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How Strongly are Business Cycles and Financial Cycles Linked in the G7 Countries

Nikolaos Antonakakis*† Max Breitenlechner‡ Johann Scharler§

March 9, 2014

Abstract

In this study we examine the dynamic interactions between credit growth and output growth using the spillover index approach of Diebold and Yilmaz (2012). Based on quarterly data on credit growth and GDP growth over the period 1957Q1–2012Q4 for the G7 countries we find that: i) spillovers between credit growth and GDP growth evolve rather heterogeneously over time and across countries, and increase during extreme economic events. ii) Spillovers between credit growth and GDP growth are of bidirectional nature, indicating bidirectional causation between the financial and real sectors. iii) In the period shorty before and on the onset of the global financial crisis, the link between credit growth and GDP growth becomes more pronounced. In particular, the financial sector plays a dominant role during the early stages of the crisis, while the real sector quickly takes over as the dominant source of spillovers. iv) Interestingly, credit growth in the US is the dominant transmitter of shocks internationally, and especially to other countries' real sectors in the run up period to (and during) the global financial crisis. Overall, our results suggest feedback effects between the financial and the real sectors that create rippling effects within and between the G7 countries during the global financial crisis.

Keywords: Business cycles; Financial cycles; Spillovers; Crisis; Recession

JEL codes: C32; E32; E44; E51; F42

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1 Introduction

The view that macroeconomic and financial sector developments are closely interrelated has a long tradition and has received renewed interest in the aftermath of the 2008 - 2009 crisis. An extensive literature studies the implications of financial frictions for the business cycle and the interrelationship between the financial sector and real economic activity.[1] Empirically, Schularick and Taylor (2012) show that credit growth is a predictor of financial crisis.[2] Recessions which are associated with financial disruptions are generally deeper and last longer (see also Claessens et al., 2012; Jordà et al., 2013).[3]

The purpose of this paper is to provide a characterization of the time-varying relationship between real credit growth and real GDP growth at business cycle frequencies for each of the G7 countries. To do so, we apply the VAR-based spillover index approach recently introduced by Diebold and Yilmaz (2009, 2012). This methodology allows us to decompose spillovers into those coming from (or to) a particular source (variable) and thus, to identify the main recipients and transmitters of shocks. The spillover methodology which was originally applied to study the interaction between asset returns (Diebold and Yilmaz, 2009, 2012), has already attracted significant attention and has been applied successfully to exchange rates (McMillan and Speight, 2010; Bubák et al., 2011; Antonakakis, 2012), equity markets (Yilmaz, 2010; Zhou et al., 2012), sovereign bond yield spreads (Antonakakis and Vergos, 2013), business cycles, growth and volatility spillovers (Yilmaz, 2009; Antonakakis and Badinger, 2012), and money supply and asset markets spillovers (Cronin, 2013).

In line with Koop et al. (1996), Pesaran and Shin (1998) and Diebold and Yilmaz (2012), our analysis is based on a generalized vector autoregressive framework, in which forecast-error variance decompositions are invariant to the ordering of the variables.[4] In the context of the present study, this is particularly important since it is hard, if not impossible, to justify one particular causal ordering of the variables. Theoretical as well as empirical contributions suggest that credit growth and changes in real economic activity are strongly intertwined with causality

[1]See for example, Bernanke et al. (1996, 1999), Bernanke and Gertler (1989), Kiyotaki and Moore (1997), Fostel and Geanakoplos (2008), Brunnermeier (2009); Brunnermeier and Pedersen (2009), Gertler and Kiyotaki (2010), and Jermann and Quadrini (2012) among many others.

[2]Mendoza and Terrones (2008) and Gourinchas and Obstfeld (2011) provide similar studies with empirical evidence pointing in the same direction. See also Martin and Rey (2006) for international aspects.

[3]A related, although somewhat distinctive branch of the literature studies the impact of structural credit supply shocks on the business cycle (see for example Buch and Neugebauer, 2011; Helbling et al., 2011; Peersman, 2011; Gambetti and Musso, 2012; Meeks, 2012; Hristov et al., 2012).

[4]In contrast to a Cholesky-factor identification, which was originally used in the spillover analysis (see Diebold and Yilmaz, 2009)

potentially running in both directions.

Of course, the generalized VAR framework has advantages as well as drawbacks. A disadvantage is that it aggravates the identification of causal effects in a strict sense in the impulse response analysis. Nevertheless, by fully accounting for the pattern of observed correlation between shocks it increases the relevance from a policy perspective in light of the increased synchronization of shocks between credit growth and the business cycle.

We find that the strength of spillover effects between credit growth and real GDP growth varies strongly across the G7 countries and over time. While Germany, Japan and the US exhibit reasonablly high spillover effects between credit growth and output growth with around 20 percent in total and with approximately 30 percent between financial and real sectors, Canada, France, Italy and the UK are characterized by total spillover effects of below 10 percent. However, credit growth is as much a sender as it is a receiver of spillovers in each country. We also find that spillovers increase during recession periods. Finally, the analysis of spillover effects among the G7 economies identifies the US as a transmitter of credit shocks before and during the global financial crisis.

The remainder of the paper is organized as follows. Section 2 discusses the application of the spillover index approach to disentangle the intricate relationships between credit growth and GDP growth and describes the data used. Section 3 presents the empirical findings. Section 4 summarizes the results and concludes this study.

