal tax code provisions set to expire in future years; and (iii) the extent of disagreement among economic forecasters over future US federal government purchases and the future US CPI price level. They also construct an index of European economic policy uncertainty (Germany, France, Italy, Spain, UK) which is analogous to their US news-based index and available since 1993. Since both indices are available for much shorter time periods than my overall sample, I consider these indices in the robustness checks only.

terms as the risk free rate, using the 10-year maturity for all countries, with the exception of Finland (5-year bond yield) and the United Kingdom (5-year note yield). Returns in local currency are then converted to US dollar returns using exchange rates vs. the US dollar, adjusted for re-denominations, when and where necessary.

The trade data are taken from Mitchell (1998a, 1998b and 1998c) for the period 1885-1947 and from the IMF's Direction of Trade Statistics (DOTS) for the period 1948-2011. A few missing data points are replaced with their last known values.[15] In the calculations of X^{reg}, one should be aware that bilateral trade data are available for only some of my 13 European countries prior to 1948. I therefore proxy the actual share of intra-European trade with that based on a subset of European countries reported in Mitchell pre-1948, which I rebase to the actual share of intra-European trade (i.e. with the full set of 13 European trading partners) in 1948 (the first year available from the DOTS database).

As regards the instruments, I use Mitchell (1998a, 1998b, 1998c) for the data on nominal GDP. To proxy the share of durables in the economy (i.e. the share of economic activity particularly prone to be affected by large global stock market volatility shocks due to non-convex labour and capital adjustment costs) I take the share of manufacturing in output. The latter also comes from Mitchell as well as –where data are missing– the *Historical national Accounts* database maintained by the Groningen Growth and Development Centre for the period 1885-2004.[16] After 2005, I use the OECD's *Annual National Accounts* database. Again, a few missing data points are replaced with their last known values. The data on real GDP per capita growth are from Barro and Ursúa (2008) prior to 2006 and from the WEO afterwards. I calculate annual inflation using CPI data obtained from GFD. The public debt data are from Ali Abbas et al. (2010) and the dates of systemic banking crises are from Reinhart (2010). The dates of regular and ad-hoc communiqués by G7 and G20 Finance Ministers and Governors are from the G8-G20 information centre maintained by the G8-G20 Research Group of the University of Toronto.[17] The indices of US and European economic policy uncertainty are from Baker, Bloom and Davies (2012). The data on the Fed's discount rate, Fed fund market rate and Fed fund target rate are from GFD.

[15] This does not affect the consistency of the estimation since we use the trade variable as instruments, i.e. always lagged, given that we do not want them to be contemporaneous with the dependant variable.
[16] See http://www.ggdc.net/databases/hna.htm.
[17] See http://www.g7.utoronto.ca/.

IV. Results

Stylised facts

What are the main features of large global stock market volatility shocks in the last 130 years? Table 1 presents the main stylised facts on the 43 such shocks identified using Bloom (2009)'s methodology. They are ranked by decreasing size in σ-units terms (i.e. numbers of standard deviations of unanticipated stock market volatility). The three largest stock market volatility shocks that hit the global economy between 1885 and 2011 were, respectively: the market crash of October 1929 (an almost 8-σ shock); the (immediate aftermath of) Lehman Brothers' collapse in October 2008 (an above 6-σ shock); and the "Black Monday" market crash of October 1987 (an above 5-σ shock). In those months, unanticipated stock market volatility surged by between 35 and 50 percentage points (in annualised terms), peaking to 80% in October 1929. Figure 3 shows the distribution of the shocks by size. Large global stock market volatility shocks averaged 2.9-σ, which is equivalent to a 19 percentage points increase in (annualised) unanticipated volatility.

In terms of type, about half of the shocks (21) were economic ones. They include events as different as e.g. the panic of 1907 (March 1907), which subsequently led to the creation of the Federal Reserve in 1913; the Russian and LTCM crises (September 1998); or the European sovereign debt crisis (September 2011). One other large global uncertainty and risk aversion shock is the first oil price shock of 1973, in the aftermath of the Kippur war. Roughly another half of the shocks are non-economic ones. They include 12 wars, such as the Anschluss of Austria by Germany (April 1938) that preluded World War II; the start of the Korean war (June 1950); that of the second Gulf War (February 2003); or the launch of Sputnik (October 1957), one of the peaks in diplomatic tensions during the Cold War. Other non-economic shocks include pure political events (e.g. the Russian revolution of November 1917) as well as terrorist attacks (e.g. the assassination of President Kennedy in November 1963 or 9/11 in September 2001). A few shocks (three in total) are mixed in nature, pertaining to both economic and political developments.

In terms of origin, upwards of three-quarters of the shocks stem from the US, with the remaining ones being common shocks. It is comforting that pure regional shocks, such as the Asian crisis of 1997-98, are not picked up by my identification scheme. Overall, 11 of the 17 events identified by Bloom (2009) as major stock market volatility shocks over 1962-2008 are also identified here over 1885-2011 (Bloom's remaining 6 events are not picked up as major shocks because they become too small in magnitude once the sample is extended by a further 80 years).

Figure 4 provides an intuition for the relationship between international equity returns and large global stock market volatility shocks by plotting the former against the latter. The relationship is clearly negative, suggesting that the adverse impact of large global stock market volatility shocks on international equity markets increases with their size, and that most of the shocks are "bad" news shocks. There are exceptions to that, with some of the shocks being associated with a muted, or even positive, market reaction on average. Arguably, it is not always easy to distinguish conceptually "bad" shocks from "good" ones. For instance, the outbreak of a war is a seemingly "bad" shock for many sectors in the economy, but it can be at the same time a "good" shock for other sectors, such as weapon or steel industries, which can be expected to benefit sizeably from it.

Simple factor model estimates

Table 2 reports estimates for the simple factor model of Eq. (1)-(2) with country-time varying beta loadings; fixed effects; time (5-year) effects; and robust-to-heteroskedasticity and clustered heterogeneity standard errors. The US is excluded from specifications (2) and (4). "Massive" outliers (i.e. observations for which the monthly equity market return exceeded +/- 30%, i.e. above twice the bottom/top 1%-ile of monthly returns across the sample) are excluded from specifications (3) and (4).

The unconditional beta loading for the global factor is found to be close to unity. This is very much in line with the earlier literature on international stock return co-movements that assumed constant-unit betas (as in e.g. Heston and Rouwenhorst (1994)'s influential study) as well as with the more recent literature documenting that global factor exposures have increased from values close to zero to values closer to one as markets have become increasingly integrated in post-1970s data (see e.g. Bekaert and Harvey, 1997, 2000; Ng, 2000; Fratzscher, 2002).

The unconditional beta loading for the regional factor is much smaller. It is insignificantly different from zero when the US is included in the sample (as in specification (1) and (3)), and slightly negative when the US is excluded therefrom. This suggests that regional developments helped international equity markets decouple slightly from global developments, although the magnitude of this effect is very small, at best.

Globalisation plays a significant role in driving the intensity of international stock return co-movements, however. The conditional beta loadings are statistically significant for both the global and regional factors, with a positive sign. This means that conditional betas can differ appreciably from their unconditional values, and that stronger global and regional trade linkages contribute to increase significantly global and regional equity market integration.[18] Not only do the estimates confirm earlier findings in the literature for recent decades (as in e.g. Baele and Ingehlbrecht, 2009), but they substantiate them further by showing that similar patterns were already present in earlier phases of

[18] Taking the sum of the unconditional and conditional estimates (together with the values of global and regional trade), the global betas are in the order of 1.2, while the regional betas are on the order of 0.4 (see the discussion of Figure 5 and 6 hereafter).

globalisation. Importantly, they show for the first time how crucially conditional betas varied not only with phases of expansion of globalisation, but also with phases of retrenchment, as in the interwar period.

The major impact on global equity market integration of long-run globalisation cycles, i.e. of protracted phases of expansion or retrenchment in global and regional trade openness, is evident from Figures 5 and 6. The left quadrant of Figure 5 shows the evolution over time of the un-weighted cross-country average of the global beta estimates. The right quadrant shows the evolution of its corresponding standard deviation. Figure 6 plots similar data for the regional beta estimates.

Global equity market co-movements were relatively strong during the first era of globalization (pre-1914). They declined after the outbreak of World War I to bottom in the 1930s as trade protectionism and capital controls became widespread. After 1945, global equity market integration has increased unabated, to peak just before the onset of the global economic and financial crisis of 2007/8. Regional market co-movements are somewhat more stable over time. One exception is World War II, which particularly disrupted trade relationships on the European continent, resulting in large swings in the estimated regional betas.

The overall fit of the model, at around 0.25-0.30, is very close to the one obtained on more recent samples (see e.g. Bekaert et al., 2011). Is the model a good predictor of the large global stock market volatility events that occurred in the last 130 years? This is explored in Figure 7 which plots actual equity returns in the respective months of the 43 major stock market volatility events against fitted returns obtained with the model (using the specification in column 2 of Table 2). If the model predicted the relative severity of the impact of the shocks perfectly, observations should perfectly scatter along the 45-degree line. The fit is arguably not perfect, but the model does a pretty good job. When I run a regression of actual on predicted returns indeed, I find:

$$R_{i,t} = -.424 + 1.045\hat{R}_{i,t} + \eta_{i,t} \qquad \overline{R}^2 = 0.53$$
$$(.267)\,(.038)$$

The slope coefficient is close to unity, and the adjusted R^2 over 50%, confirming the model's good fit. As seen from Figure 7, it makes only a few big "misses" for some countries and events.

