Financial volatility, currency diversification and banking stability

Justine Pedrono [1]

[1] CEPII, Aix-Marseille Univ., CNRS, EHESS, Centrale Marseille, AMSE

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Motivation

From the literature :

Evans and McMillan [2009], Rey [2013], Miranda-Agrippino and Rey [2015], Ivashina et al. [2015], Pedrono and Violon [2017]

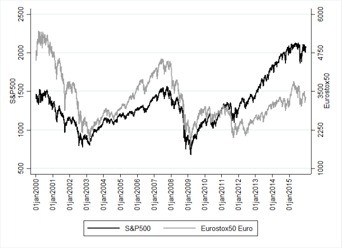
- European banks : a transatlantic asymmetry in international banking (Baba et al. [2009], McGuire and Von Peter [2012])
- EA global banks exposed to the global financial cycle :
  - Co-movements between assets $\{C, C^\star\}$
  - Major influence of US monetary policy on credit conditions worldwide $\{L, L^\star\}$
- Regarding exchange rate, assets and liabilities : domestic currency appreciation with positive shock on domestic interest rate.
  Engel [1996], Kearns and Manners [2006], Ehrmann et al. [2011]

- $\{C, C^\star, L, L^\star, S\}$ within EA banks' balance sheet are linked all together.

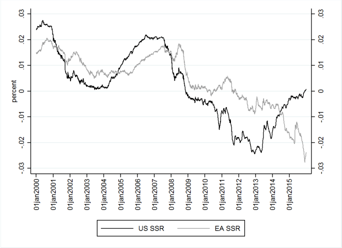
Aim of this paper :

- Link the bank's exposure to the global financial cycle to the banking volatility

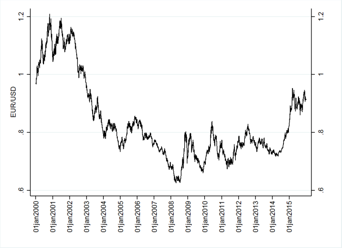
Illustration



(a) International stock market indices



(b) Shadow short rates (SSR), daily returns



(c) Exchange rate

Figure: **Financial markets.** Sources : Bloomberg, The Reserve Bank of New Zealand.

This paper

Theoretical model :

- Stochastic processes to define assets, liabilities and foreign exchange rate marginal variation
- Equity returns :
  - A residual of total asset and liability marginal variations
- Volatility of equity :
  - Leverage and variance covariance matrix between $\{C, C^\star, L, L^\star, S\}$

Data and empirical application :

- Daily data on :
  - International stock market indices
  - US and EA Shadow Short Rate
  - Foreign exchange rate
- Bi-variate DCC GARCH :
  - Conditional variances and correlations
  - Estimation of efficient currency diversification

Key ingredients :

- Differentiating each source of risk within global bank's volatility
- Identification of the global financial cycle : conditional correlations

Equity

Total assets :

$$A = C + SC^{\star} \quad \text{with} \quad \frac{C}{A} = (1-\psi) \;\; ; \;\; \frac{SC^{\star}}{A} = \psi$$

Total liabilities :

$$D = L + SL^{\star} \quad \text{with} \quad \frac{L}{D} = (1-\lambda) \;\; ; \;\; \frac{SL^{\star}}{D} = \lambda$$

Bank's equity is defined through E such that :

$$E = A - D$$

Bank's leverage l :

$$l = D/E$$

Following the Basel III framework, we assume that leverage is defined by authorities. Using definitions of l and E, we obtain the bank's equity SDE :

$$\begin{aligned} d\tilde{E} = \frac{dE}{E} &= (1+l)\frac{dA}{A} - l \cdot \frac{dD}{D} \\ &= (1+l)\left((1-\psi)\, d\tilde{C} + \psi(d\tilde{C}^{\star} + d\tilde{S})\right) - l\left((1-\lambda)\, d\tilde{L} + \lambda(d\tilde{L}^{\star} + d\tilde{S})\right) \end{aligned}$$

Volatility of equity with currency diversification

Introducing 10 covariances $\{\sigma_{CC^\star}, \sigma_{LL^\star}, \sigma_{LC}, \sigma_{L^\star C^\star}, \sigma_{L^\star C}, \sigma_{LC^\star}, \sigma_{SC}, \sigma_{SC^\star}, \sigma_{SL^\star}, \sigma_{SL}\}$