2 Empirical Methodology and Data

2.1 Measuring Spillovers

The spillover index approach introduced by Diebold and Yilmaz (2009) builds on the seminal work on VAR models by Sims (1980) and the well-known notion of variance decompositions. This approach allows an assessment of the contributions of shocks to variables to the forecast error variances of both the respective and the other variables of the model. Using rolling-window estimation, the evolution of spillover effects can be traced over time and illustrated by spillover plots. For the purpose of the present study, we use the variant of the spillover index in Diebold and Yilmaz (2012), which extends and generalizes the methodology introduced in Diebold and Yilmaz (2009).

The starting point for the analysis is the following P-th order, K-variable VAR

$$y_t = \sum_{p=1}^{P} \Theta_i y_{t-i} + \varepsilon_t \tag{1}$$

where $y_t = (y_{1t}, y_{2t}, \ldots, y_{Kt})$ is a vector of K endogenous variables, $\Theta_i, i = 1, ..., P$, are $K \times K$ parameter matrices and $\varepsilon_t \sim (0, \Sigma)$ is vector of disturbances that are independently distributed over time; $t = 1, ..., T$ is the time index and $k = 1, ..., K$ is the variable index.

Key to the dynamics of the system is the moving average representation of model (1), which is given by $y_t = \sum_{j=0}^{\infty} A_j \varepsilon_{t-j}$, where the $K \times K$ coefficient matrices A_j are recursively defined as $A_j = \Theta_1 A_{j-1} + \Theta_2 A_{j-2} + \ldots + \Theta_p A_{j-p}$, where A_0 is the $K \times K$ identity matrix and $A_j = 0$ for $j < 0$.

Following Diebold and Yilmaz (2012) we use the generalized VAR framework of Koop et al. (1996) and Pesaran and Shin (1998), which produces variance decompositions invariant to the variable ordering. According to this framework, the H-step-ahead forecast error variance decomposition is

$$\phi_{ij}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \Sigma A_h' e_i)}, \tag{2}$$

where Σ is the (estimated) variance matrix of the error vector ε, σ_{jj} the (estimated) standard deviation of the error term for the j-th equation and e_i a selection vector with one as the i-th element and zeros otherwise. This yields a $K \times K$ matrix $\phi(H) = [\phi_{ij}(H)]_{i,j=1,\ldots K}$, where each entry gives the contribution of variable j to the forecast error variance of variable i. The main diagonal elements contains the (own) contributions of shocks to the variable i to its own forecast error variance, the off-diagonal elements show the (cross) contributions of the other variables j to the forecast error variance of variable i.

Since the own and cross-variable variance contribution shares do not sum to one under the generalized decomposition, i.e., $\sum_{j=1}^{K} \phi_{ij}(H) \neq 1$, each entry of the variance decomposition matrix is normalized by its row sum, such that

$$\tilde{\phi}_{ij}(H) = \frac{\phi_{ij}(H)}{\sum_{j=1}^{K} \phi_{ij}(H)} \tag{3}$$

with $\sum_{j=1}^{K} \tilde{\phi}_{ij}(H) = 1$ and $\sum_{i,j=1}^{K} \tilde{\phi}_{ij}(H) = K$ by construction.

This ultimately allows to define a total (volatility) spillover index, which is given by

$$TS(H) = \frac{\sum_{i,j=1, i\neq j}^{K} \tilde{\phi}_{ij}(H)}{\sum_{i,j=1}^{K} \tilde{\phi}_{ij}(H)} \times 100 = \frac{\sum_{i,j=1, i\neq j}^{K} \tilde{\phi}_{ij}(H)}{K} \times 100 \tag{4}$$

which gives the average contribution of spillovers from shocks to all (other) variables to the total forecast error variance.

This approach is quite flexible and allows to obtain a more differentiated picture by considering directional spillovers: Specifically, the directional spillovers received by variable i from all other variables j are defined as

$$DS_{i \leftarrow j}(H) = \frac{\sum_{j=1, j \neq i}^{K} \tilde{\phi}_{ij}(H)}{\sum_{i,j=1}^{K} \tilde{\phi}_{ij}(H)} \times 100 = \frac{\sum_{j=1, j \neq i}^{K} \tilde{\phi}_{ij}(H)}{K} \times 100 \tag{5}$$

and the directional spillovers transmitted by variable i to all other variables j as

$$DS_{i \rightarrow j}(H) = \frac{\sum_{j=1, j \neq i}^{K} \tilde{\phi}_{ji}(H)}{\sum_{i,j=1}^{K} \tilde{\phi}_{ji}(H)} \times 100 = \frac{\sum_{j=1, j \neq i}^{K} \tilde{\phi}_{ji}(H)}{K} \times 100. \tag{6}$$

Notice that the set of directional spillovers provides a decomposition of total spillovers into those coming from (or to) a particular source.

By subtracting Equation (5) from Equation (6) the net spillover from variable i to all other variables j are obtained as

$$NS_i(H) = DS_{i \rightarrow j}(H) - DS_{i \leftarrow j}(H), \tag{7}$$

providing information on whether a country (variable) is a receiver or transmitter of shocks in net terms. Put differently, Equation (7) provides summary information about how much each market contributes to the volatility in other markets, in net terms.

Overall, the spillover index approach provides measures of the intensity of interdependence across countries and variables and allows a decomposition of spillover effects by source and recipient.

2.2 Data description

We collect quarterly data on domestic credit, Gross Domestic Product (GDP) and GDP deflator for the G7 countries over the period 1957Q1-2012Q4 from the International Financial Statistics database (IFS) of the International Monetary Fund (IMF).[5] The values of all variables are taken at the start of each quarter. Domestic credit is defined as total claims of banks with national residency. To obtain the maximum length for each country we combine the tow series "Domestic Credit" and "Domestic Claims" from the IFS dataset. See Table 1 for specific data availability in each country and a detailed list of each variable and its data source (including all specific table codes).