Of course, insofar as large global stock market volatility shocks can affect the global and regional factor themselves, such a simple factor model cannot distinguish between international equity market co-movements that are due to shock exposures from those that are due to global and regional market interdependence (over and beyond these exposures). Nor cannot it say much about what drives differences in exposures to large global stock market volatility shocks across countries and time. These differences may (or may not) depend on trade integration, alongside other potential theoretical determinants. This is what we take up with the decomposition model of the next section.

Decomposition model estimates

Table 3 reports estimates of the decomposition model of Eq. (1')-(2') with a constant gamma loading (i.e. with **Z** = 0), fixed effects, time effects and robust-to-heteroskedasticity and clustered heterogeneity standard errors. The US is excluded from specifications (2) and (4) and "massive" outliers from specifications (3) and (4).

The estimates for the global and regional beta loadings are very close to the simple factor model estimates, which underscores the robustness of the previous findings. Strikingly, the gamma loading (i.e. the average estimated impact of a large global stock market volatility shock on global equity markets) is found to be strongly significant and large in economic magnitude, with an estimate of about -1.2 per σ-shock unit (with $\sigma \approx$ 6.5% change in unanticipated volatility). In other words, a shock of average size (i.e. 2.9-σ) is associated with a correction in global equity markets of about 22% in the month when the shock occurs. Such an estimated magnitude is not implausible. For instance, the *actual* decline of global equity markets during the collapse of Lehman Brothers (an over 6-σ global stock market volatility shock) averaged 25% in October 2008 alone, and a cumulated 43% between September and October 2008. The results are robust across different specifications, e.g. if one excludes the US from the estimation (as in columns 2 or 4 of Table 3) or outliers (as in columns 1 or 2).

Unsurprisingly, the results are also unaltered if one adds to the model the main (i.e. direct) effects of global and regional trade linkages (which is unlike the conventional specifications of Bekaert, Harvey and Ng, 2005, and Bekaert, Hodrick and Zhang, 2009, which exclude the main effects), insofar as those are slow-moving variables that capture little of the variance of stock returns at the monthly frequency. The results are again robust if I use the US market return as an alternative to the global market return. In this case, the average estimated impact of a large global stock market volatility shock on global equity markets is actually 20% larger (with an estimate of about -1.4 per σ-shock unit).

Does the impact of the shocks vary according to their type? Figure 8 examines the issue and shows estimated gamma loadings broken down between economic shocks and non-economic shocks for both the full sample and three selected sub-periods (using specification 1 of Table 3). The nature of the shocks does matter. The estimated gamma loading is about -1 per σ-shock unit for economic shocks. But for non-economic shocks (i.e. wars, terrorist attacks, or other political events), it is close to be 50% larger, at almost -1.5. This suggests that the economically sizeable impact of global stock market volatility shocks on international equity markets is not merely a reflection of potential endogeneity issues, since results turn out to be stronger when the estimation is restricted to "strictly" exogeneous (i.e. non-economic) shock. This also indicates that my overall results, based on a mix of both economic and non-economic shocks, are rather on the conservative side.

The geographical origin of the shocks also matters, as shown in Figure 9. The estimated gamma loading is about -1.1 per σ-shock unit for shocks originating in the US. For shocks originating outside the US (e.g. the Russian revolution of November 1917, the oil price shock 1973 or the European sovereign debt crisis of September 2011), it is about 30% larger, at around -1.4. This suggests that my estimates on the importance of the impact of large stock market volatility shocks for international equity markets are not uniquely driven by US-specific developments, thereby underscoring their more general character.

As a further sensitivity test, I included lags of the volatility shocks of various orders (one, three and six months) to assess whether there effect persists over time. None of the lags were found to be statistically significant, which suggests that the impact of the shocks is immediately discernible in equity markets and identifiable in the month when they occur, in line with the efficient market hypothesis.

To what extent is there heterogeneity across countries and time in the response of equity markets to large global stock market volatility shocks? And what explains this heterogeneity? Evidence on this is provided in Table 4, which reports the full decomposition model estimates of Eq. (1')-(2') where all beta and gamma loadings are allowed to vary across both the country and time dimensions.

The gamma loadings are now interacted with the four classes of instruments reviewed in section III, namely: the share of the manufacturing sector (a proxy for durables in output composition); the share of bilateral trade with the US and the trade openness ratio (international linkages); a set of country-specific fundamentals (domestic growth, inflation, public debt, the trade balance and banking crises); and, as a proxy for global policy responses, G7/G20 communiqués release dates, changes in the Fed's key policy interest rates and indices of US and European policy-related economic uncertainty (results for the latter two are not reported for the sake of brevity, but are available upon request). As aforementioned, all these instruments are lagged. The regressions include country effects, time effects as well as the main (i.e. direct) effects of all the instruments on global equity returns (also not reported for the sake of brevity).

What comes out clearly from Table 4 is the significant role played by international trade linkages in transmitting large global volatility shocks across equity markets. The interaction of the major stock market volatility shocks with the share of both bilateral trade with the US and the openness ratio are statistically significant and negative, either when they are included alone (as in column 2) or along with the other instruments (as in column 5).[19] There is no evidence that the remaining instruments play a role as international transmission channels, by contrast. The interactions of the major stock market volatility shocks with the proxies for output composition, country fundamentals and global policy response metrics are all found to be statistically insignificant indeed.[20]

How economically important is the impact of international trade linkages in transmitting large global stock market volatility shocks across equity markets? Figure 10 shows the evolution of the cross-country average of the conditional gammas (obtained with specification 2 of Table 4). The figure in the right quadrant shows the evolution of their respective standard deviation. In a nutshell, the figure shows the evolution of both the average intensity of the reaction of international equity markets to the shocks, conditional on international trade linkages, and of its dispersion across countries (as a complement, the evolution of the conditional gammas in each country is shown in Figure 11).

The figure underscores how much the way global equity markets have reacted to large global stock market volatility shocks over the last 130 years has depended crucially on the various phases of expansion and retrenchment of globalisation. The estimated impact of the stock market volatility shocks differs by a factor of up to a third, depending on the intensity of countries' integration into global trade. This is non-negligible, although still lower than the 80% difference in magnitude between the global equity market correction triggered by the Black Monday of 1929 and that triggered by the collapse of Lehman Brs in 2008, arguably.

Towards the end of globalisation's first era in 1914, conditional gammas averaged -1.25. This means that, on average, a large global stock market volatility shock was accompanied with a roughly 23% correction in global equity markets. By 1945, conditional gammas averaged less than -0.85, reflecting the severe disruptions in global economic, financial and monetary relations after the Great Depression and World War II. An *identically* large global stock market volatility shock was then associated with a milder correction, of some 16% (i.e. a third less) on average. But the relentless expansion in globalisation post-1945 led to a reversion of conditional gammas to an average of close to -1.3, equivalent to a global equity market correction of 24%, again for an identical shock. In other words, the results reveal a neglected channel through which long cycles of expansion and retrenchment of globalisation can affect interdependence between

[19] This is also reminiscent of findings in Forbes (2012) –based on post-1990 data– that countries are more vulnerable to contagion if they have greater trade exposure.

[20] Similarly, we find no significant impact of interactions with changes in the Fed's key policy rate or with indices of policy uncertainty (as aforementioned, these results are not reported for the sake of brevity but are available from the author upon request).

economies: they can heighten or dampen their exposure to large global stock market volatility shocks and acute surges in global uncertainty and risk aversion.[21]

Figures 11 and 12 make globalisation's influence more concrete still. The figures plot the pre-1945 (post-1945) average of each country's gamma loadings against their respective pre-1945 (post-1945) trade openness ratios. In other words, they show how open economies are more affected by the shocks than more closed ones, on average, both before and after World War II. The observations nicely scatter around a downward sloping line, with a roughly similar slope. One outlier is Canada, which is even more vulnerable to large global stock market volatility shocks than its overall trade openness ratio would suggest, reflecting the overarching weight of the US economy in its trade relations.

The key messages that emerges from the figures is that highly open economies are far more affected than more closed ones by acute surges in global uncertainty and risk aversion. To take two post-1945 examples, an economy such as the Netherlands, whose trade openness ratio averaged 90% of GDP, has a conditional gamma loading 40% higher (in absolute terms) than a less open economy like Sweden, whose openness is only 50% of GDP. Even more extreme is the difference between Belgium, whose trade openness ratio averaged upwards of 100% of GDP, and has a conditional gamma loading 70% higher (in absolute terms) than that of Spain, whose openness ratio is merely 30% of GDP.[22]

V. Conclusions

My paper has estimated the transmission of large global stock market volatility shocks to international equity markets from the earlier (pre-1914) to the modern era of globalisation. My estimates suggest that global equity market valuations correct on average by about 20% in the month when such shocks occur, and that the substantial heterogeneity in responses across both countries and time is driven by differences in global trade integration and the extent of globalisation itself.

Earlier literature, based on post-1970 data, had already provided evidence that global equity market co-movements tended to increase as the global economy had become increasingly integrated, notwithstanding significant time-variations. The much

[21] This might partly echo Rajan (2005)'s point –in his discussion as to whether financial development had made the world riskier– that technological change, deregulation and new institutions had expanded opportunities while making financial risks created by the system at the same time greater.

[22] The difference between the Netherland and Sweden's estimated conditional gamma loadings is -0.24. The difference between Belgium and Spain's estimated conditional gamma loading is -0.42. Both differences are to be compared with an unconditional gamma loading of -0.60 (see the second column of Table 4).

longer perspective taken in this paper has allowed addressing a possible bias in this literature, which relates to its focus on a distinct period when globalisation had been trending upwards relentlessly. To my best knowledge, I have shown here for the first time how crucially conditional betas –the estimated intensity of global and regional equity market interdependence based on international trade linkages– varied not only with phases of expansion of globalisation, but also with phases of retrenchment, as in the interwar period. This suggests that global financial markets may experience protracted phases of integration, but also fragmentation. The price-based measures of global financial market integration over a full century presented in the paper might also help address limitations of quantity-based or regulation-based measures.