Volatility of equity return :

$$
\begin{aligned}
Var\left(\frac{d\tilde{E}}{dt}\right) = & \sum Var \text{ of each component of the BS : } \sigma^2_C \; \sigma^2_{C^\star} \; \sigma^2_L \; \sigma^2_{L^\star} \; \sigma^2_S \\
& + \text{The exposure to the global financial cycle : } \sigma_{CC^\star}, \sigma_{LL^\star} \\
& - \text{The Asset-Debt hedging strategy : } \sigma_{LC} \; \sigma_{L^\star C^\star} \; \sigma_{L^\star C} \; \sigma_{LC^\star} \\
& +/- \text{ The FX channel on converted returns and costs : } \sigma_{SC}, \sigma_{SC^\star}, \sigma_{SL^\star}, \sigma_{SL}
\end{aligned}
$$

"Efficient" share of foreign asset $\widehat{\psi}$: min. of banking volatility (similarly for $\widehat{\lambda}$)

$$
\begin{aligned}
\widehat{\psi} = & + \text{share of } C \text{ in asset-side risk} \\
& + \text{risk reduction related to part of liability side being also in foreign currency} \\
& + \text{share of } C^\star \text{ risk that can be hedged with } L^\star \\
& + \text{share of } C^\star \text{ risk that can be hedged with } L
\end{aligned}
$$

Details FX channel

An application to the US and EA financial markets

Data

- C : log returns of the Eurostox50 index
- $C^\star$: log returns of the S&P500 index
- L : EA SSR changes for EA monetary tightening
- $L^\star$: US SSR changes for US monetary tightening
- S : the USD/EUR FX

Identifying variances of $\{C, C^\star, L, L^\star, S\}$ and correlations between the different components :

▷ 10 bivariate DCC GARCH(1,1) using daily data from 2000 to 2015 Details

Compared to cointegration analysis :

▷ Capture the potential change in financial integration as mentioned by Evans and McMillan [2009].

Main results from DCC GARCH

- Identification of financial distress :
  - bursting of the Dotcom bubble (2001-2002)
  - the subprime crisis (2008-2009)
  - global volatility surge in 2008
- Assets are more volatile
  - $\{\sigma_C, \sigma_{C^\star}\} > \{\sigma_S\} > \{\sigma_L, \sigma_{L^\star}\}$
- US Vs EA volatility
  - $\sigma_C > \sigma_{C^\star}$ except for 2008
  - $\sigma_L > \sigma_{L^\star}$ for 2000, 2003, 2009 and since 2011
- Confirm the global financial cycle :
  - $\{\rho_{CC^\star}, \rho_{LL^\star}\}$, all positive with some dynamics
  - $\{\rho_{LC}\ \rho_{L^\star C^\star}\ \rho_{L^\star C}\ \rho_{LC^\star}\}$, all positive with dynamics
- Correlations regarding FX :
  - $\{\rho_{SC}, \rho_{SC^\star}, \rho_{SL^\star}, \rho_{SL}\}$: positive to negative dynamic depending on sub-period

Vol. DCC

Efficient diversification

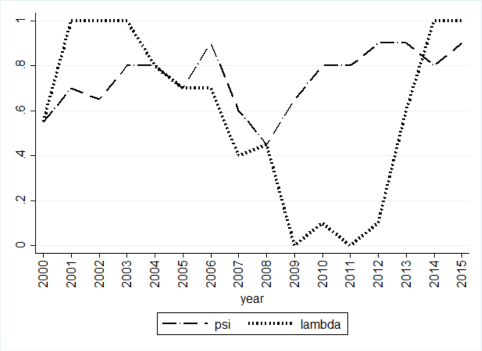


Figure: Efficient currency diversification of bank's balance sheet (2000-2015) : ψ and λ are defined as to minimize the volatility of bank's equity.

2008 : peak in vol. but large ρ_{LC} and $\rho_{L^\star C^\star}$, and FX compensation with $\rho_{SC} = -\rho_{SC^\star}$ and $\rho_{SL} = -\rho_{SL^\star}$:

- Currency diver. still stabilizing

2009-2012 : large compensation effect with $\rho_{SC^\star} < 0$, plus $\rho_{LC^\star} > \rho_{L^\star C^\star}$:

- Currency mismatch is optimal

After 2012, $\rho_{LC} < \rho_{L^\star C}$ and $\rho_{SC^\star}$ increases and becomes positive :

- Currency mismatch is absorbed

Conclusion

⇒ Link the bank's exposure to the global financial cycle to the banking stability.