[Insert Table 1 about here]

[5] Only for Canada's domestic credit, we preferred to use data from the Statistics Canada instead. This decision was mainly driven by the fact that: i) the IFS credit series for Canada ends already in 2008Q4 and ii) in 2001Q4 the series jumps significantly to due changes in the definition of the variable (Canada adopted the IMF's "Monetary and Financial Statistics Manual 2000" in 2001).

We then deflate the credit and GDP series by the GDP deflator to obtain their real counterparts. Finally, we take the fourth differences of the natural logarithms of real credit and real GDP so as to obtain annual real credit growth rates and real GDP growth rates, respectively.[6]

Descriptive statistics on annual real credit growth and real GDP growth rates are presented in Table 2. The UK experienced the highest rate of real credit growth (56.39 percent) in the sample. Equivalently, Japan exhibits the highest growth rate of real GDP (15.39 percent). The countries' averages of real credit and real GDP growth lie within [3.46, 7.28] percent and [1.33, 4.35] percent, respectively. The range as well as the relatively high standard deviations across countries reveal a substantial variation within the variables.

[Insert Table 2 about here]

3 Results

3.1 Spillovers between Credit Growth and Output Growth within countries

In Table 3 we report the estimates of the spillover indices for each country based on 12-quarters ahead forecast error variance decompositions.[7] For each country, the ij-th entry, where i and j denote credit growth or output growth, is the estimated contribution to the forecast error variance of variable i coming from innovations to variable j. Hence, the diagonal elements ($i = j$) measure own-variable spillovers of output growth and credit growth within countries, while the off-diagonal elements ($i \neq j$) capture cross-variable spillovers between output growth and credit growth. The total volatility spillover index defined in Equation (4) is approximately equal to the grand off-diagonal entry relative to the column sum including diagonals (or row sum including diagonals), expressed in percentage points.

[Insert Table 3 here]

Summarizing the information in Table 3, we see that the strength of spillovers between credit growth and output growth is rather heterogeneous across countries. Total spillovers are relatively high in Germany, Japan and in the US with total spillover indices of 36.5 percent, and 25 percent and 21.8 percent respectively. In contrast, in the UK (7.7 percent) and Canada (7.6 percent) total spillovers are relatively low suggesting that credit growth and the business cycle

[6] We have also explored the robustness of our results based on the Hodrick–Prescott filtered series of the real credit and real GDP and our results are very similar to those presented below.

[7] The lag–lenght of the VAR specifications is based on the Akaike Information Critetion (AIC).

are not as closely linked. In France and Italy the estimated values for the total spillover index are slightly higher with 9.7 percent and 9.4 percent, respectively.

Turning to the directional spillovers we see that countries with high total spillovers also have relatively high spillovers from credit growth to output growth ranging from 22.1 percent in Japan to 31.8 percent in Germany. In the US, credit growth contributes 27.8 percent to fluctuations in output growth. While these spillovers are quantitatively sizable, we also see that spillovers originating in the real sector of the economy have a substantial impact on the dynamics of credit with directional spillover indices of 15.8 percent in the US, 27.9 percent in Japan and 42.3 percent in Germany. In the remaining countries in our sample, directional spillovers are generally low with estimated directional spillover indices below 10 percent, expect for spillovers from output growth to credit growth in Italy, where the spillover index is 14.4 percent.

Overall, we see that, throughout the countries in our sample, credit growth is as much a sender as it is a receiver of spillovers indicating bidirectional causality between the financial and the real sector.

Although the use of an average measure of financial and business cycle spillovers provides a good indication of the financial and business cycle transmission mechanism, it might mask interesting information on movements in spillovers due to secular features of financial and business cycles. Hence, we are very interested in examining how spillovers evolve over time. To achieve that, we estimate the model in Equation (1) using 50-quarter rolling windows and obtain the variance decompositions and spillover indices.[8] Figure 1 plots the time-varying total spillover indices for each country in our sample, based on rolling window estimation.

[Insert Figure 1 here]

In Germany and the US, which are characterized by relatively high spillovers according to Table 3, we observe that, despite some fluctuations, total spillover indices are persistently high throughout the sample. In Japan, which according to Table 3 also has relatively high total spillovers, when we take the full sample into account, we see that total spillovers decline since around 2000 and amount to around 10 percent towards the end of the sample. Similarly, total spillovers also decline in Canada in the mid 1990s.

The most striking observation is, however, that around the onset of the recent financial crisis the total spillover indices increase in all countries with the exception of Japan. Thus,

[8] We have also experimented using alternative n-quarter rolling windows (such as 30, 40 and 60 quarters) and our conclusions reached have not been affected.

the link between the business cycle and credit growth becomes exceptionally pronounced during this period, suggesting that the financial sector was exceptionally strongly involved in the last recession.

Figure 2 shows the time varying net directional spillovers from credit growth to real GDP growth.

[Insert Figure 2 here]

In Canada, net spillovers are strongly positive in the 1980s and fluctuate around zero afterwards. In France and Germany, we observe mostly positive net spillovers until the late 2000s, whereas Italy is characterized by negative spillovers, expect a brief period in the mid 2000s. Net spillovers are negative in Japan since the early 1990s and turned into positive only recently. In the US we observe a similar pattern, although the increase in net spillovers is substantially more pronounced. And in the UK, net spillovers frequently change sign.