Previous literature had also shown that global political uncertainty was reflected in the equity return volatility of trade-dependent domestic industries, suggesting that trade brings in foreign political risk. My paper has uncovered the significant influence of globalisation and international trade linkages as transmission channels of acute surges in global uncertainty and risk aversion across equity markets. The equity markets of economies highly open to global trade have been significantly more affected than those of more closed ones by large global stock market volatility shocks over the last 130 years.

From a policy perspective, these results might be helpful in identifying countries that may be particularly vulnerable to acute surges in global uncertainty and risk aversion, thereby deserving specific attention in multilateral surveillance exercises of global financial spillovers.

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Table 1: Overview of large global stock market volatility shocks

Ranking	Date	Shock size (in σ terms)	Detrended volatility (in % per year)	Trend (in % per year)	Volatility (in % per year)	Event	Type	Location
1	October 1929	7.6	49.7	31.1	80.8	Black Thursday, Monday and Tuesday (24, 28 and 29 Oct.)	Economic	US
2	October 2008	6.4	41.4	24.1	65.4	Lehman Brs. collapse	Economic	US
3	October 1987	5.4	35.2	23.0	58.2	Black Monday (19 Oct.)	Economic	US
4	September 1932	4.8	31.4	40.8	72.2	Uncertainties on Federal government's crisis response and economic outlook; stock market trough	Economic	US
5	September 1946	4.8	31.1	19.6	50.7	Unwinding of war-time economy; strikes	Economic	US
6	March 1907	4.7	30.2	19.7	49.9	Panic of 1907 ("Rich man's panic" of March)	Economic	US
7	July 1893	4.2	27.2	20.2	47.4	Panic of 1893 (collapse of railroad companies, bank runs, suspension of Sherman Silver Purchase	Economic	US
8	May 1901	4.1	26.8	19.5	46.3	Panic of 1901 on struggles between trusts to control the Northern Pacific Railway company	Economic	US
9	May 1962	3.8	24.5	15.8	40.3	Controversies over President Kennedy's economic policy (tax bill)	Economic	US
10	December 1895	3.6	23.5	21.6	45.1	Market concerns over free coinage of silver; US-UK tensions over Venezuela's border (Monroe	Economic & political	US
11	May 1940	3.4	22.2	24.3	46.4	Battle of France/Roosevelt asks Congress for extraordinary military credits	War	Outside US/US
12	May 1970	3.3	21.7	17.4	39.0	Cambodia and Kent State	War	Outside US
13	April 1938	3.3	21.6	28.4	50.0	Anschluss of Austria by Germany	War	Outside US
14	November 1890	3.1	19.9	17.7	37.5	Republican party defeat in Congress elections; Barings-near bankruptcy; McKinley tariffs	Economic & political	US
15	February 1932	3.0	19.6	40.4	60.1	Uncertainties on Federal government's crisis response and economic outlook	Economic	US
16	December 1899	2.8	18.0	20.3	38.3	Philippines-American war; Boer war	War	US
17	April 1933	2.8	17.9	40.1	58.0	F. Roosevelt's first New Deal (Emergency Banking Act, Economy Act)	Economic	US
18	March 1898	2.7	17.8	21.4	39.2	Spanish-American war (Cuba, Guam, Porto Rico, Philippines)	War	US
19	September 1937	2.6	16.8	29.0	45.8	War concerns (Sino-Japanese war; Spanish civil war; European situation)	War	US
20	September 2001	2.6	16.6	26.1	42.7	9/11 terrorist attacks	Terror	US
21	September 1955	2.5	16.2	17.4	33.6	President Eisenhower's illness	Political	US
22	September 1974	2.4	15.7	21.2	36.8	Franklin National	Economic	US
23	September 1998	2.3	14.9	24.4	39.2	Russian, LTCM defaults	Economic	Outside US/US
24	June 1950	2.3	14.7	17.8	32.5	Korean War	War	US
25	June 1931	2.2	14.6	38.7	53.3	President Hoover's moratorium on World War I debt payments. Aftermath of Creditanstalt's failure	Economic	US
26	August 1911	2.2	14.4	18.2	32.6	Market speculation about a railroad company (Union Pacific)	Economic	US
27	November 1963	2.2	14.3	15.0	29.4	Assassination of JFK	Terror	US
28	February 1946	2.2	14.1	19.3	33.4	Unwinding of war-time economy; strikes	Economic	US
29	July 2002	2.1	13.7	24.8	38.5	Worldcom and Enron	Economic	US
30	March 1926	2.1	13.5	17.5	31.0	Burst of 1920s' real estate bubble (notably in Florida)	Economic	US
31	February 2003	2.0	13.2	23.3	36.5	Gulf War II	War	US
32	November 1948	2.0	12.7	19.0	31.7	Truman upset presidential victory	Political	US
33	August 1919	1.9	12.6	20.3	32.9	Social tensions (strikes in railroad companies; inflation)	Economic	US
34	August 1982	1.9	12.2	20.9	33.1	Monetary cycle turning point	Economic	US
35	October 1957	1.9	12.1	17.5	29.6	Sputnik (Cold War)	War	US
36	July 1896	1.8	12.0	21.8	33.8	Market concerns over free coinage of silver; gold outflows	Economic & political	US
37	December 1916	1.8	11.9	19.6	31.5	Market concerns about US being drawn into World War I	War	US
38	September 2011	1.8	11.7	25.6	37.3	Sovereign debt crisis in Europe	Economic	Outside US
39	April 1939	1.8	11.5	26.8	38.2	Escalation of military tensions in Europe	War	Outside US
40	December 1941	1.8	11.5	20.7	32.2	Pearl Harbor surprise attack. War declaration of the US on Japan	War	US
41	December 1973	1.7	11.3	20.9	32.2	OPEC I, Arab-Israeli War	Oil	Outside US
42	November 1917	1.7	11.2	20.1	31.2	Russian revolution	Political	Outside US
43	June 1930	1.7	11.0	34.5	45.5	President Hoover signs the Smooth-Hawley Tariff Act	Economic	US

Note: the table presents an overview of the 43 large global stock market volatility shocks identified over the period 1885-2011 following the methodology of Bloom (2009). Stock market volatility shocks are defined as months when unanticipated stock market (S&P 500) volatility is significantly high, i.e. in excess of 1.65 standard deviations above the Hodrick–Prescott detrended mean of the stock-market volatility series. We use a 6-month exclusion window to avoid counting the same shock twice. The immediate reported source of the shock is identified using the *New York Times*' online archives. See Section II for further methodological details.

Table 2: Simple factor model estimates

	(1)	(2)	(3)	(4)
	Baseline	Excl. US	Incl. outliers	Incl. outliers & excl. US
Global factor	0.966***	1.074***	0.980***	1.092***
	(0.136)	(0.105)	(0.140)	(0.105)
Global factor × openness	0.003**	0.003*	0.003**	0.003*
	(0.001)	(0.001)	(0.001)	(0.001)
Regional factor	0.022	-0.080***	0.022	-0.080***
	(0.108)	(0.014)	(0.109)	(0.014)
Regional factor × reg. trade	0.008***	0.009***	0.008***	0.009***
	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.110	0.546***	-0.713***	-0.722***
	(0.316)	(0.015)	(0.013)	(0.021)
Country effects	YES	YES	YES	YES
Time effects	YES	YES	YES	YES
Observations	20,067	18,558	20,097	18,588
Number of cty	17	16	17	16
Adjusted *R*-squared	0.349	0.352	0.329	0.331
log likelihood	-58284	-53998	-59562	-55257
F-statistic	1.555	153.5	327.9	340.9
p-value	0.193	0	0	0

Note: the table reports estimates of the simple factor model of Eq. (1)-(2) with country-time varying beta loadings; fixed effects; time (5-year) effects; and robust-to-heteroskedasticity and clustered heterogeneity standard errors. The US is excluded from specifications (2) and (4) and "massive" outliers (i.e. observations for which the monthly equity market return exceeded +/- 30%, i.e. above twice the bottom/top 1%-ile of monthly returns across the sample) from specifications (3) and (4). The model is estimated over the full sample, i.e. Jan. 1885-Oct. 2011. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Decomposition model estimates (constant gamma loading)

	(1) Baseline	(2) Excl. US	(3) Incl. outliers	(4) Incl. outliers & excl. US
Shocks	-1.170***	-1.114***	-1.223***	-1.172***
	(0.128)	(0.126)	(0.134)	(0.132)
Global factor	0.982***	1.003***	0.996***	1.020***
	(0.086)	(0.095)	(0.088)	(0.096)
Global factor × openness	0.003**	0.003*	0.003**	0.003*
	(0.001)	(0.001)	(0.001)	(0.001)
Regional factor	0.021	-0.080***	0.020	-0.081***
	(0.107)	(0.013)	(0.108)	(0.013)
Regional factor × reg. trade	0.008***	0.009***	0.008***	0.009***
	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.196	0.632***	0.194	0.630***
	(0.318)	(0.014)	(0.316)	(0.021)
Country effects	YES	YES	YES	YES
Time effects	YES	YES	YES	YES
Observations	20,025	18,521	20,055	18,551
Number of cty	17	16	17	16
Adjusted R-squared	0.350	0.352	0.329	0.330
log likelihood	-58157	-53888	-59434	-55147
F-statistic	2.026	175.2	56.15	175.7
p-value	0.0844	0	5.07e-11	0

