

Online Appendixes to The Synchronization of Business Cycles and Financial Cycles in the Euro Area*

William Oman

International Monetary Fund and CES, Université Paris 1
Panthéon-Sorbonne

Appendix A. Robustness Tests

This appendix presents robustness tests of the main results of the paper. The robustness tests replicate the main results using an 8- to 120-quarter bandpass filter instead of a 32- to 120-quarter bandpass filter to measure both business cycles and financial cycles. The 8- to 120-quarter frequency band captures both the high-frequency components (ranging from 8 to 32 quarters) and medium-frequency components (ranging from 32 to 120 quarters) of the cycles. This frequency band is similar to the one used by Comin and Gertler (2006).

Figures A1, A2, A3, and A4 present robustness tests of the measurement of national and aggregate euro-area business cycles and financial cycles, as well as a robustness test of the volatility of national financial cycles. Figure A5 presents a robustness test of the leverage cycle at the aggregate euro-area level. Table A1 presents robustness tests of the analysis of business and financial cycle concordance (first two columns) and similarity (last two columns) at six different levels: the euro area (first three rows); high- versus

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low-amplitude countries (fourth to sixth rows); high- versus low-amplitude countries, excluding Germany (seventh to ninth rows); Germany versus high-amplitude countries (tenth to twelfth rows); high-amplitude countries relative to the euro-area median (thirteenth to fifteenth rows); and low-amplitude countries relative to the euro-area median (last three rows). Table A2 presents robustness tests of the average level of the euro-area leverage cycle during each five-year period preceding euro-area recessions since 1980. Table A3 tests the robustness of the analysis on the concordance of business cycles and financial cycles within individual euro-area countries. Figure A6 presents a robustness test of the leverage cycle at the level of country groups.

The paper's main results are robust to the use of an 8- to 120-quarter frequency band instead of a 32- to 120-quarter frequency band. The robustness tests are summarized below.

A.1 Positive Euro-Area Leverage Cycle in the Run-up to Euro-Area Recessions

The finding that each five-year period that preceded a euro-area recession after 1990 is characterized by a positive aggregate euro-area leverage cycle is confirmed in figure A5 and table A2.

A.2 Lower Synchronicity of Financial Cycles Relative to Business Cycles

The finding that, overall, financial cycles are less synchronized than business cycles is confirmed by table A1 (first three rows). Table A1 (first three rows, first two columns) shows that the average degree of business cycle concordance is higher than the average degree of financial cycle concordance. Table A1 (first three rows, last two columns) shows that the average degree of business cycle amplitude similarity is higher than the average degree of financial cycle amplitude similarity.

A.3 Increase in Business Cycle Synchronization and Decrease in Financial Cycle Synchronization

The finding that, following euro introduction, average business cycle synchronization increased while average financial cycle

synchronization decreased is confirmed by table A1 (first twelve rows, first two columns). Table A1 (first twelve rows, first column) shows that business cycle concordance increased and reached very high levels (with the average bilateral concordance statistic reaching 0.85 in the crisis period), including between high- and low-amplitude countries. By contrast, table A1 (first twelve rows, second column) shows that financial cycle concordance remained relatively stable at a much lower level (with average bilateral concordance statistics for the three periods ranging from 0.53 to 0.59), and was not broad based, as there was significant desynchronization between high-amplitude countries and Germany.

A.4 Stronger Financial Cycle Desynchronization between High-Amplitude and Low-Amplitude Countries

The finding that financial cycle desynchronization was more pronounced between high-amplitude and low-amplitude countries, especially Germany, is confirmed by table A1 (fourth to seventh row, second column; last six rows, fourth column). Table A1 (fourth to seventh row, second column) shows that the degree of financial cycle concordance between high- and low-amplitude countries fell following euro introduction and remained low in the crisis period. Similarly, table A1 (last six rows, fourth column) shows that the degree of amplitude similarity of the composite financial cycle of the high-amplitude country group relative to the euro-area median was significantly lower in each period than the degree of amplitude similarity of the composite financial cycle of the low-amplitude country group relative to the euro-area median. Furthermore, the former fell significantly in the boom period and remained relatively low in the crisis period, while the latter remained relatively high in both the boom and crisis periods.

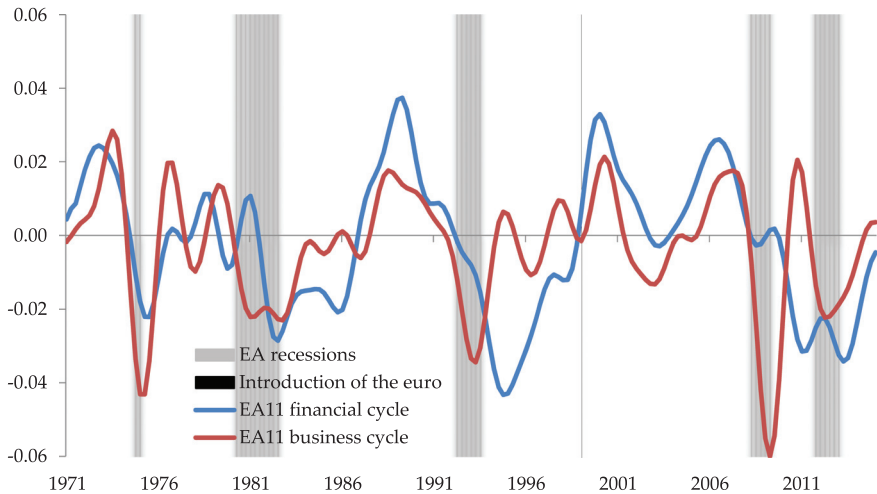
A.5 Divergence between the Leverage Cycles of the High-Amplitude Country Group and Germany