Recall that total spillovers increase strongly before and during the last recession in almost all countries. Looking at the time–varying net spillovers, we can identify explicitly the relationship between credit growth and output growth during this period. Conventional wisdom holds that the financial sector was a major driving force during the financial crisis in the US and the subsequent global downturn. In line with this view, we find that credit growth becomes a net transmitter in the US since the mid 2000s. Similarly, net spillovers turn positive in Japan towards the end of the sample. In Germany and Italy, credit growth is the dominant transmitter briefly during the onset of the global financial crisis, but net spillovers turn negative, indicating that through most of the crisis period, bank credit followed real economic developments in these countries. This observation is also true in Canada and, to a stronger extent, in France. In the UK, the pattern is less clear since net spillovers changed signs frequently.

Thus, in most countries, the financial sector played a dominant role during early stages, while the real sector quickly took over as the dominant source of spillovers.

3.2 Spillovers across Countries

To examine whether credit expansions and contractions in one country spill over into other countries' real and financial sectors we now look at spillovers across countries. As it seems plausible that credit market conditions in one country can influence not only credit in other countries but also their growth rate of output, we estimate a VAR with credit growth and output growth variables for each countries. Again, we drop Italy due to the limited data availability. Based on a twelve–variable VAR, we then again conduct the spillover analysis. Table 4 presents these results. The total spillover index which receives a value of 48 percent shows that international spillovers appear to be quantitatively pronounced on average. More importantly, credit growth in the US is the dominant transmitter of shocks internationally, and especially to other countries' real sectors, followed by credit growth in Japan. For instance, innovations to credit growth in the United States explain 29.2%, 20.1%, 15.8%, 14.1% and 6.8% of the 12-quarter forecast error variance of output growth in Canada, UK, Germany, France and Japan, respectively. In addition, innovations to credit growth in the United States explain 1.6%, 1.9%, 0.9%, 0.6% and 2.1% of the 12-quarter forecast error variance of credit growth in the aforementioned countries, respectively. These results are in line with Helbling et al. (2011), who find adverse effects of US credit shocks on the business cycles of the G7 countries during the recent financial crisis. In addition, our results suggest that, US credit growth was responsible for the magnification of spillovers within and between countries' real and (to lesser extend) financial sectors.

[Insert Table 4 here]

Turning our attention to the evolution of total spillovers of credit growth and real GDP growth across the G6 countries over time, we observe according to Figure 3 that total spillovers are considerably high and become exceptionally pronounced, reaching a peak during extreme economic events, such as the 1987 stock market crash, the Asian crisis and the Great Recession of 2007–2009. This result is consistent with the studies from Claessens et al. (2012) and Jordà et al. (2013), which indicate a mutually negative influence of financial turmoil and economic recessions.

[Insert Figure 3 here]

Figure 4 shows the time–varying net directional spillovers from credit growth and real GDP growth across the G6 countries.

[Insert Figure 4 here]

Overall, the results are very revealing, when we consider the link of credit growth and GDP growth spillovers across countries and (financial and real) sectors simultaneously. In particular, the dominance of the credit growth spillovers in net terms becomes extremely less pronounced across countries and sectors, with the only exception of Japan, wherein net spillovers from credit growth during the Asian crisis reached around 50%. Interestingly, the US was a net receiver of credit growth spillovers till the beginning of 2000 and became a net transmitter of credit growth shocks in the run up to (and during) the global financial crisis and until 2010. After 2010, US GDP growth spillovers in net terms became the dominant factors of contagion and magnification of shocks, thus gaining particular importance in the simultaneous feedback effects across countries' real and financial sectors. This suggest that credit growth in the US since the 2000s might have contributed to the 2007–2009 global financial crisis. The shock in the financial sector was then transmitted to the real sector which was then fed back to the financial sector creating rippling effects within and between the G7 countries.

4 Conclusions

In this paper, we study the time-varying relationship between credit growth and real GDP growth at business cycle frequencies for each of the G7 countries using the spillover index of Diebold and Yilmaz (2009, 2012) and which is the main contribution of this study. In particular, we adopt the generalized identification scheme of Diebold and Yilmaz (2012) to address the potential bidirectional causation between credit growth and output growth.

We find several stylized facts, which are consistent with the existing research. Firstly, the link between credit growth and real GDP growth particularly tightens during crises periods. This result is consistent with the studies from Claessens et al. (2012) and Jordà et al. (2013), which indicate a mutually negative influence of financial turmoil and economic recessions. Our analysis reveals that during such periods, spillovers increase between sectors and also among countries. Secondly, credit growth is as much a sender as it is a receiver of spillover shocks, confirming the bidirectional causation between the two sectors. Thirdly, credit growth in the US is a dominant international transmitter of shocks and especially to other countries real sectors. This pattern is most prominent during the last global financial crisis. Similarly, Helbling et al. (2011) detect adverse effects of US credit shocks on the business cycles of the G7 countries during the recent financial crisis.

Furthermore, the time–varying analysis of the net spillover effects reveals that in the run up of the crisis, credit growth is a transmitter of spillover shocks in most of the countries in our sample. However, with the start of the crisis, shocks of real GDP growth become relative more important. Except in the US, where the financial sector is a permanent transmitter of net spillovers within the US and across the G6 economies.

Finally, the strength and direction of spillover effects evolves rather heterogonously across countries. In particular, we find one group of countries with especially high spillover effects (Germany, Japan and the US), and on the other hand, countries (Canada, France, Italy and the UK) with a relative weaker link between the financial sector and the real sector.

Future research along these lines is thus called for so as to clarify these particular differences in the dynamic evolution of spillovers between credit cycles and business cycles.