- An application to the US and EA financial markets
  - Identification of the global financial cycle
  - Diversification reduces equity volatility even during large financial distresses such as 2008.

⇒ The currency dimension of banks' balance sheet then offers an interesting potential regulatory tool to improve the resilience of banks :

- Possible to hedge FX risk completely.
- Possible to understand the consequences of banks' external positions : currency mismatch may improve banking stability.
- Possible to improve stress test exercises by including FX adjustments.

⇒ Extension :

- Compared efficient diversification and observed diversification
- Explain differences in currency diversification
- Explain conditional correlations.

Equity return volatility

$$
\begin{aligned}
\mathrm{Var}(\frac{d\tilde{E}}{dt}) = {} & \Sigma_{ortho} \\
& + \underbrace{2(1+l)^2\psi(1-\psi)\sigma_{CC^\star}}_{\textit{global financial cycle risk}} + \underbrace{l^2\lambda(1-\lambda)\sigma_{LL^\star}}_{\textit{global financial cycle risk}} \\
& - \underbrace{2(1+l)l\left[(1-\psi)\left((1-\lambda)\sigma_{LC} + \lambda\sigma_{L^\star C}\right) + \psi\left(\lambda\sigma_{L^\star C^\star} + (1-\lambda)\sigma_{LC^\star}\right)\right]}_{\textit{A-D hedging strategies}} \\
& + \underbrace{2(\psi + l(\psi-\lambda))\,(1+l)\left[(1-\psi)\sigma_{SC} + \psi\sigma_{SC^\star}\right]}_{\textit{FX channel, asset}} \\
& - \underbrace{2(\psi + l(\psi-\lambda))\,l\left[(1-\lambda)\sigma_{SL} + \lambda\sigma_{SL^\star}\right]}_{\textit{FX channel, liability}}
\end{aligned} \tag{1}
$$

where :

$$\Sigma_{ortho} = ((1+l)(1-\psi))^2\sigma_C^2 + ((1+l)\psi)^2\sigma_{C^\star}^2 + (\psi + l(\psi-\lambda))^2\sigma_S^2 + (l(1-\lambda))^2\sigma_L^2 + (l\dot{\lambda})^2\sigma_{L^\star}^2$$

▸ Return

Efficient asset diversification

$$\frac{\partial \Sigma^2_{global}}{\partial \psi} = 0 \;\mid \lambda \text{ constant}$$

$$\begin{aligned}
\widehat{\psi}_{global} = & \frac{\sigma^2_C - \sigma_{CC^\star} - \sigma_{SC}}{\sigma^2_C + \sigma^2_{C^\star} + \sigma^2_S - 2\left(\sigma_{CC^\star} + \sigma_{SC} - \sigma_{SC^\star}\right)} \\
& + \lambda \left(\frac{l}{1+l}\right) \frac{\sigma^2_S + \sigma_{SC^\star} - \sigma_{SC}}{\sigma^2_C + \sigma^2_{C^\star} + \sigma^2_S - 2\left(\sigma_{CC^\star} + \sigma_{SC} - \sigma_{SC^\star}\right)} \\
& + \underbrace{\lambda \left(\frac{l}{1+l}\right) \frac{\sigma_{SL^\star} + \sigma_{L^\star C^\star} - \sigma_{L^\star C}}{\sigma^2_C + \sigma^2_{C^\star} + \sigma^2_S - 2\left(\sigma_{CC^\star} + \sigma_{SC} - \sigma_{SC^\star}\right)}}_{\text{share of } C^\star \text{ risk that can be hedged with } L^\star} \\
& + \underbrace{(1-\lambda) \left(\frac{l}{1+l}\right) \frac{\sigma_{SL} + \sigma_{LC^\star} - \sigma_{LC}}{\sigma^2_C + \sigma^2_{C^\star} + \sigma^2_S - 2\left(\sigma_{CC^\star} + \sigma_{SC} - \sigma_{SC^\star}\right)}}_{\text{share of } C^\star \text{ risk that can be hedged with } L} \qquad (2)
\end{aligned}$$