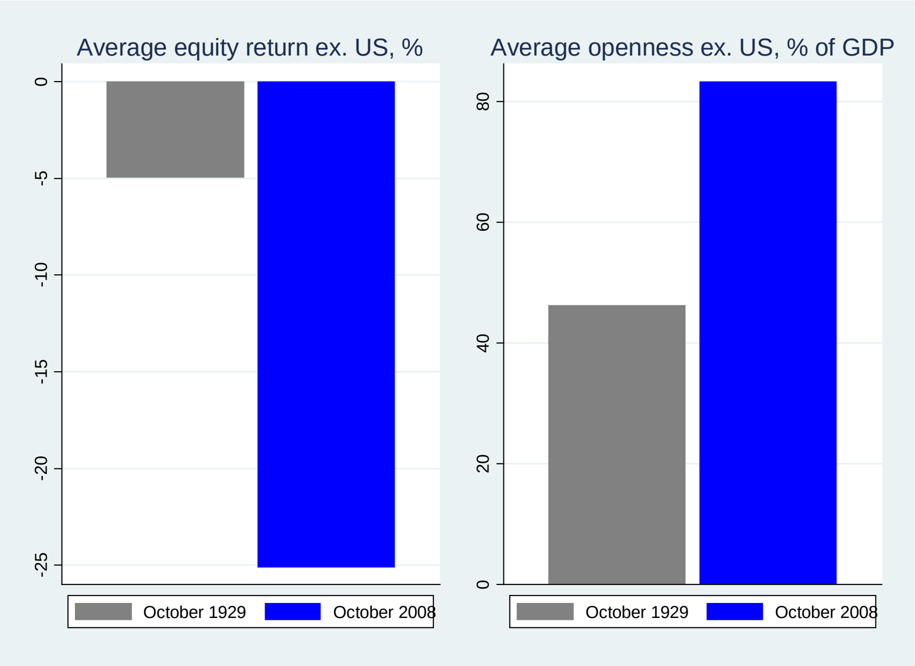
Note: the table reports estimates of the decomposition model of Eq. (1')-(2') with a constant gamma loading; fixed effects; time (5-year) effects; and robust-to-heteroskedasticity and clustered heterogeneity standard errors. The US is excluded from specifications (2) and (4) and "massive" outliers (i.e. observations for which the monthly equity market return exceeded +/- 30%, i.e. above twice the bottom/top 1%-ile of monthly returns across the sample) from specifications (3) and (4). The model is estimated over the full sample, i.e. Jan. 1885-Oct. 2011. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Decomposition model estimates (full model)

	(1) Output composition	(2) International trade linkages	(3) Country fundamentals	(4) Policy response	(5) All instruments
Shocks	-1.267***	-0.606*	-1.275***	-1.164***	-0.472
	(0.390)	(0.332)	(0.171)	(0.128)	(0.501)
Shocks × industry share/GDP	0.003				-0.009
	(0.011)				(0.011)
Shocks × Trade openness		-0.007*			-0.005*
		(0.003)			(0.003)
Shocks × Share of trade with the US		-0.013*			-0.011**
		(0.007)			(0.005)
Shocks × Growth			-0.025		-0.008
			(0.020)		(0.018)
Shocks × Inflation			0.020		0.018
			(0.028)		(0.029)
Shocks × Public debt			-0.000		-0.000
			(0.002)		(0.001)
Shocks × Trade balance/GDP			-0.027		-0.010
			(0.016)		(0.015)
Shocks × Banking crises			0.632		0.190
			(0.441)		(0.415)
Shocks × G7/G20 statements				0.024	0.031
				(0.149)	(0.159)
Global factor	0.971***	1.007***	0.967***	0.979***	0.981***
	(0.086)	(0.096)	(0.084)	(0.087)	(0.097)
Global factor × openness	0.003**	0.003*	0.003**	0.003**	0.003**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Global factor × shocks	0.007	-0.002	-0.012	0.008	-0.002
	(0.017)	(0.015)	(0.018)	(0.012)	(0.020)
Regional factor	0.021	-0.071***	0.022	0.022	-0.074***
	(0.105)	(0.019)	(0.104)	(0.105)	(0.018)
Regional factor × regional trade	0.008***	0.009***	0.008***	0.008***	0.009***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Regional factor × shocks	-0.006	-0.030	-0.008	-0.006	-0.027
	(0.026)	(0.021)	(0.024)	(0.026)	(0.020)
Country effects	YES	YES	YES	YES	YES
Time effects	YES	YES	YES	YES	YES
Instrument main effects	YES	YES	YES	YES	YES
Constant	0.208	0.450***	0.245	-0.611***	-0.967**
	(0.313)	(0.134)	(0.492)	(0.024)	(0.358)
Observations	19,236	18,510	19,269	20,001	16,978
Number of cty	17	16	17	17	16
Adjusted R-squared	0.350	0.353	0.360	0.350	0.364
log likelihood	-55969	-53827	-55803	-58073	-49334
F-statistic	4.891	175.1	1.863	205.3	40.34
p-value	0.00142	0	0.112	0	2.17e-09

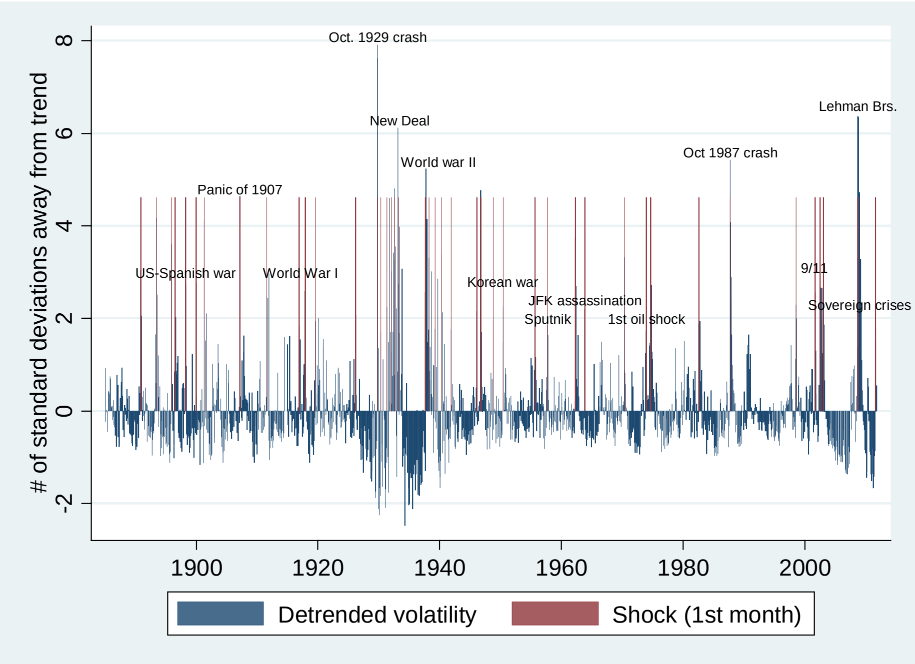
Note: the table reports the full decomposition model estimates of Eq. (1')-(2') with country-time-varying gamma loadings; fixed effects; time (5-year) effects; and robust-to-heteroskedasticity and clustered heterogeneity standard errors. The US is excluded from specifications (2) and (4) and "massive" outliers (i.e. observations for which the monthly equity market return exceeded +/- 30%, i.e. above twice the bottom/top 1%-ile of monthly returns across the sample) from specifications (3) and (4). The model is estimated over the full sample, i.e. Jan. 1885-Oct. 2011.*** p<0.01, ** p<0.05, * p<0.1.

Figure 1: Two largest global stock market volatility shocks and globalisation
(Stock market crash of 1929 vs. Lehman Brs. collapse)



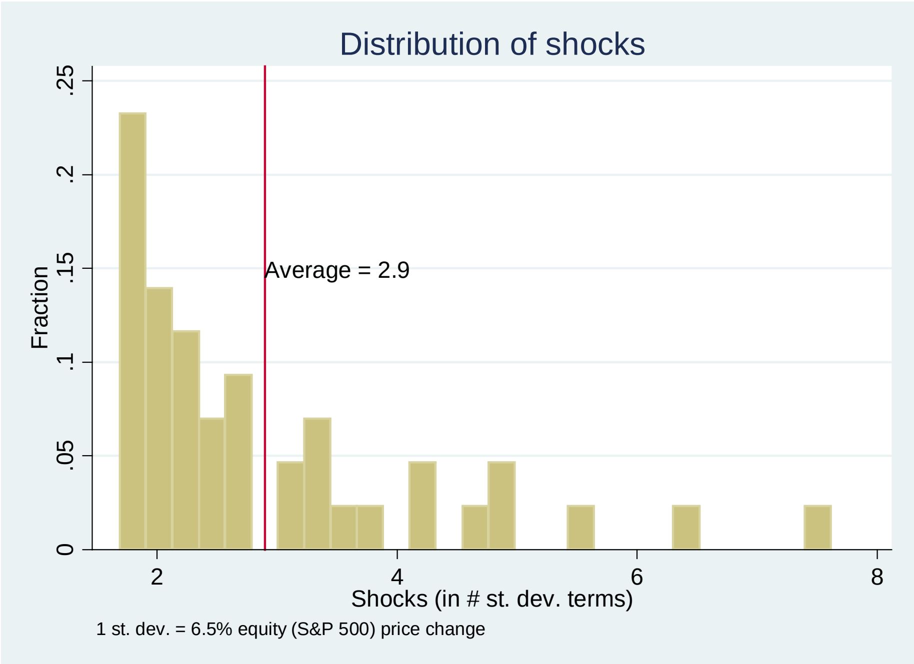
Note: the figure shows evidence on the impact of the two largest global stock market volatility shocks ever (the stock market crash of October 1929 and the collapse of Lehman Brs.) and one of their main potential international transmission channels, namely: (i) the average equity return in the month of the shock (left quadrant) and (ii) the average degree of openness in the year of the shock (right quadrant).