Finally, the finding that the high-amplitude country group and Germany experienced divergence in terms of their respective leverage cycles is confirmed by figure A6. First, the figure shows that the leverage cycles of the high- and low-amplitude groups diverged

strongly after 2002, with the divergence driven mainly by an increase in the volatility of the high-amplitude group's leverage cycle, as the volatility of the low-amplitude group's leverage cycle increased much less over the sample period. The volatility of the low-amplitude group's leverage cycle increased from a peak-to-trough difference of around 5 percentage points in the 1980s to a peak-to-trough difference of around 9 percentage points in the 2000s. The volatility of the high-amplitude group's leverage cycle increased much more, from a peak-to-trough difference of around 11 percentage points in the 1980s to a peak-to-trough difference of over 26 percentage points in the 2000s. Second, the figure shows that the leverage cycle of the high-amplitude group diverged markedly from that of Germany from 2003 to 2014. The former rose explosively from 2003 until its peak in 2006, while the latter became increasingly negative over the same period (with a brief rebound in 2005). Third, the reversal in the leverage cycle of the high-amplitude group between 2007:Q1 and 2013:Q2 is of a similar magnitude as the preceding upswing, with the leverage cycle falling from around 15 percent to around -11 percent. The leverage cycles of all country groups except Germany became negative around 2011:Q1. Fourth, Germany's leverage cycle exhibits different cyclical patterns from the other country groups starting in 1990 and Germany is the only region where the leverage cycle was negative at the height of the boom period, becoming negative in 2003:Q3 and reaching its trough in 2007:Q3. Conversely, Germany exhibited a positive leverage cycle as early as 2012:Q2, whereas all the other regions' leverage cycles remained negative throughout the second half of the crisis period. Finally, figure A6 shows that the 1992–93 and 2008–09 euro-area recessions were preceded by upswings in the leverage cycles of all country groups except Germany.

These patterns are very similar to those exhibited by leverage cycles at the country group level when measuring cycles using a 32- to 120-quarter frequency band. Taken together, these elements confirm the robustness of the finding that Germany and the high-amplitude group diverged not only in terms of financial cycles but also in terms of leverage cycles (i.e., of cyclical dynamics in the credit-to-GDP ratio).

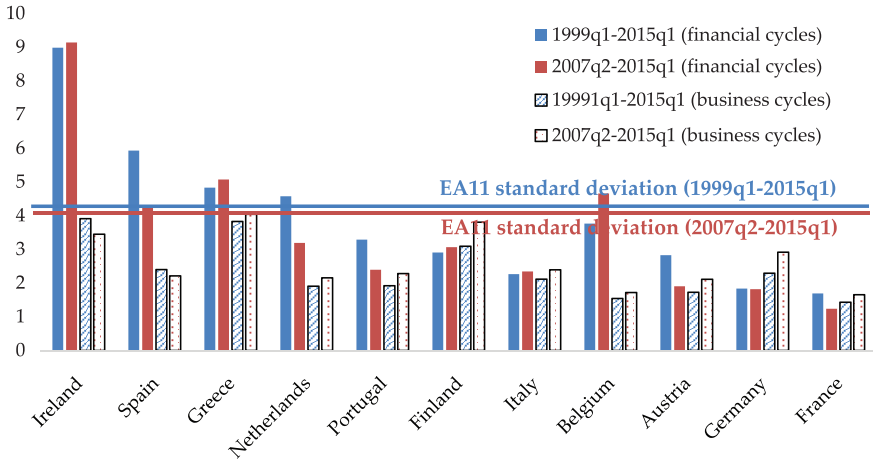
Figure A1. Euro-Area Financial Cycle and Business Cycle, and Recessions



Sources: BIS, OECD, CEPR, author's calculations.

Notes: The blue line shows the composite EA11 financial cycle, corresponding to the GDP-weighted average of the financial cycles of the eleven sample euro-area countries, in year-on-year percentage change. Following the methodology proposed by Drehmann, Borio, and Tsatsaronis (2012), the financial cycle is based on the credit-to-GDP ratio, credit to the non-financial private sector, and residential property prices. All series are normalized to 1985:Q1. The second and third variables are in real terms (deflated by CPI) and in logs. The financial cycle is defined as the simple average of the cyclical component (defined as frequencies between 8 and 120 quarters) of the three series, filtered in annual growth rates. For three countries (Austria, Portugal, and Greece) residential property price data do not extend back far enough in time and were therefore excluded from the composite financial cycle measure. The red line shows the composite EA11 business cycle, corresponding to the GDP-weighted average of the business cycles of the eleven sample euro-area countries, in year-on-year percentage change. The business cycle is defined as the cyclical component (also defined as frequencies between 8 and 120 quarters) of real, seasonally adjusted GDP normalized to 1985:Q1. The shaded areas represent euro-area recessions (from the quarter following the peak through the quarter of the trough) as defined by the CEPR Euro Area Business Cycle Dating Committee.

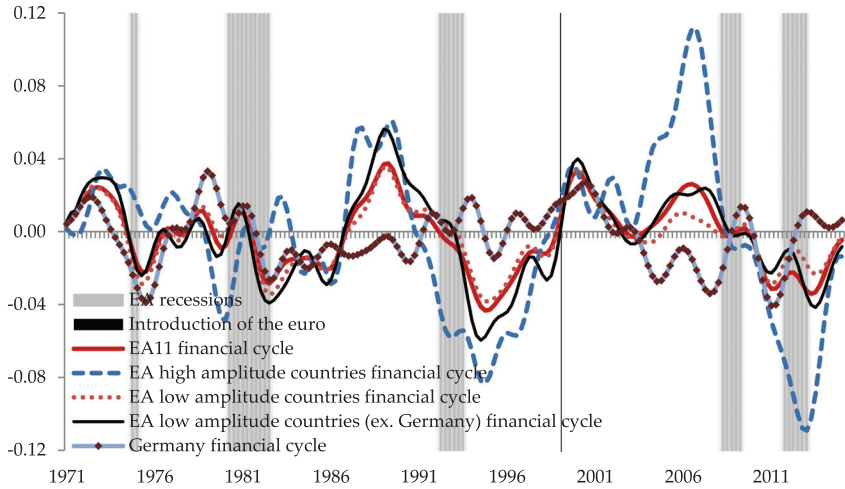
Figure A2. Standard Deviation of National Business and Financial Cycles, 1999:Q1–2007:Q1, 2007:Q2–2015:Q1



Sources: Author’s calculations.