Return

Efficient liability diversification

Similarly for the "Efficient" share of foreign liability $\widehat{\lambda}$:

$$\frac{\partial \Sigma^2_{global}}{\partial \lambda} = 0 \mid \psi \text{ constant}$$

$$\begin{aligned}
\widehat{\lambda}_{global} = & \frac{\sigma_L^2 - \sigma_{LL^\star} - \sigma_{SL}}{\sigma_L^2 + \sigma_{L^\star}^2 + \sigma_S^2 - 2(\sigma_{LL^\star} + \sigma_{SL} - \sigma_{SL^\star})} \\
& + \psi \left(\frac{1+I}{I}\right) \frac{\sigma_S^2 + \sigma_{SL^\star} - \sigma_{SL}}{\sigma_L^2 + \sigma_{L^\star}^2 + \sigma_S^2 - 2(\sigma_{LL^\star} + \sigma_{SL} - \sigma_{SL^\star})} \\
& + \underbrace{\psi \left(\frac{1+I}{I}\right) \frac{\sigma_{L^\star C^\star} + \sigma_{SC^\star} - \sigma_{LC^\star}}{\sigma_L^2 + \sigma_{L^\star}^2 + \sigma_S^2 - 2(\sigma_{LL^\star} + \sigma_{SL} - \sigma_{SL^\star})}}_{\text{share of } L^\star \text{ risk that can be hedged with } L^\star} \\
& + \underbrace{(1-\psi) \left(\frac{1+I}{I}\right) \frac{\sigma_{SC} + \sigma_{L^\star C} - \sigma_{LC}}{\sigma_L^2 + \sigma_{L^\star}^2 + \sigma_S^2 - 2(\sigma_{LL^\star} + \sigma_{SL} - \sigma_{SL^\star})}}_{\text{share of } L^\star \text{ risk that can be hedged with } C}
\end{aligned} \tag{3}$$

Return

The FX channel

On the asset side

- Following empirical literature (Ehrmann et al. [2011]) : $\sigma_{SC^\star} > 0$ and $\sigma_{SC} < 0$

  Assuming that $\sigma_{SC} = -\sigma_{SC^\star}$ and :

  - ▷ $\psi = 0.5$: FX channel=0
  - ▷ $\psi > 0.5$: a positive shock on $\{r, r^\star\}$ goes with a foreign currency appreciation
    - ▷ Converted asset returns increase, thus :
    - A relatively low λ increases Σ^2 (i.e when $\frac{\psi}{\lambda} > \frac{l}{1+l}$) : no compensation
    - A relatively large λ decreases Σ^2 (i.e when $\frac{\psi}{\lambda} < \frac{l}{1+l}$) : compensation
  - ▷ $\psi < 0.5$: a positive shock on $\{r, r^\star\}$ goes with a foreign currency depreciation
    - ▷ Converted asset returns decrease, thus :
    - A relatively low λ decreases Σ^2 (i.e when $\frac{\psi}{\lambda} > \frac{l}{1+l}$) : compensation
    - A relatively large λ increases Σ^2 (i.e when $\frac{\psi}{\lambda} < \frac{l}{1+l}$) : no compensation

- When $\psi = \lambda = 0$, or when $\frac{\psi}{\lambda} = \frac{l}{1+l}$, FX channel=0

Return

DCC GARCH

Two steps : 1) estimate the conditional volatility of each one of the two series $\{i, j\}$ from univariate GARCH(1,1) ; 2) capture from the first step the dynamic correlation between the two series.
Suppose r_t a 2x1 vector of returns of 2 assets at time t, H_t a 2x2 matrix of conditional variances of r_t at time t and z_t a 2x1 vector of iid errors such that $E[z_t] = 0$ and $E[z_t z_t^T] = I$. Then, univariate GARCH is such that :

$$r_t = H_t^{1/2} z_t \tag{4}$$

Decomposing the covariance matrix H_t into conditional standard deviation D_t from univariate GARCH, and a correlation matrix R_t capturing the dynamic correlation $\{i, j\}$, the DCC GARCH introduces the following extension :

$$H_t = D_t R_t D_t \tag{5}$$

Where the varying conditional correlation matrix R_t is defined as :