Figure 2: 130 years of large global stock market volatility shocks



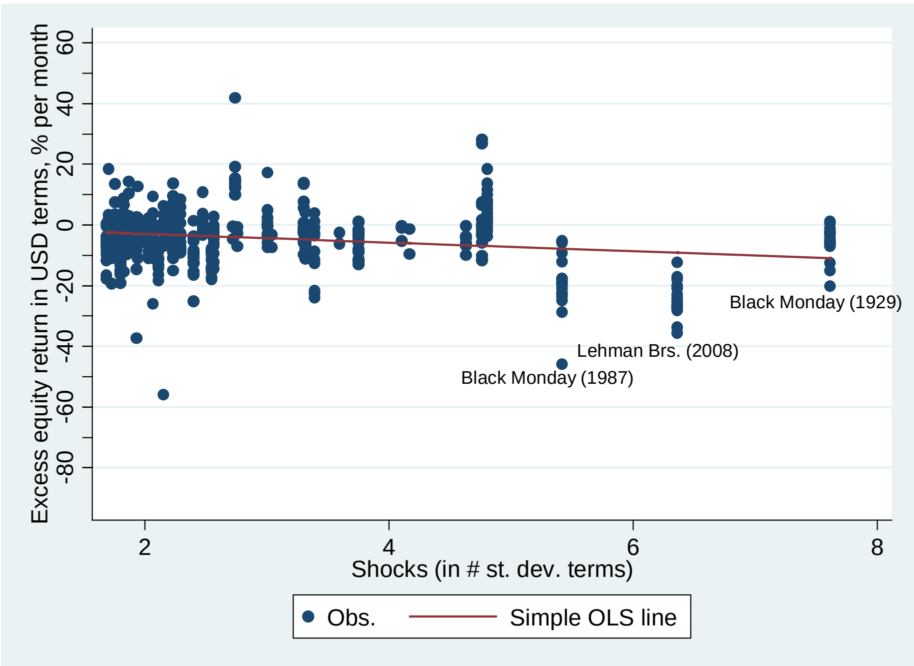
Note: the figure shows the 43 large global stock market volatility shocks identified over 1885-2011 (shown as red vertical lines), i.e. months when unanticipated stock market volatility was significantly high, i.e. in excess of 1.65 standard deviations above its mean (using a 6-month exclusion window to avoid counting the same shock twice).

Figure 3: Histogram of the large global stock market volatility shocks (full sample)



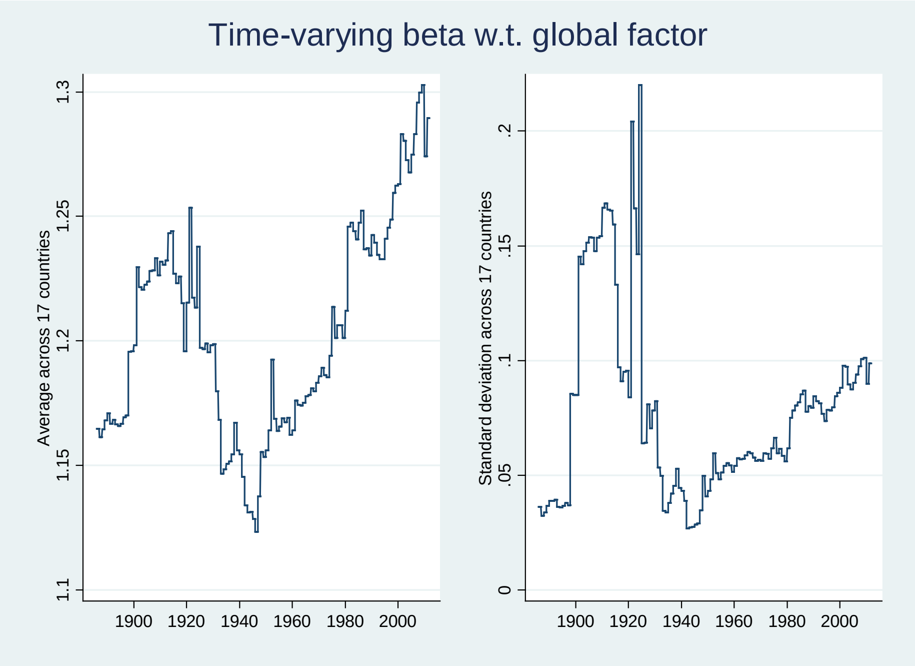
Note: the figure shows the distribution of the large global stock market volatility shocks by size, measured in terms of units of standard deviations of the unanticipated stock market (S&P 500) volatility series (with 1 standard deviation roughly equalling a 6.5% change in unanticipated volatility).

Figure 4: Large global stock market volatility shocks vs. excess equity returns (16 countries; 1885-2011)



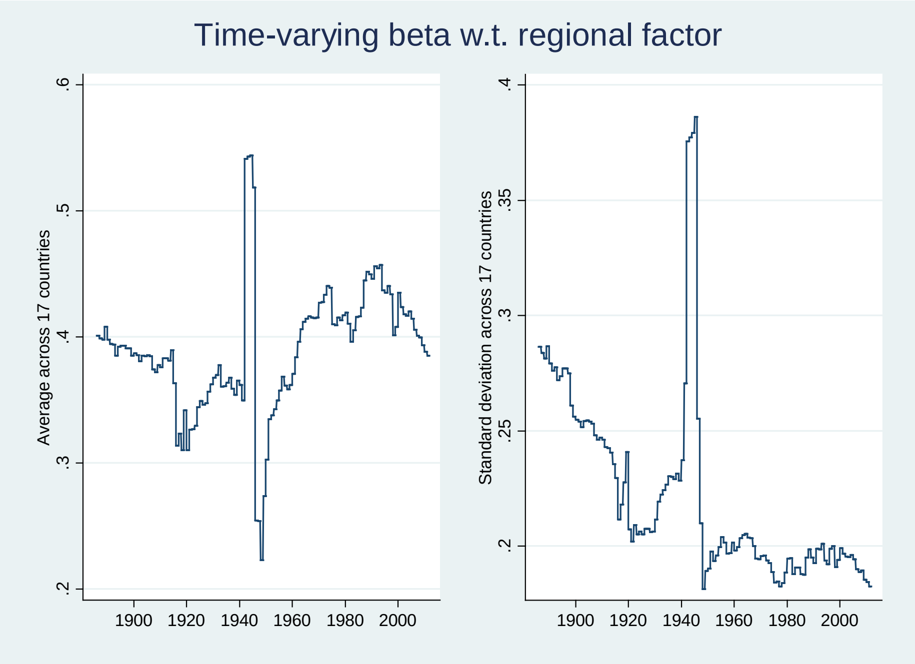
Note: The figure plots excess equity returns against the stock market volatility shocks for the full sample, where stock market volatility shocks are measured in terms of units of standard deviations of the unanticipated stock market (S&P 500) volatility series (with 1 standard deviation roughly equalling a 6.5% change in unanticipated volatility).

Figure 5: Simple factor model – Global beta estimates



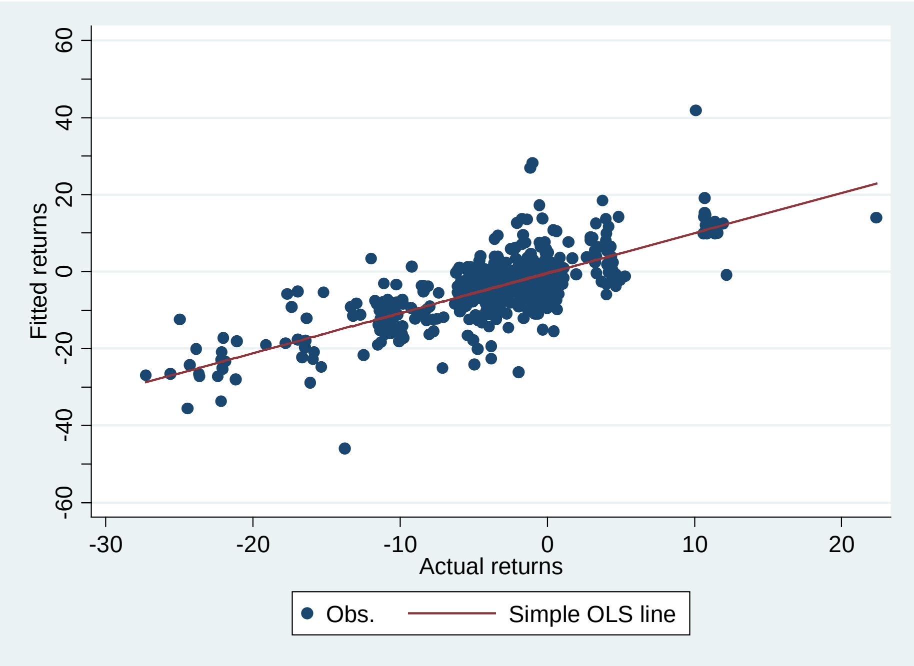
Note: The figure in the left quadrant shows the un-weighted cross-country average of the time-varying global factor loading estimates β^{glo} obtained with the simple factor model estimates of Eq.(1)-(2). The figure in the right quadrant shows the evolution of the dispersion of the global factor loadings across countries.