Notes: See figure A1. The blue and red lines indicate the standard deviation, in percent, of the financial cycles of all eleven countries in the sample over 1999:Q1–2015:Q1 and 2007:Q2–2015:Q1, respectively.

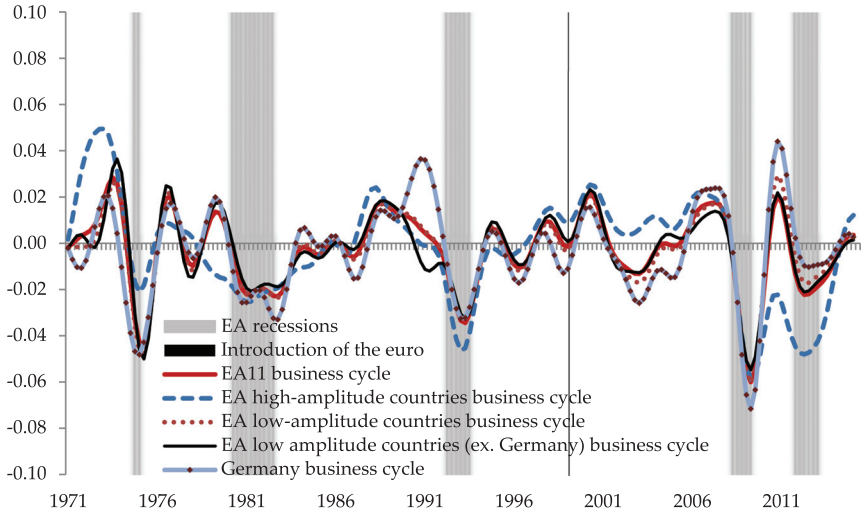
Figure A3. Euro-Area Financial Cycles: EA11, High-Amplitude Countries, Low-Amplitude Countries, Low-Amplitude Countries excluding Germany, and Germany



Sources: OECD, CEPR, author's calculations.

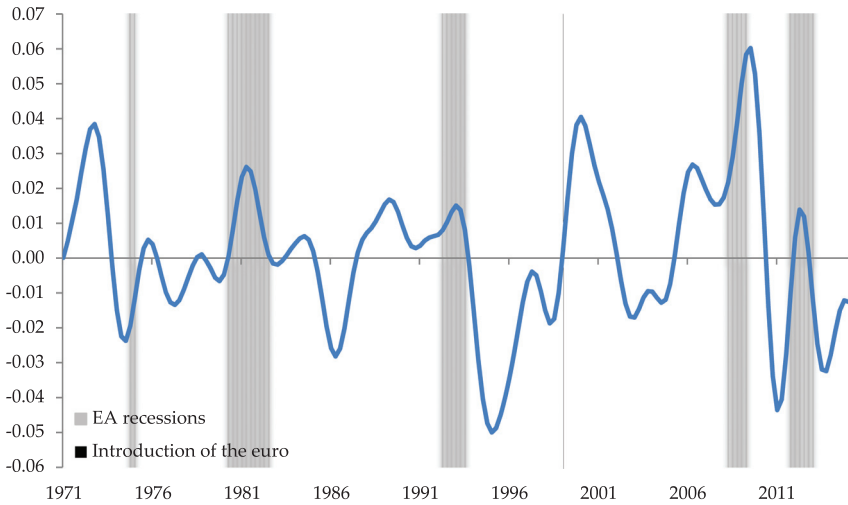
Notes: See figure A1. High-amplitude countries include Spain, Ireland, and Greece; low-amplitude countries include Germany, France, Italy, Netherlands, Belgium, Austria, Finland, and Portugal.

Figure A4. Euro-Area Business Cycles: EA11, High-Amplitude Countries, Low-Amplitude Countries, Low-Amplitude Countries excluding Germany, and Germany



Sources: OECD, CEPR, author's calculations.

Notes: See figure A1. High-amplitude countries include Spain, Ireland, and Greece; low-amplitude countries include Germany, France, Italy, Netherlands, Belgium, Austria, Finland, and Portugal.

Figure A5. Euro-Area Leverage Cycle

Sources: BIS, OECD, CEPR, author's calculations.

Notes: The composite EA11 leverage cycle corresponds to the GDP-weighted average of the leverage cycles of the eleven sample euro-area countries, in year-on-year percentage change. Following the methodology proposed by Drehmann, Borio, and Tsatsaronis (2012), the leverage cycle corresponds to the cyclical component (defined as frequencies between 8 and 120 quarters) of the credit-to-GDP ratio (in percentage points and normalized to 1985:Q1), filtered in annual growth rates.