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Table 1: Data availability and sources

Country	Variable	Data Availability	Source	Table Code
CAN	Credit	1957Q1-2012Q4	Statistics Canada	176-0015
	GDP	1957Q1-2012Q4	IMF-IFS	156"99BAC"Q
	GDP_def	1957Q1-2012Q4	IMF-IFS	156"99BIR"Q
FRA	Credit	1957Q1-2012Q4	IMF-IFS	132"32"Q
	GDP	1970Q1-2012Q3	IMF-IFS	132"99B_C"Q
	GDP_def	1970Q1-2012Q3	IMF-IFS	132"BIR"Q
GER	Credit	1957Q1-2012Q4	IMF-IFS	134"32"Q
	GDP	1960Q1-2012Q3	IMF-IFS	134"99B_C"Q
	GDP_def	1960Q1-2012Q3	IMF-IFS	134"BIR"Q
ITA	Credit	1970Q1-2012Q4	IMF-IFS	136"32"Q
	GDP	1980Q1-2012Q4	IMF-IFS	136"99B_C"Q
	GDP_def	1980Q1-2012Q4	IMF-IFS	136"BIR"Q
JAP	Credit	1957Q1-2012Q4	IMF-IFS	158"32"Q
	GDP	1957Q1-2012Q4	IMF-IFS	158"99BAC"Q
	GDP_def	1957Q1-2012Q4	IMF-IFS	158"99BIR"Q
UK	Credit	1959Q1-2012Q4	IMF-IFS	112"32"Q
	GDP	1957Q1-2012Q4	IMF-IFS	112"99B_C"Q
	GDP_def	1957Q1-2012Q4	IMF-IFS	112"99BIR"Q
USA	Credit	1957Q1-2012Q4	IMF-IFS	111"32"Q
	GDP	1957Q1-2012Q4	IMF-IFS	111"99BAC"Q
	GDP_def	1957Q1-2012Q4	IMF-IFS	111"99BIR"Q

Note: GDP is seasonally adjusted; the base year of the GDP deflator is 2005. For Canada's domestic credit a different data source is used, because (i) the IFS series ends already in 2008Q4 and (ii) in 2001Q4 the series jumps significantly due to a change in the definition of the indicator (Canada adopted the IMF's "Monetary and Financial Statistics Manual 2000" in 2001).

Table 2: Descriptive statistics

	CAN		FRA		GER		ITA		JPN		UK		US	
	RCRgr	RGDPgr	RCRgr	RGDPgr	RCRgr	RGDPgr	RCRgr	RGDPgr	RCRgr	RGDPgr	RCRgr	RGDPgr	RCRgr	RGDPgr
Mean	0.0571	0.0323	0.0506	0.0218	0.0482	0.0243	0.0346	0.0133	0.0728	0.0435	0.0529	0.0232	0.0404	0.0301
Std	0.0402	0.0230	0.0804	0.0182	0.0432	0.0248	0.0402	0.0215	0.0881	0.0430	0.1025	0.0227	0.0317	0.0244
Min	-0.0659	-0.0385	-0.0420	-0.0437	-0.0535	-0.0711	-0.0412	-0.0725	-0.1592	-0.0963	-0.1635	-0.0637	-0.0387	-0.0467
Max	0.1694	0.0813	0.5559	0.0604	0.1322	0.0962	0.1496	0.0620	0.4781	0.1539	0.5639	0.0993	0.0951	0.0936

Table 3: Spillover table of real credit growth and real GDP growth within the G7

	CANADA			FRANCE		
	From (j)			*From (j)*		
To (i)	CREDITgr	GDPgr		CREDITgr	GDPgr	
CREDITgr	93.7	6.3		90.3	9.7	
GDPgr	8.8	91.2		9.2	90.8	
Contr. to others	8.8	6.3	Total Spillover	9.2	9.7	Total Spillover
Contr. inc. own	101.5	97.5	Index = 7.6%	99.5	100.5	Index = 9.4%
	GERMANY			ITALY		
	From (j)			*From (j)*		
To (i)	CREDITgr	GDPgr		CREDITgr	GDPgr	
CREDITgr	58.7	41.3		95.0	5.0	
GDPgr	31.8	68.2		14.4	85.6	
Contr. to others	31.8	41.3	Total Spillover	14.4	5.0	Total Spillover
Contr. inc. own	89.5	109.5	Index = 36.5%	109.4	90.6	Index = 9.7%
	JAPAN			UK		
	From (j)			*From (j)*		
To (i)	CREDITgr	GDPgr		CREDITgr	GDPgr	
CREDITgr	72.1	27.9		91.6	8.4	
GDPgr	22.1	77.9		7.1	92.9	
Contr. to others	22.1	27.9	Total Spillover	7.1	8.4	Total Spillover
Contr. inc. own	94.2	105.8	Index = 25.0%	98.7	100.3	Index = 7.7%
	US					
	From (j)					
To (i)	CREDITgr	GDPgr				
CREDITgr	84.2	15.8				
GDPgr	27.8	72.2				
Contr. to others	27.8	15.8	Total Spillover			
Contr. inc. own	112	88	Index = 21.8%			