Figure 6: Simple factor model – Regional beta estimates



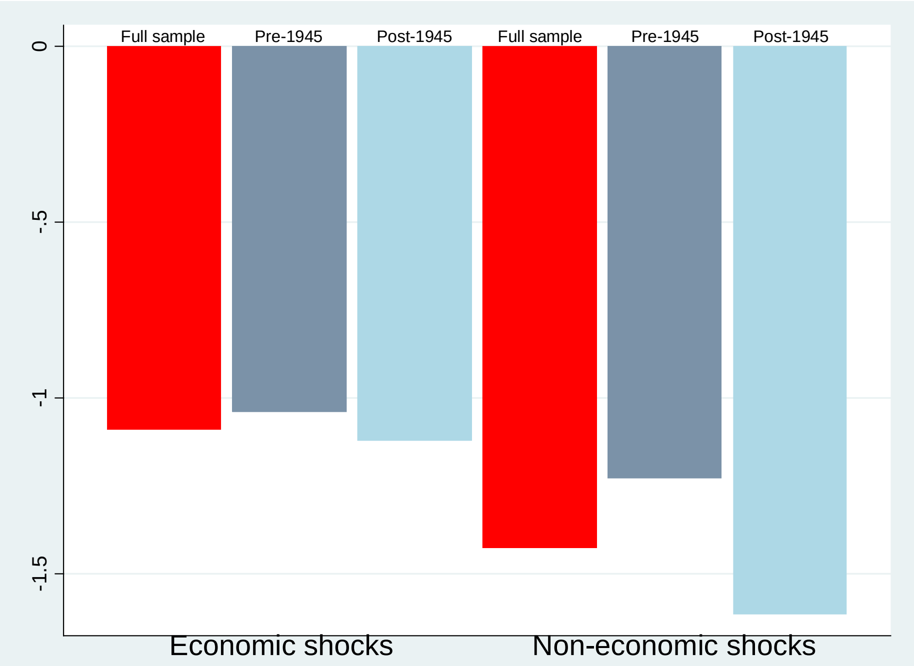
Note: The figure in the left quadrant shows the un-weighted cross-country average of the time-varying regional factor beta loading estimates β^{reg} obtained with the simple factor model of Eq.(1)-(2). The figure in the right quadrant shows the evolution of the dispersion of the global factor loadings across countries.

Figure 7: Simple factor model – Actual vs. fitted returns



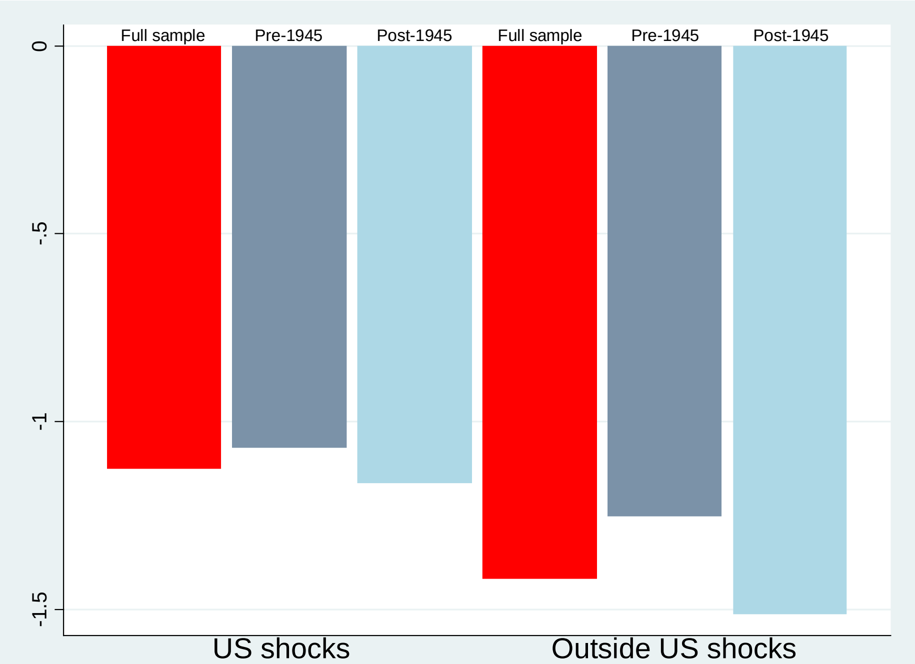
Note: The figure the plots actual equity returns in the 16 countries of my sample during the 43 major stock market volatility events that occurred between 1885 and 2011 against the fitted returns obtained with the simple factor model with time-varying beta loadings of Eq. (1)-(2).

Figure 8: Decomposition model with a constant gamma loading
(Breakdown of gamma estimates by shock type and period)



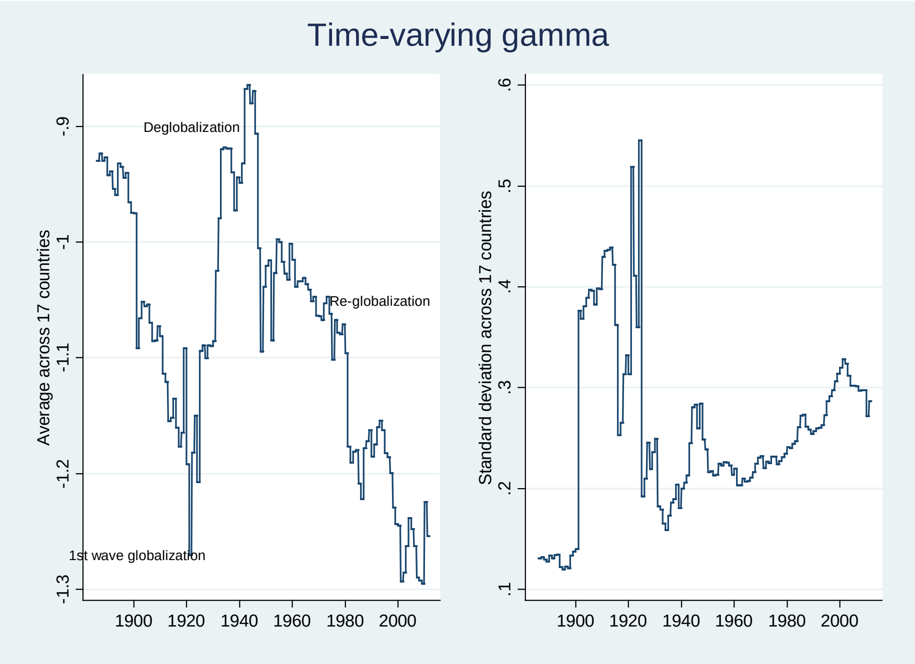
Note: the figure shows the estimated equity market return elasticity gamma to a 1-σ stock market volatility shock ($\approx$ 6.5% change in unanticipated volatility) broken down between (i) economic shocks and (iii) non-economic shocks for the full sample and three selected periods using the encompassing model of Eq. (1')-(2').

Figure 9: Decomposition model with a constant gamma loading
(Breakdown of gamma estimates by shock origin and period)



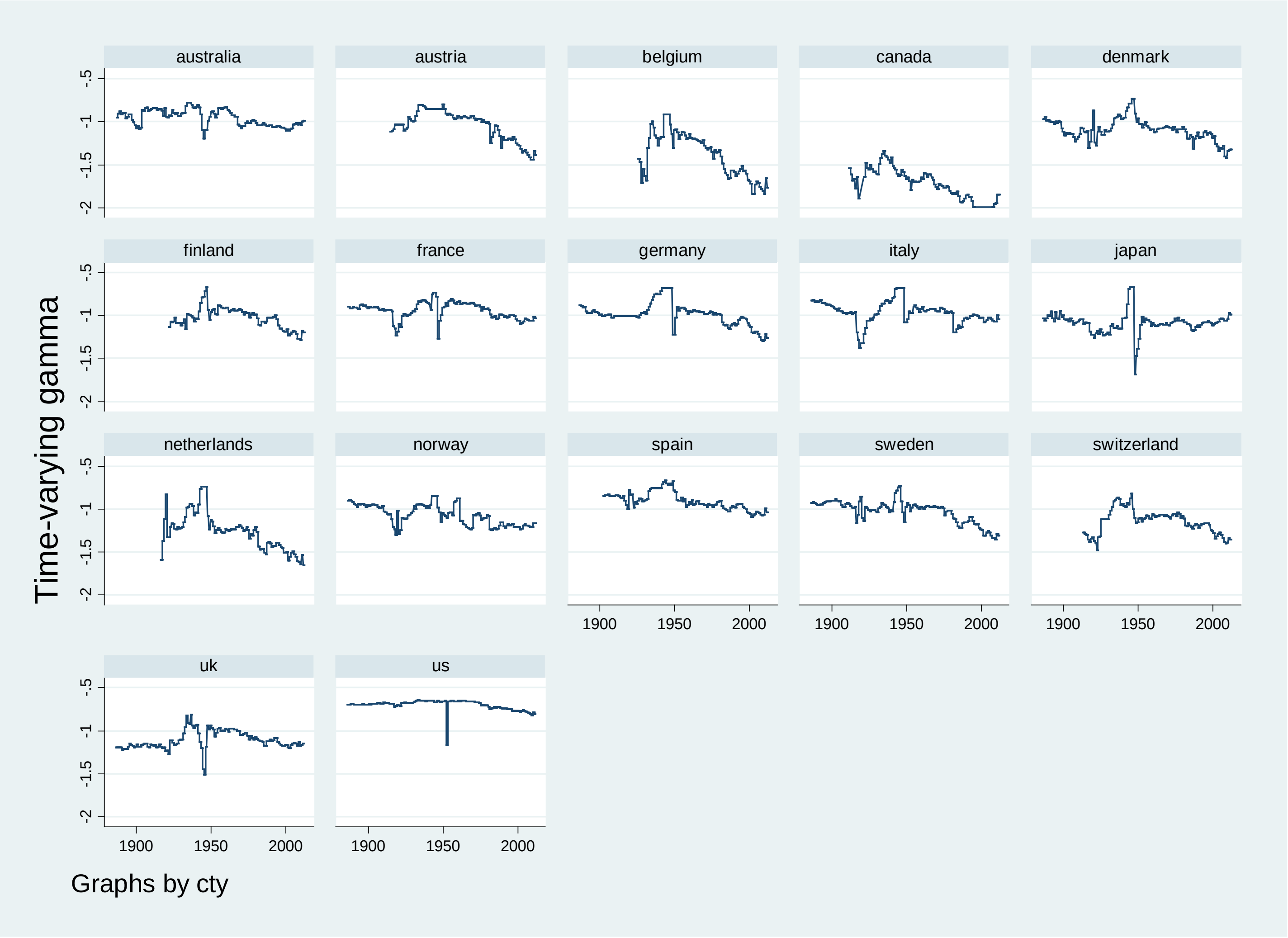
Note: the figure shows the estimated equity market return elasticity to a 1-σ stock market volatility shock (≈ 6.5% change in unanticipated volatility) broken down between (i) shocks originating in the US and (iii) common shocks originating outside the US for the full sample and three selected periods using the encompassing model of Eq. (1')-(2').