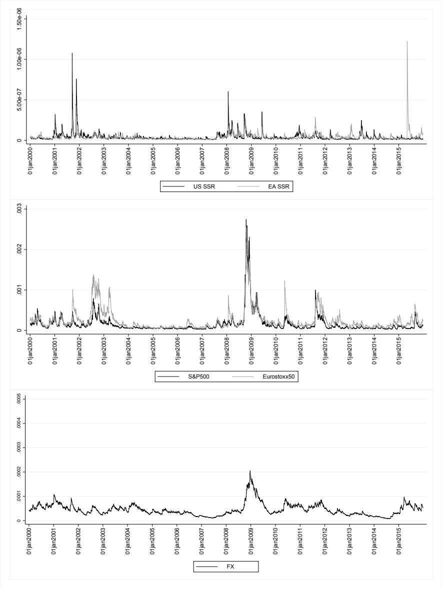
$$R_t = (I \odot Q_t)^{-1/2} \, Q_t \, (I \odot Q_t)^{-1/2} \tag{6}$$

$$Q_t = (1 - a - b)\bar{Q} + a\epsilon_{t-1}\epsilon_{t-1}^T + bQ_{t-1} \tag{7}$$

Therefore, the dynamic matrix process Q_t is a function of $\bar{Q}$, the unconditional correlation matrix of the standardized errors ϵ_t. Our results suggest that all correlations are mean-reverting process where $(a + b) < 1$. Additionally, all Wald tests reject the null hypothesis where $a = b = 0$: conditional correlations are dynamic.

Return

Conditional variance



Identification of financial distress :

- 2001-2002 : the bursting of the dotcom bubble
- 2008-2009 : the subprime crisis
- 2008 : peak in volatility

Assets are more volatile :

- $\{\sigma_C, \sigma_{C^\star}\} > \{\sigma_S\} > \{\sigma_L, \sigma_{L^\star}\}$

US Vs EA volatility :

- $\sigma_C > \sigma_{C^\star}$ except for 2008
- $\sigma_L > \sigma_{L^\star}$ for 2000, 2003, 2009 and since 2011

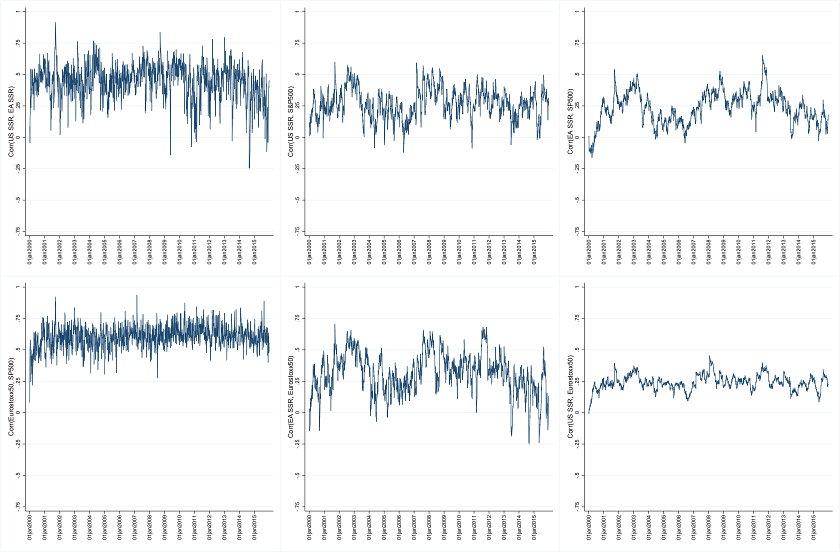
Conditional variance

	$\sigma^2_{C^\star}$	σ^2_C	σ^2_S	$\sigma^2_{L^\star}$	σ^2_L
2000	1.80e-04	2.12e-04	5.72e-05	2.47e-08	2.91e-08
2001	1.86e-04	2.81e-04	6.17e-05	1.14e-07	4.83e-08
2002	1.86e-04	2.81e-04	6.17e-05	1.14e-07	4.83e-08
2003	1.24e-04	3.11e-04	4.53e-05	3.32e-08	3.61e-08
2004	6.07e-05	9.75e-05	4.75e-05	2.87e-08	2.66e-08
2005	5.52e-05	7.09e-05	3.63e-05	2.23e-08	1.83e-08
2006	5.27e-05	1.03e-04	2.73e-05	1.87e-08	1.84e-08
2007	1.05e-04	1.17e-04	1.67e-05	3.43e-08	2.44e-08
2008	5.84e-04	5.60e-04	6.22e-05	9.43e-08	8.33e-08
2009	2.98e-04	3.34e-04	7.61e-05	3.74e-08	4.59e-08
2010	1.30e-04	2.30e-04	5.59e-05	3.93e-08	2.76e-08
2011	2.03e-04	3.28e-04	5.77e-05	4.05e-08	6.08e-08
2012	8.13e-05	1.95e-04	3.38e-05	2.25e-08	3.54e-08
2013	6.29e-05	1.17e-04	2.47e-05	3.87e-08	4.92e-08
2014	6.14e-05	1.29e-04	1.70e-05	2.43e-08	2.71e-08
2015	1.01e-04	2.24e-04	5.77e-05	2.23e-08	8.39e-08