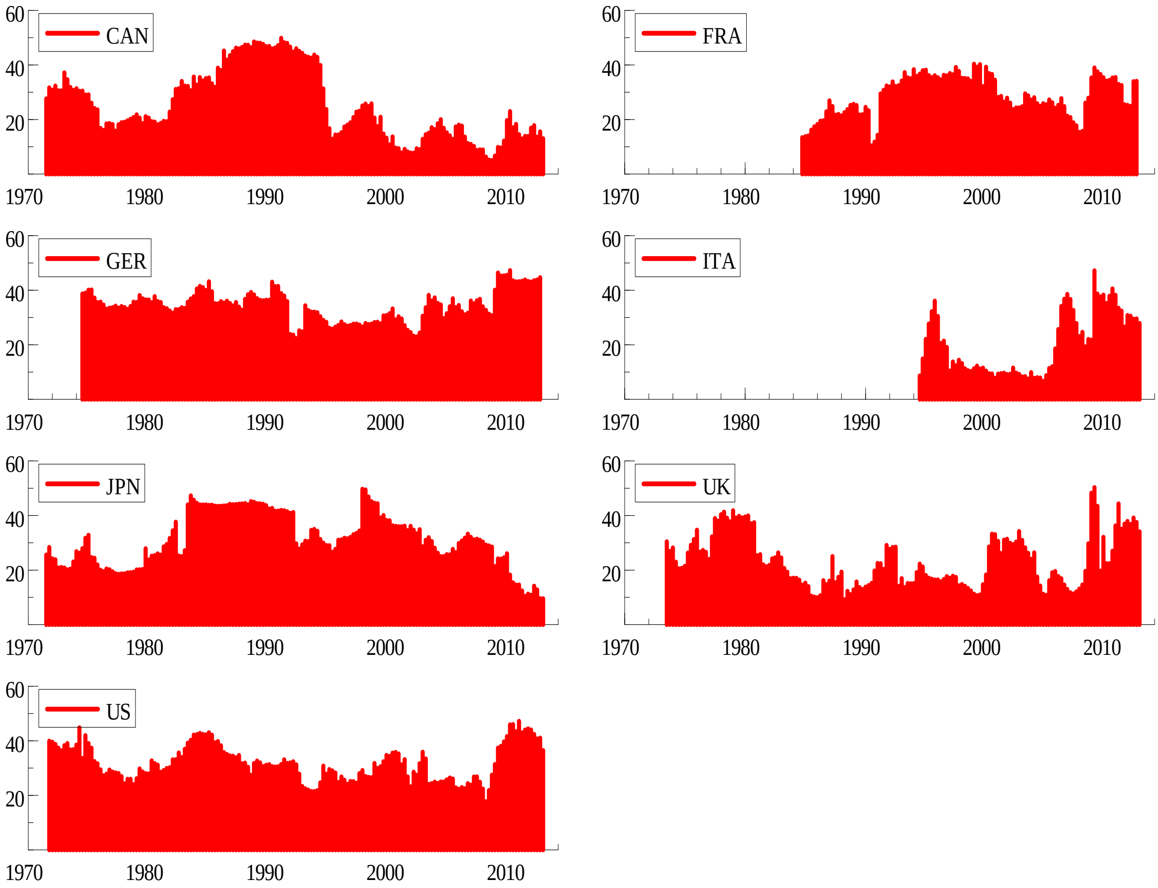
Note: Spillover indices, given by Equations (2)-(7), calculated from variance decompositions based on 12-step-ahead forecasts.

Table 4: Spillover table of real credit growth and real GDP growth between the G6

	From (j)												
To (i)	CANCRgr	FRACRgr	GERCRgr	JPNCRgr	UKCRgr	USCRgr	CANGDPgr	FRAGDPgr	GERGDPgr	JPNGDPgr	UKGDPgr	USGDPgr	From Others
CANCRgr	76.4	0.3	1.7	2.3	2.2	1.6	10.2	1.5	0.5	1.5	0.7	1.1	24
FRACRgr	0.4	80.1	0.4	2.2	7.8	0.6	0.4	2.4	0.8	3.6	0.3	0.9	20
GERCRgr	0.6	1.3	60.4	1.4	0.8	0.9	3.0	3.7	16.3	1.7	6.4	3.5	40
JPNCRgr	1.7	3.8	7.4	67.0	0.3	2.1	0.2	0.5	3.6	11.3	1.6	0.4	33
UKRCRgr	0.6	1.0	0.1	4.6	64.9	1.9	1.3	0.9	0.6	2.4	3.7	17.8	35
USRCRgr	1.0	1.4	1.2	5.5	6.7	45.9	8.5	4.1	3.5	5.0	13.2	4.1	54
CANGDPgr	3.3	0.3	0.7	4.4	5.1	29.2	35.9	4.2	2.3	3.2	9.9	1.5	64
FRAGDPgr	0.6	7.7	2.5	11.9	3.0	14.1	10.1	31.0	5.5	5.2	8.2	0.1	69
GERGDPgr	0.5	2.8	10.6	7.6	0.6	15.8	3.2	10.9	26.0	12.6	8.7	0.7	74
JPNGDPgr	0.2	4.5	2.6	28.8	0.6	6.8	1.7	3.6	4.5	42.7	3.4	0.8	57
UKGDPgr	1.2	0.3	1.7	3.5	1.3	20.1	3.7	4.8	4.9	2.7	47.5	8.5	53
USGDPgr	1.1	0.3	0.4	2.5	7.6	23.7	4.0	0.7	0.9	0.4	13.6	44.7	55
Contr. to others	11	24	29	75	36	117	46	37	43	50	70	39	Total Spillover
Contr. incl. own	88	104	90	142	101	163	82	68	69	92	117	84	Index=48.1%