Figure 10: (Full) Decomposition model – Gamma loading estimates



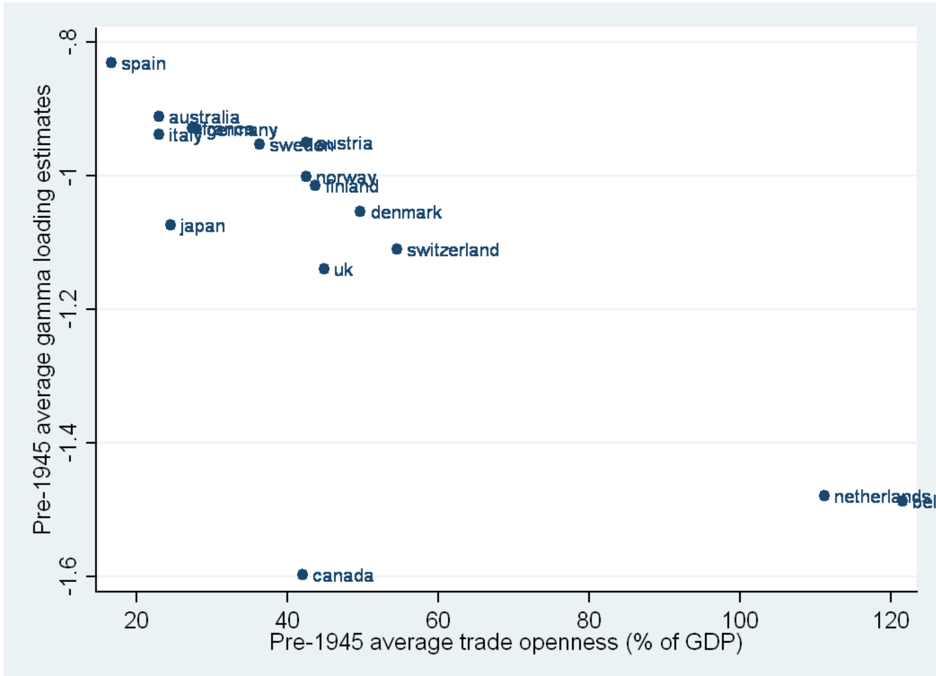
Note: The figure in the left quadrant shows the un-weighted cross-country average of the country-time-varying gamma loading estimates with the full decomposition model of Eq. (1')-(2'). The figure in the right quadrant shows the dispersion of the gamma estimates across countries at each point in time.

Figure 11: (Full) Decomposition model – Gamma loading estimates
(Breakdown by country)



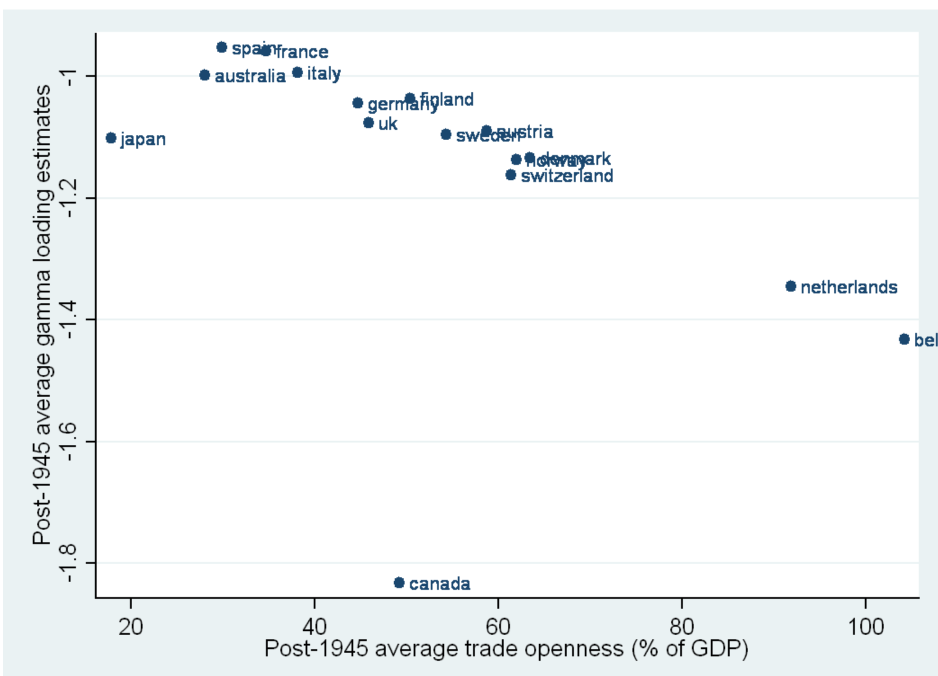
Note: The figure shows the estimated country- time-varying gamma loading estimates for each of our sample's 16 countries (and the US) obtained with the full decomposition model of Eq. (1')-(2').

Figure 12: Intensity of shock transmission vs. globalisation *(Pre-1945)*



Note: the figure plots the average conditional gamma loading estimate pre-1945 for each country of my sample obtained with the full decomposition model of Eq. (1’)-(2’) against their respective average trade openness pre-1945.

Figure 13: Intensity of shock transmission vs. globalisation *(Post-1945)*



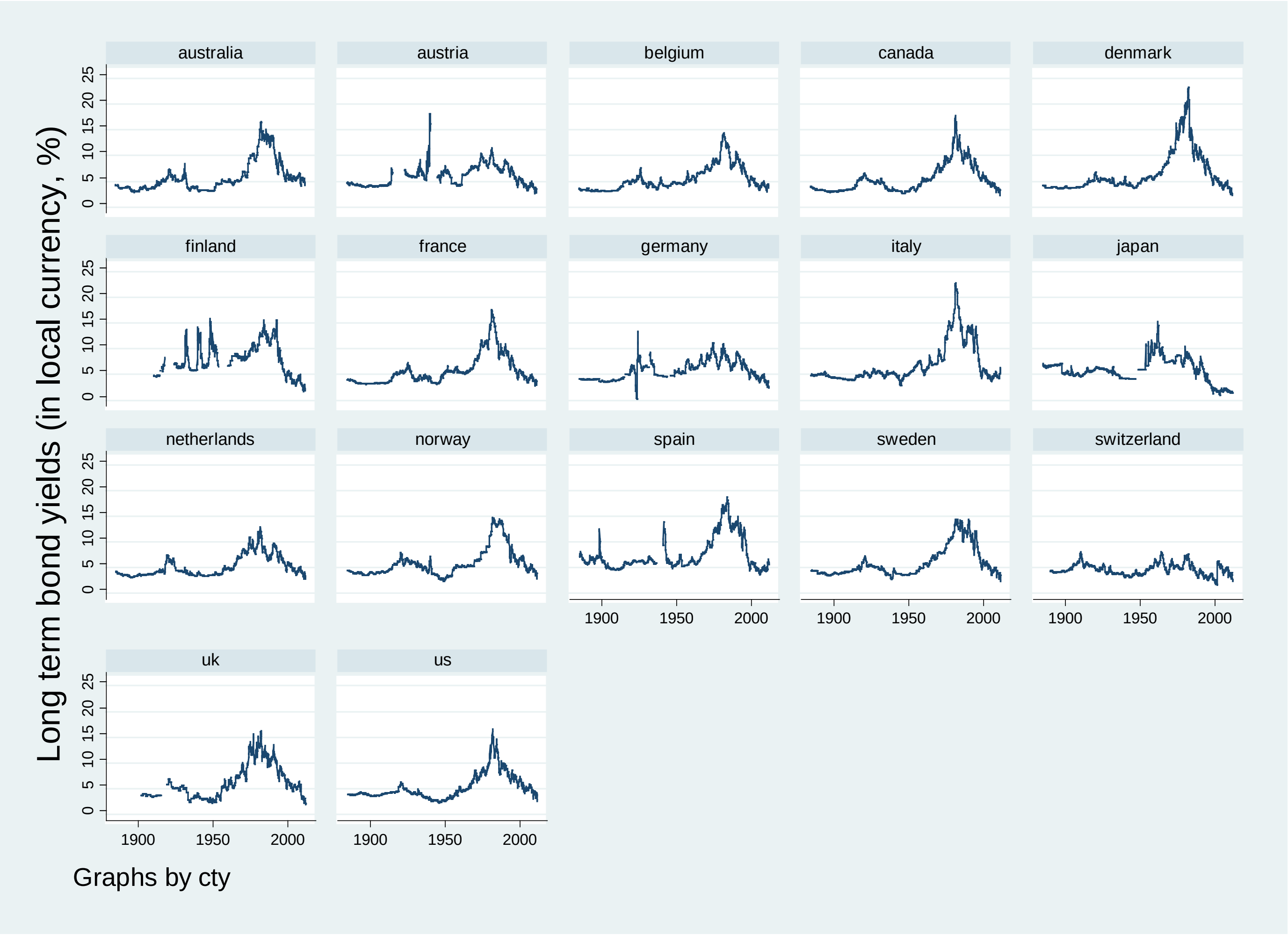
Note: the figure plots the average conditional gamma loading estimate post-1945 for each country of my sample obtained with the full decomposition model of Eq. (1’)-(2’) against their respective average trade openness post-1945.