Table A1. Concordance Statistics and Similarity Measures for Business Cycles and Financial Cycles across Euro-Area Countries

	Period	Concordance		Similarity	
		Business Cycles	Financial Cycles	Business Cycles	Financial Cycles
EA11	1971–1998	0.66 (0.64)	0.55 (0.53)	0.46 (0.27)	0.32 (0.15)
	1999–2007	0.70 (0.66)	0.59 (0.59)	0.38 (0.26)	0.37 (0.17)
	2007–2015	0.85 (0.82)	0.53 (0.53)	0.54 (0.40)	0.34 (0.26)
High- vs. Low-Amplitude Countries	1971–1998	0.60 (0.62)	0.57 (0.55)	—	—
	1999–2007	0.71 (0.66)	0.54 (0.56)	—	—
	2007–2015	0.87 (0.86)	0.54 (0.54)	—	—
High- vs. Low-Amplitude Countries (ex. Germany)	1971–1998	0.60 (0.63)	0.58 (0.55)	—	—
	1999–2007	0.70 (0.65)	0.61 (0.58)	—	—
	2007–2015	0.86 (0.86)	0.62 (0.56)	—	—
Germany vs. High-Amplitude Countries	1971–1998	0.58	0.54	—	—
	1999–2007	0.73	0.40	—	—
	2007–2015	0.88	0.40	—	—
High-Amplitude Countries	1971–1998	—	—	0.23	0.39
	1999–2007	—	—	0.11	−0.01
	2007–2015	—	—	−0.16	0.26
Low-Amplitude Countries	1971–1998	—	—	0.67	0.73
	1999–2007	—	—	0.58	0.71
	2007–2015	—	—	0.87	0.67

(continued)

Table A1. (Continued)

Source: Author's calculations.

Notes: Cells show the concordance statistics and similarity measures for various country groups. All numbers are GDP-weighted averages, with simple averages in parentheses, except for the concordance statistics for Germany versus high-amplitude countries and the similarity measures for high- and low-amplitude countries, which are simple averages (as they are calculated using the composite business and financial cycles for high- and low-amplitude countries). The similarity measures for high- and low-amplitude countries correspond to the similarity of these country groups' composite business or financial cycles with the median euro-area business or financial cycle, respectively (see section 2.2.2 for details on the methodology). The concordance statistic measures the fraction of time that two series are in the same phase of the cycle, with the series being perfectly procyclical (countercyclical) if the statistic is equal to one (zero). The similarity measure maximizes similarity of a given variable in the cross-section with respect to a reference value (set to be the median value, for all sample countries, of the variable under consideration). GDP-weighted averages and simple averages are calculated using the bilateral concordance statistics or similarity measures of all sample countries. High-amplitude countries include Spain, Ireland, and Greece; low-amplitude countries include Germany, France, Italy, Netherlands, Belgium, Austria, Finland, and Portugal. The exact periods shown in the table are 1971:Q1–1998:Q4, 1999:Q1–2007:Q1, and 2007:Q2–2015:Q1

Table A2. Average Level of the Euro-Area leverage Cycle during Each Five-Year Period Preceding Euro-Area Recessions since 1980

EA Recession	Five-Year Period Preceding EA Recession	8- to 120-Quarter BP Filter	32- to 120-Quarter BP Filter
First/Last Quarter	First/Last Quarter	Average (percent)	
1980:Q2–1982:Q3	1975:Q1–1980:Q1	–0.4	–0.6
1992:Q2–1993:Q2	1987:Q1–1992:Q1	0.7	0.8
2008:Q3–2009:Q2	2003:Q2–2008:Q2	0.5	0.7
2011:Q4–2013:Q1	2006:Q3–2011:Q3	1.6	2.0
	Average	0.6	0.7

Sources: CEPR, author's calculations.

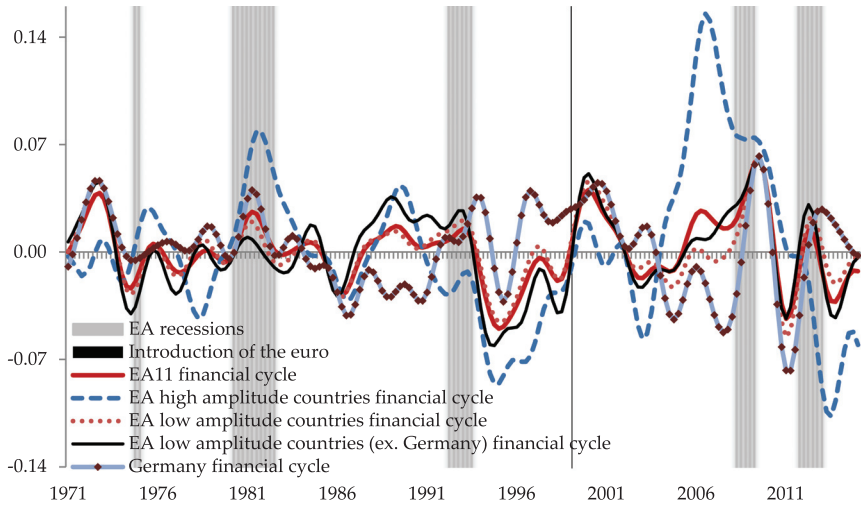
Notes: Average level, for each five-year period preceding euro-area recessions since 1980, of the EA11 leverage cycle (GDP-weighted average of the leverage cycles, respectively, of Germany, France, Italy, Spain, Netherlands, Belgium, Finland, Austria, Ireland, Greece, and Portugal), in year-on-year percentage change. The “8- to 120-Quarter BP Filter” column shows estimates for the leverage cycle generated using an 8- to 120-quarter frequency band for the bandpass filter, while the “32- to 120-Quarter BP Filter” column shows estimates for the leverage cycle generated using a 32- to 120-quarter frequency band for the bandpass filter.