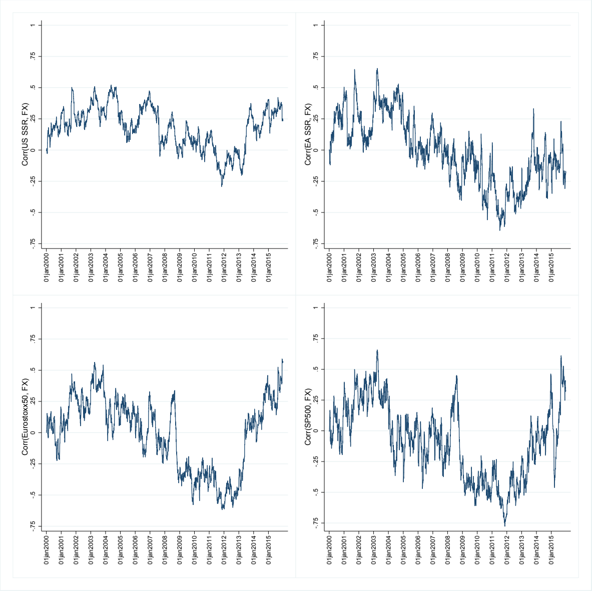
Table: Conditional variances. S, C, $C^\star$, L and $L^\star$ refer to the exchange rate, the eurostoxx 50 index, the S&P500 index, the euro Shadow Short Rate and the US Shadow Short Rate respectively.

Return

Conditional correlations : assets and liabilities



Conditional correlations : foreign exchange rate



Conditional correlations :

	$\rho_{LL^\star}$	$\rho_{CC^\star}$	ρ_{LC}	$\rho_{L^\star C^\star}$	$\rho_{LC^\star}$	$\rho_{L^\star C}$	$\rho_{SL^\star}$	ρ_{SL}	ρ_{SC}	$\rho_{SC^\star}$
2000	0.44	0.52	0.20	0.20	0.04	0.14	0.15	0.21	0.00	0.02
2001	0.48	0.58	0.33	0.28	0.26	0.25	0.27	0.28	0.20	0.21
2002	0.43	0.60	0.49	0.39	0.32	0.27	0.26	0.14	0.22	0.31
2003	0.45	0.60	0.44	0.30	0.32	0.28	0.36	0.40	0.41	0.36
2004	0.50	0.57	0.25	0.20	0.13	0.22	0.41	0.37	0.14	-0.07
2005	0.43	0.58	0.20	0.20	0.14	0.21	0.18	0.10	0.17	-0.04
2006	0.47	0.62	0.23	0.14	0.11	0.16	0.32	0.03	0.01	-0.12
2007	0.51	0.61	0.40	0.35	0.27	0.28	0.22	0.04	0.00	-0.11
2008	0.50	0.59	0.45	0.40	0.37	0.33	0.13	-0.16	-0.01	0.05
2009	0.50	0.64	0.34	0.26	0.28	0.25	0.08	-0.07	-0.35	-0.44
2010	0.44	0.64	0.36	0.27	0.33	0.24	0.04	-0.27	-0.36	-0.44
2011	0.42	0.65	0.45	0.34	0.37	0.30	-0.06	-0.42	-0.44	-0.52
2012	0.43	0.63	0.37	0.28	0.31	0.26	-0.07	-0.35	-0.49	-0.46
2013	0.47	0.62	0.21	0.19	0.17	0.18	0.09	-0.17	-0.09	-0.22
2014	0.36	0.62	0.20	0.26	0.20	0.22	0.23	-0.12	0.17	0.01
2015	0.31	0.59	0.15	0.26	0.13	0.22	0.30	-0.10	0.32	0.15

Table: Conditional correlations. S, C, $C^\star$, L and $L^\star$ refer to the exchange rate, the eurostoxx 50 index, the S&P500 index, the euro Shadow Short Rate and the US Shadow Short Rate respectively.

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