DETACHABLE APPENDIX

Figure A1: Nominal equity prices in selected economies: 1885-2011

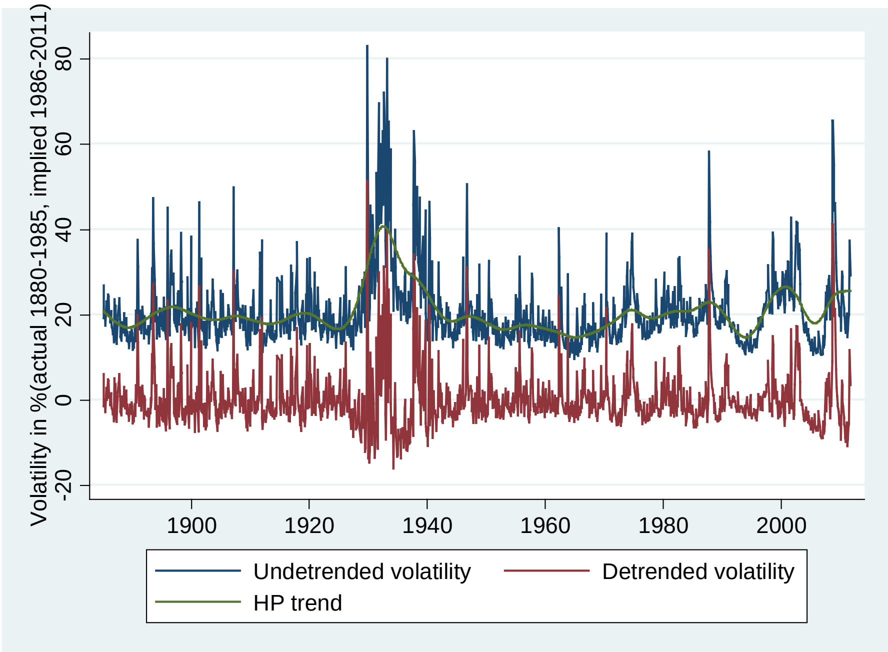
Note: the figure shows the evolution over 1885-2011 of the logarithm of the equity market indices (in nominal and local currency terms) of the 16 economies in my sample (and the US) for which data at the monthly frequency starting prior to 1922 at least are available. See Section III for further details on the data sources.

Figure A2: Nominal long-term bond yields in selected economies: 1885-2011



Note: the figure shows the evolution over 1885-2011 of the long-term bond yields (in nominal and local currency terms) of the 16 economies in my sample (and the US) for which data at the monthly frequency starting prior to 1922 at least are available. The 10-year maturity government bond yield is used for all countries, with the exception of Finland (5-year bond yield) and the United Kingdom (5-year note yield). See Section III for further details on the data sources.

Figure A3: Estimating large global stock market volatility shocks



Note: the figure shows the monthly volatility of the US equity market (S&P 500) in percent per year over 1885-2011 (using implied volatility, i.e. the VXO index, for the period 1986-2011, and realised volatility, i.e. the standard deviation of monthly returns, for the period 1885-1985). The chart also shows the long-run equity market volatility trend (estimated using a Hodrick-Prescott filter with λ = 129,600) as well as the unanticipated (detrended) component of equity market volatility, which is used to identify stock market volatility shocks.

Figure A4: Comparing two volatility measures to identify shocks

Note: the figure shows the large global uncertainty shocks identified using exactly Bloom (2009)'s methodology compared with those identified using realised volatility throughout the sample period.

Table A1: Factor orthogonalisation estimates

	(1)	(2)
Global factor		0.927***
		(0.005)
Shocks	-0.947***	-0.016
	(0.029)	(0.024)
Constant	0.079***	0.027**
	(0.015)	(0.013)
Observations	25,755	25,755
Adjusted *R*-squared	0.0406	0.565
log likelihood	-59535	-54793
F-statistic	1091	16705
p-value	0	0

Note: the table reports estimates for the orthogonalisation of the global factor (column 1) and the regional factor (column 2) as explained in section III. Standard errors are reported in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Selected examples of press articles of events reported to be at the origin of large global stock market volatility shocks[23]

March 1898: Spanish-American War

March 7, 1898

THE FINANCIAL MARKETS

Again, throughout the past week, Wall Street's whole attention has been given to the talk of war. Although the scares have been fewer, the sensationalism milder, and the apprehensions less acute, there have been fears enough to make the diplomatic crisis the dominant Wall Street factor, and to produce a nervous and erratic market in the absence of any very definite news regarding the situation.

1901: Panic of 1901

May 10, 1901

DISASTER AND RUIN IN FALLING MARKET; Panic Without a Parallel in Wall Street. LOSSES, UNTOLD MILLIONS Northern Pacific Corner Broken Too Late to Save "Shorts." BANKERS' RELIEF POOL $19,500,000 Subscribed When Money Mounted to Sixty Per Cent -- Northern Pacific Stock Went to 1,000 -- General Extent of the Crash Greater than on Black Friday.

The greatest general panic that Wall Street has ever known came upon the stock market yesterday, with the result that before it was checked many fortunes, the accumulation in some cases of years, had been completely swept away.

1917: Russian Revolution

November 9, 1917

STOCKS TUMBLE ON RUSSIAN NEWS; Flood of Liquidation Hits Exchange, Heightened by Action of Short Sellers. NEWS CHECKS BROAD RISEN. Action Considered Yet in Regard to Publishing Proportion of Short Sales. Big Sales of Steel Common. Russian Bonds Decline. STOCKS TUMBLE ON RUSSIAN NEWS Discounts News from Russia.

The stock market suffered one of the most drastic declines of the year yesterday, following the receipt of dispatches which told of the Kerensky Government's downfall.

1929: Black Thursday

October 24, 1929

PRICES OF STOCKS CRASH IN HEAVY LIQUIDATION, TOTAL DROP OF BILLIONS; PAPER LOSS $4,000,000,000 2,600,000 Shares Sold in the Final Hour in Record Decline. MANY ACCOUNTS WIPED OUT But No Brokerage House Is in Difficulties, as Margins Have Been Kept High. ORGANIZED BACKING ABSENT Bankers Confer on Steps to Support Market--Highest Break Is 96 Points. Loss in Market Values. Crash in Final Hour. Stocks Opened Strong. PRICES OF STOCKS CRASH HEAVILY Break Was Unexpected. Tickers Far Behind. No Failures Rumored. Table of Largest Declines. Curb Market Declines. PRICES SLUMP ON THE CURB. Rapid Declines Mark Final Hour, With Many Issues Affected. WHEAT TUMBLES AT CHICAGO. March Future Hits Season's Low Mark, Following Stock Slump. RESERVE STATEMENT TODAY. Bankers Differ Widely in Their Forecasts as to Loan Total.

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[23] The primary source for the press articles is the online archive of the *New York Times* as available at: http://www.nytimes.com/ref/membercenter/nytarchive.html.

Frightened by the decline in stock prices during the last month and a half, thousands of stockholders dumped their shares on the market yesterday afternoon in such an avalanche of selling as to bring about one of the widest, declines in history.

1933: President Roosevelt's inauguration and New Deal

March 16, 1933

RECORD RISE IN SHARES; $3,000,000,000 Added to Values in Day by Advance of 15%. SELLING ORDERS CANC...

Led by the New York Stock Exchange, most of the security and commodity markets in the country reopened yesterday, and investors and traders promptly showed their approval of the reconstruction program of President Roosevelt by starting one of the most emp...

1938: Anschluss of Austria by Germany

March 18, 1938

THE MARKETS

That financial markets would be thrown into great confusion by Germany's seizure of Austria, and by the subsequent rumors or conjectures regarding Germany's further attitude and the attitude of other Governments, was quite inevitable.

1941: Pearl Harbour

December 29, 1941

Partial Hardening of Market Around Week-End, After Touching Lowest of 1941

Until last week there had been little check to the decline which started with the Japanese attack on Pearl Harbor, on Sunday, Dec. 7. From, the highest of the month, THE TIMES'S stock average had declined 9 points at the beginning of last week, and the bond average had lost about 2 points in a few days after outbreak of war in Hawaii.

1950: Korean War

June 28, 1950

Stocks Rally After Big New Losses In War Scare; Sales Near 5 Million; STOCKS HERE RALLY AFTER NEW LOSSES STOCKS HERE RALLY AFTER NEW LOSSES Prices Firm Up on Coast

Securities markets the world over were subjected yesterday to wide fluctuations as the Korean situation approached a crisis of universal concern.

1957: Sputnik

October 8, 1957

INVESTORS BUYING STOCK IN MISSILES; Soviet Success Puts Market on Defense--Some Issues Plunge to 2-Year Low

The Soviet Union's successful earth satellite put Wall Street investors on the defensive yesterday.