Table A3. Concordance of Business Cycles and Financial Cycles within Individual Euro-Area Countries

	1971–1998	1999–2007	2007–2015
Austria	0.50	0.64	0.53
Belgium	0.58	0.70	0.28
Finland	0.57	0.67	0.31
France	0.44	0.67	0.63
Germany	0.53	0.58	0.19
Greece	0.51	0.42	0.56
Ireland	0.52	0.58	0.34
Italy	0.57	0.48	0.53
Netherlands	0.60	0.73	0.53
Portugal	0.45	0.76	0.41
Spain	0.66	0.55	0.69
Average	0.54	0.61	0.45
GDP-Weighted Average	0.54	0.59	0.45

Source: Author's calculations.
Notes: See table A1 for the definition of the concordance statistic. The exact periods shown in the table are 1971:Q1–1998:Q4, 1999:Q1–2007:Q1, and 2007:Q2–2015:Q1.

Figure A6. Euro-Area Leverage Cycles: EA11, High-Amplitude Countries, Low-Amplitude Countries, Low-Amplitude Countries excluding Germany, and Germany

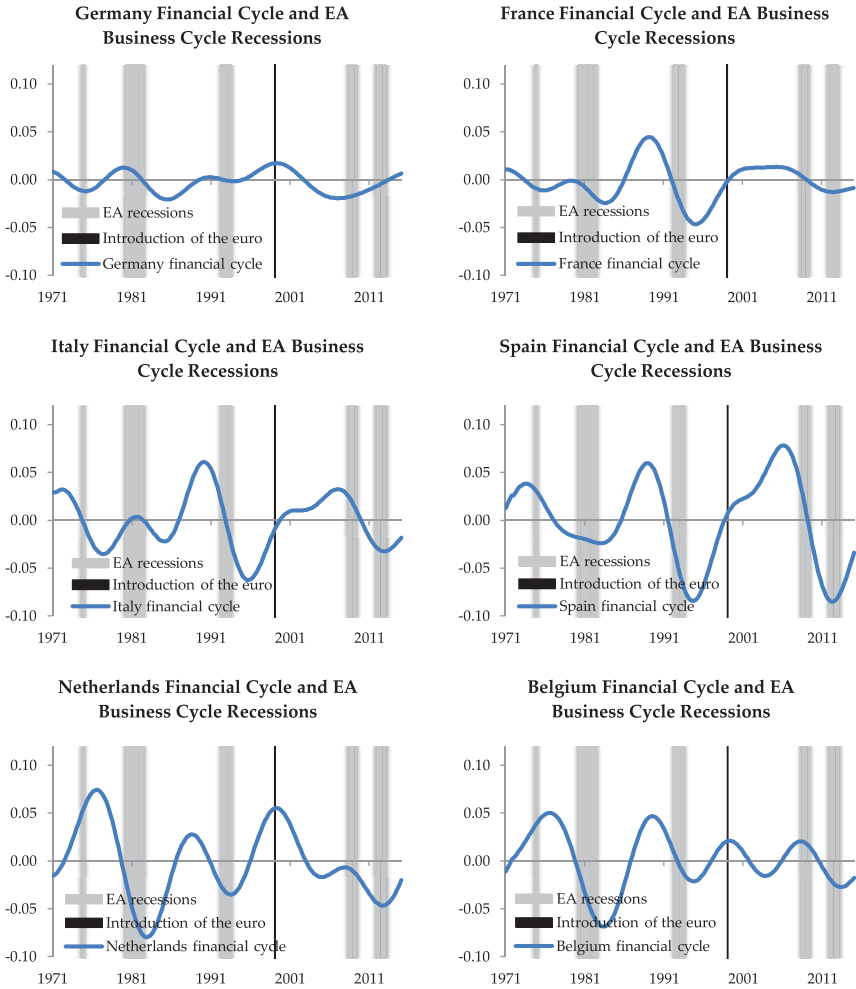


Sources: BIS, OECD, CEPR, author's calculations.

Notes: Each line represents the (composite) leverage cycle of a country group or country. See figure A5 for the definition of the leverage cycle. High-amplitude countries include Spain, Ireland, and Greece; low-amplitude countries include Germany, France, Italy, Netherlands, Belgium, Austria, Finland, and Portugal.

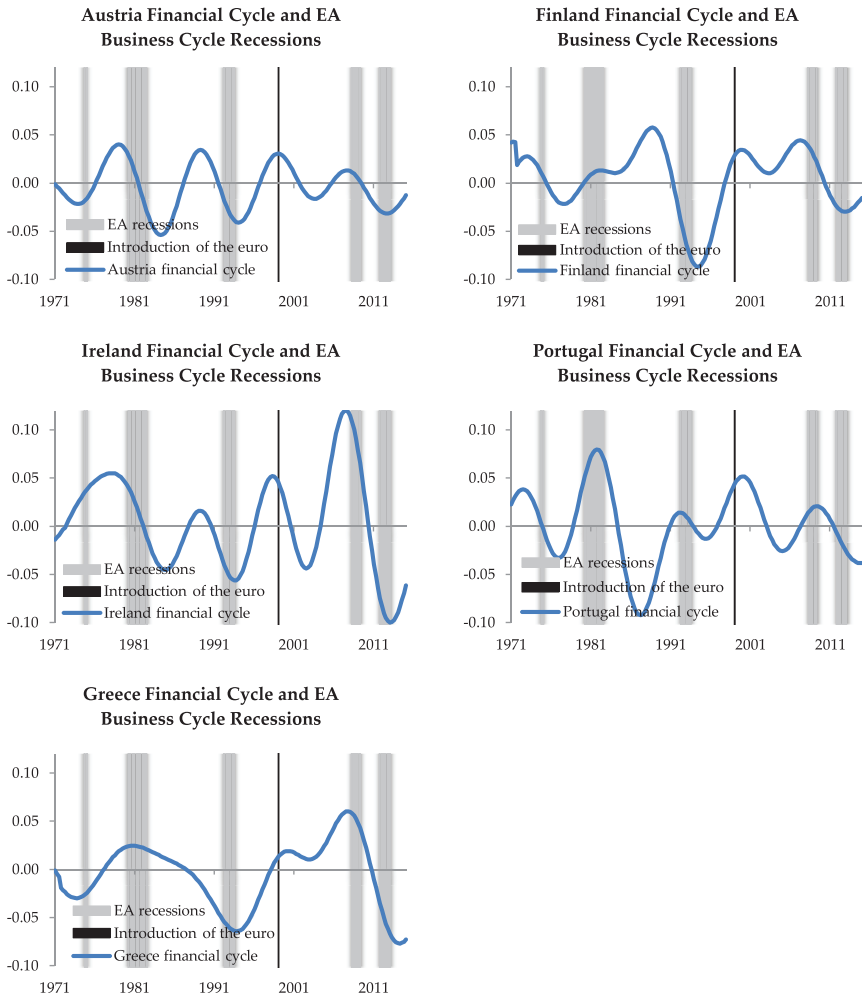
Appendix B. Additional Figures and Tables