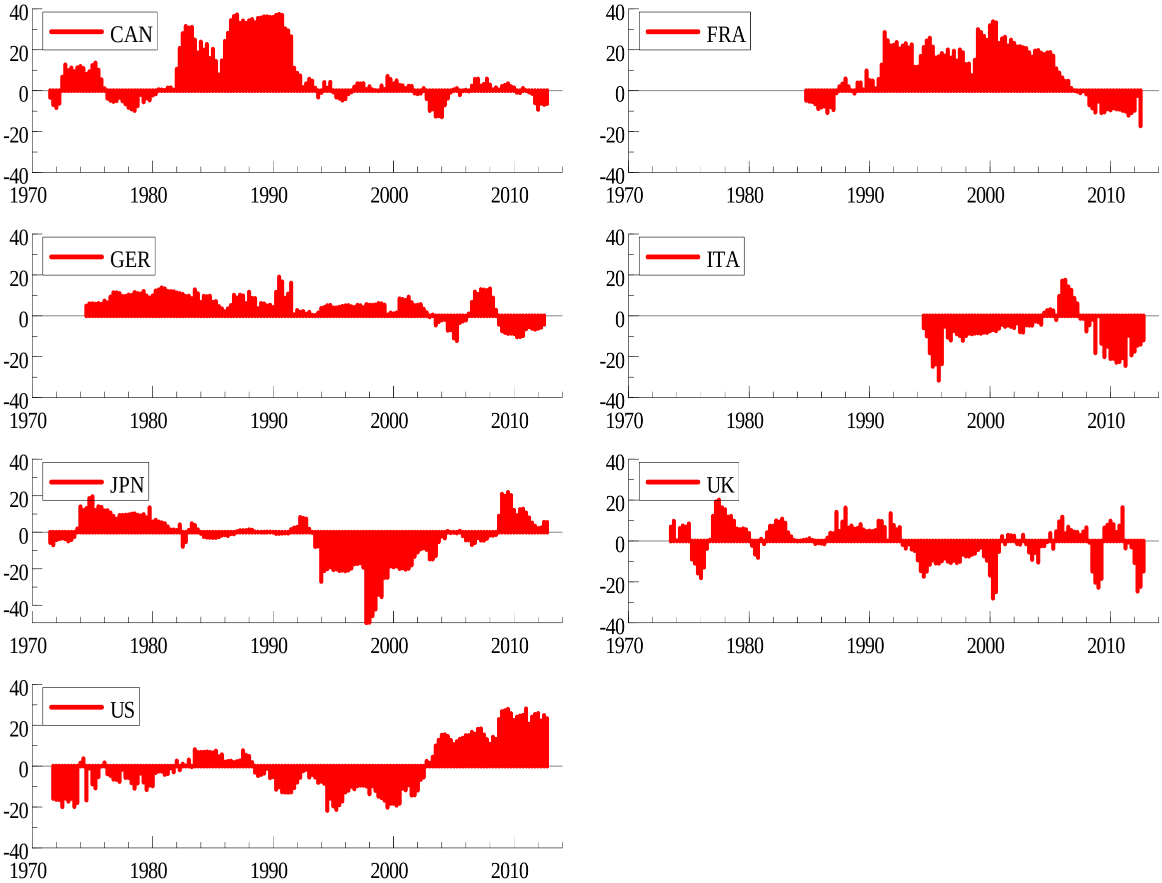
Note: Spillover indices, given by Equations (2)-(7), calculated from variance decompositions based on 12-step-ahead forecasts.

Figure 1: Total Spillovers of real credit growth and real GDP growth within the G7



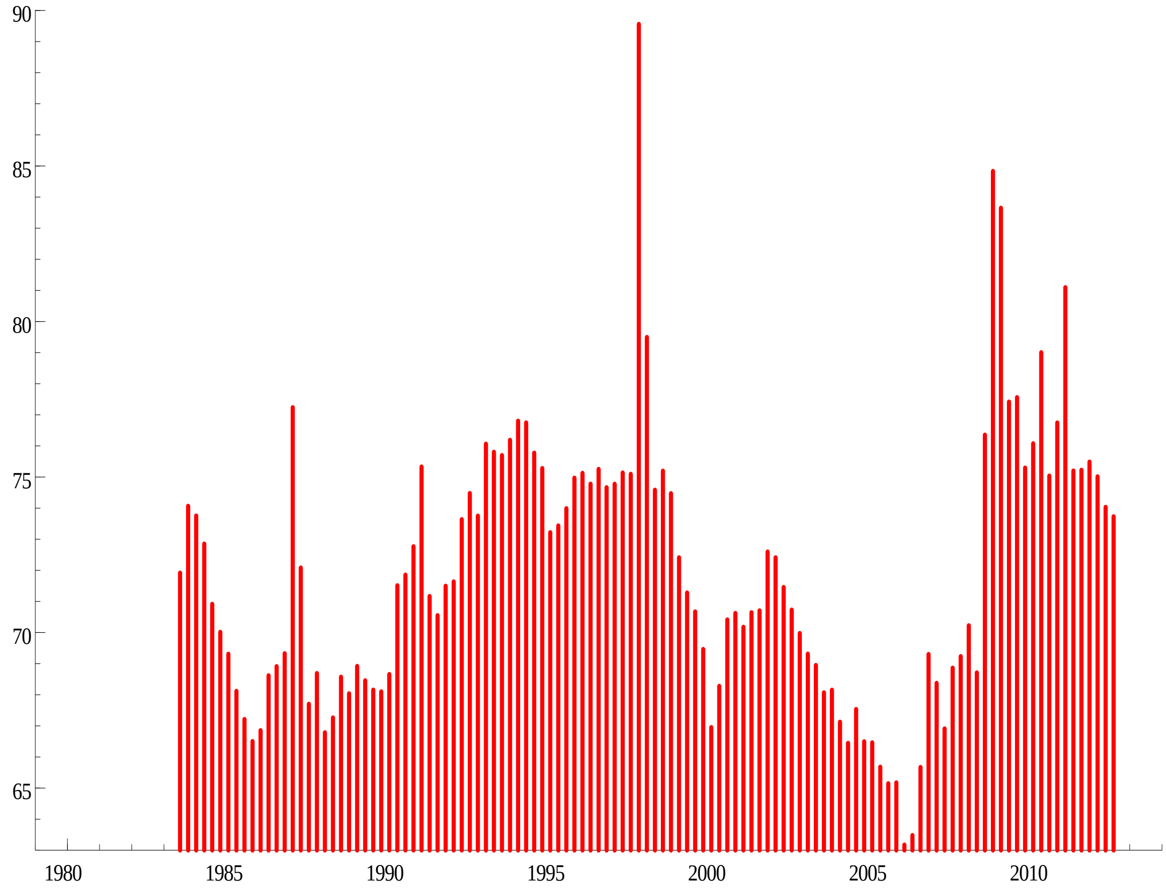
Note: Plots of moving total spillovers estimated using 50-quarter rolling windows.