Figure B1. Financial Cycles in Euro-Area Countries



(continued)

Figure B1. (Continued)



Sources: BIS, OECD, author's calculations.

Notes: Following the methodology proposed by Drehmann, Borio, and Tsatsaronis (2012), the blue line shows the financial cycle as measured by the multivariate frequency-based filter, in year-on-year percentage change. It is based on the credit-to-GDP ratio, credit to the non-financial private sector, and residential property prices. All series are normalized to 1985:Q1. The second and third variables are in real terms (deflated by CPI) and in logs. The blue line represents the average of the medium-term cyclical component of the three time series, filtered in annual growth rates. For three countries (Austria, Portugal, and Greece) residential property price data do not extend back far enough in time and were therefore excluded from the composite financial cycle measure. The shaded areas represent euro-area recessions (from the quarter following the peak through the quarter of the trough) as defined by the CEPR Euro Area Business Cycle Dating Committee, which draws mainly on Eurostat and OECD data.

Figure B2. Housing Price Cycle, Credit Cycle, and Credit-to-GDP Cycle in Euro-Area Countries



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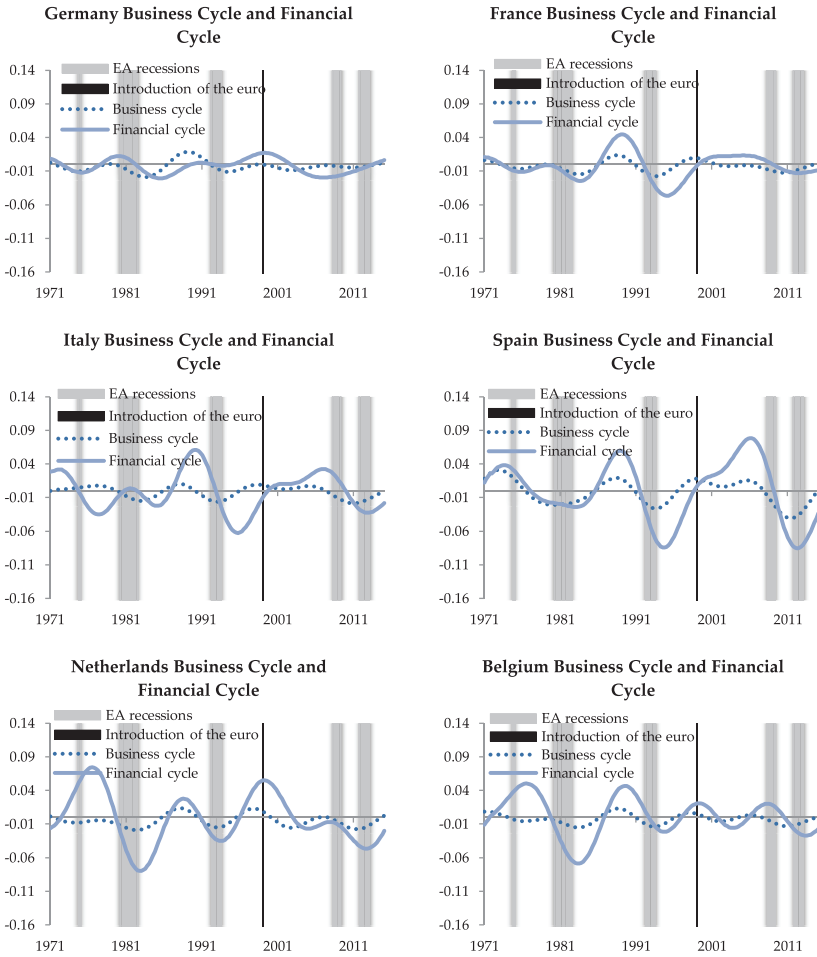
Figure B2. (Continued)



Sources: BIS, OECD, CEPR, author's calculations.

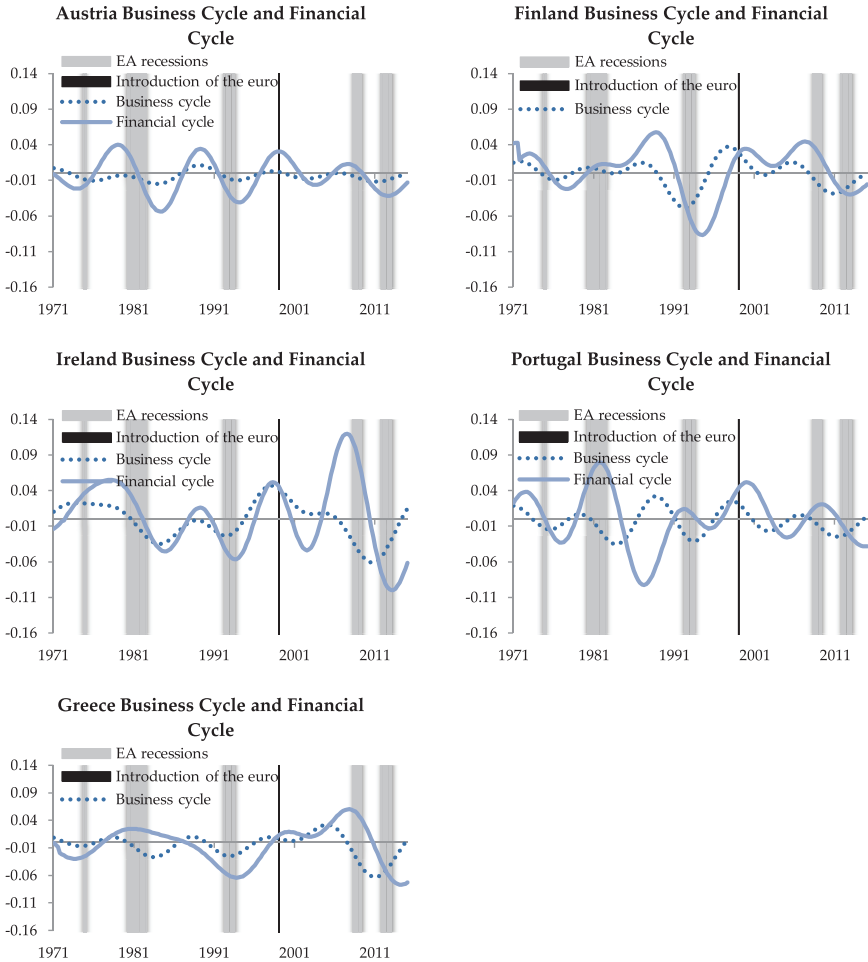
Note: See figure B1.

Figure B3. Euro-Area Countries' Business Cycles and Financial Cycles



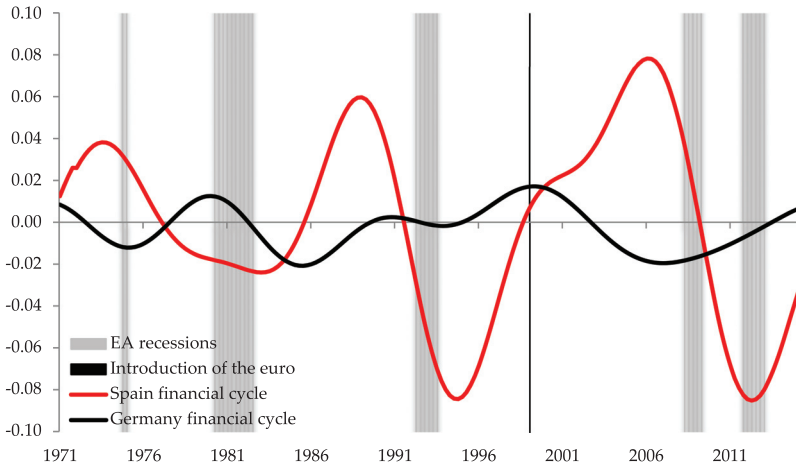
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Figure B3. (Continued)



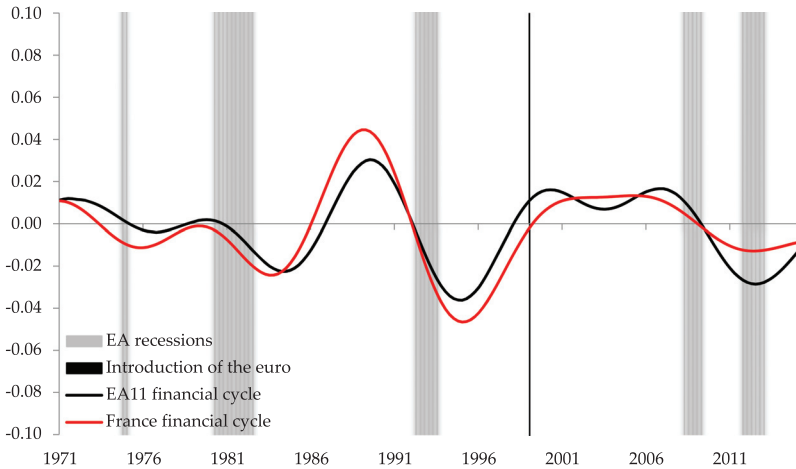
Sources: BIS, OECD, CEPR, author's calculations.
Note: See figure A1.

Figure B4. Germany vs. Spain: Diverging Financial Cycles since 1999



Sources: BIS, OECD, CEPR, author's calculations.
Note: See figure B1.

Figure B5. EA11 and France: Broadly Synchronized Financial Cycles since 1999



Sources: BIS, OECD, CEPR, author's calculations.
Note: See figure B1.

Table B1. Concordance of Business Cycles between Euro-Area Countries

	1971–1998	1999–2007	2007–2015
Austria	0.79	0.83	0.97
Belgium	0.82	0.83	0.97
Finland	0.72	0.83	0.96
France	0.82	0.79	0.93
Germany	0.76	0.76	0.93
Greece	0.81	0.61	0.97
Ireland	0.70	0.71	0.93
Italy	0.72	0.77	0.97
Netherlands	0.76	0.78	0.92
Portugal	0.82	0.80	0.95
Spain	0.65	0.82	0.95
Average	0.76	0.78	0.95
GDP-Weighted Average	0.76	0.78	0.94

Source: Author's calculations.

Notes: Each cell represents the average concordance statistic of a euro-area country's business cycle with those of other euro-area countries. The concordance statistic measures the fraction of time that two series are in the same phase of the cycle, with the series being perfectly procyclical (countercyclical) if the statistic is equal to one (zero). The exact periods shown in the table are 1971:Q1–1998:Q4, 1999:Q1–2007:Q1, and 2007:Q2–2015:Q1.