Figure 2: Net Spillovers between real credit growth and real GDP growth within the G7



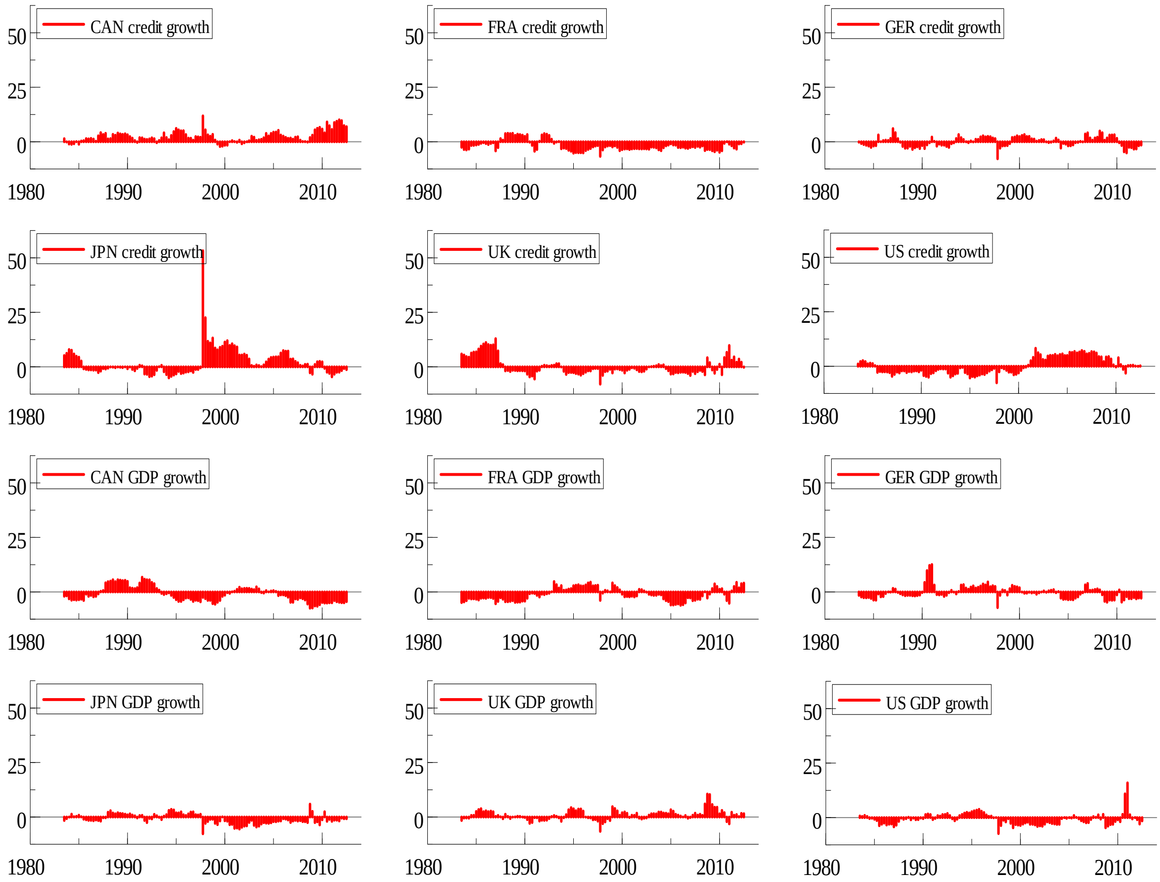
Note: Plots of moving net spillovers estimated using 50-quarter rolling windows.

Figure 3: Total Spillover of real credit and real GDP growth among the G6



Note: Plots of moving total spillovers estimated using 50-quarter rolling windows.

Figure 4: Net Spillovers between real credit and real GDP growth among the G6



Note: Plots of moving net spillovers estimated using 50-quarter rolling windows.

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Nikolaos Antonakakis, Max Breitenlechner, Johann Scharler

How strongly are business cycles and financial cycles linked in the G7 countries?

Abstract
In this study we examine the dynamic interactions between credit growth and output growth using the spillover index approach of Diebold and Yilmaz (2012). Based on quarterly data on credit growth and GDP growth over the period 1957Q1-2012Q4 for the G7 countries we find that: i) spillovers between credit growth and GDP growth evolve rather heterogeneously over time and across countries, and increase during extreme economic events. ii) Spillovers between credit growth and GDP growth are of bidirectional nature, indicating bidirectional causation between the financial and real sectors. iii) In the period shorty before and on the onset of the global financial crisis, the link between credit growth and GDP growth becomes more pronounced. In particular, the financial sector plays a dominant role during the early stages of the crisis, while the real sector quickly takes over as the dominant source of spillovers. iv) Interestingly, credit growth in the US is the dominant transmitter of shocks internationally, and especially to other countries' real sectors in the run up period to (and during) the global financial crisis. Overall, our results suggest feedback effects between the financial and the real sectors that create rippling effects within and between the G7 countries during the global financial crisis.

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