Table B2. Concordance of Financial Cycles between Euro-Area Countries

	1971–1998	1999–2007	2007–2015
Austria	0.71	0.65	0.80
Belgium	0.67	0.67	0.75
Finland	0.65	0.69	0.80
France	0.70	0.38	0.78
Germany	0.66	0.44	0.32
Greece	0.58	0.68	0.69
Ireland	0.66	0.61	0.80
Italy	0.65	0.55	0.78
Netherlands	0.63	0.59	0.81
Portugal	0.53	0.60	0.52
Spain	0.66	0.45	0.71
Average	0.65	0.57	0.71
GDP-Weighted Average	0.66	0.49	0.64

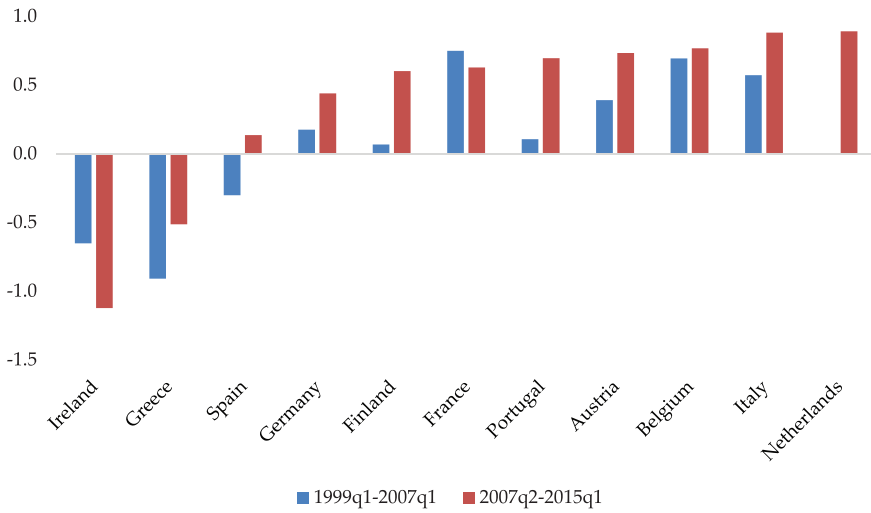
Source: Author's calculations.
Notes: See table B1. The exact periods shown in the table are 1971:Q1–1998:Q4, 1999:Q1–2007:Q1, and 2007:Q2–2015:Q1.

Table B3. Concordance of Individual Low-Amplitude Countries' Financial Cycles with Those of High-Amplitude Countries (weighted by GDP)

	1971–1998	1999–2007	2007–2015	1999–2015
Austria	0.68	0.46	0.89	0.67
Belgium	0.78	0.45	0.75	0.60
Finland	0.69	0.59	0.89	0.74
France	0.73	0.78	0.92	0.85
Germany	0.59	0.24	0.32	0.28
Italy	0.62	0.78	0.90	0.84
Netherlands	0.76	0.30	0.85	0.57
Portugal	0.49	0.38	0.47	0.42
Average	0.65	0.52	0.68	—
Average (ex. Germany)	0.68	0.67	0.87	—

Source: Author's calculations.
Notes: See table B1 for the definition of the concordance statistic. The exact periods shown in the table are 1971:Q1–1998:Q4, 1999:Q1–2007:Q1, 2007:Q2–2015:Q1, and 1999:Q1–2015:Q1.

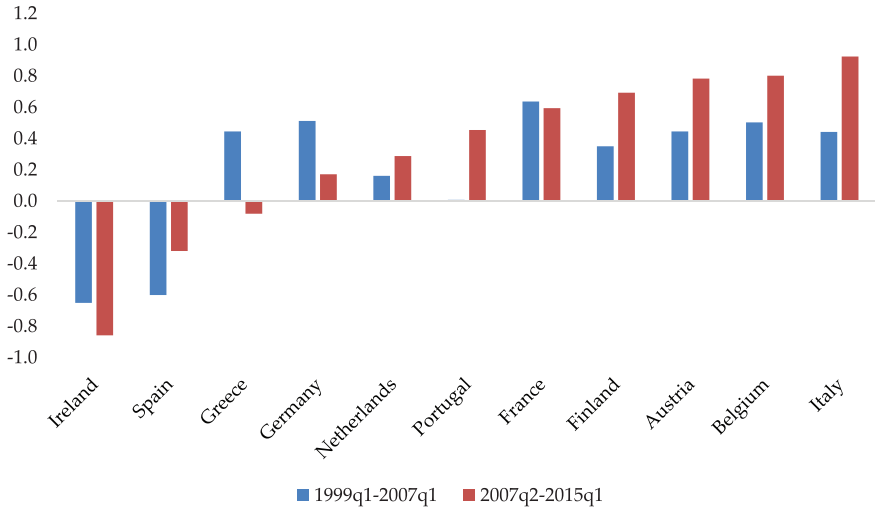
Figure B6. Similarity of Business Cycles across Euro-Area Countries



Sources: Author’s calculations.

Notes: The similarity measure maximizes similarity of a given variable in the cross-section with respect to a reference value (set to be the median value, for all sample countries, of the variable under consideration—in this chart, business cycle growth rates).

Figure B7. Similarity of Financial Cycles across Euro-Area Countries



Sources: Author's calculations.

Note: See Figure B6 for the definition of similarity.

References

- Comin, D., and M. Gertler. 2006. "Medium-Term Business Cycles." *American Economic Review* 96 (3, June): 523–51.
- Drehmann, M., C. Borio, and K. Tsatsaronis. 2012. "Characterising the Financial Cycle: Don't Lose Sight of the Medium Term!" BIS Working Paper No. 380 (June).