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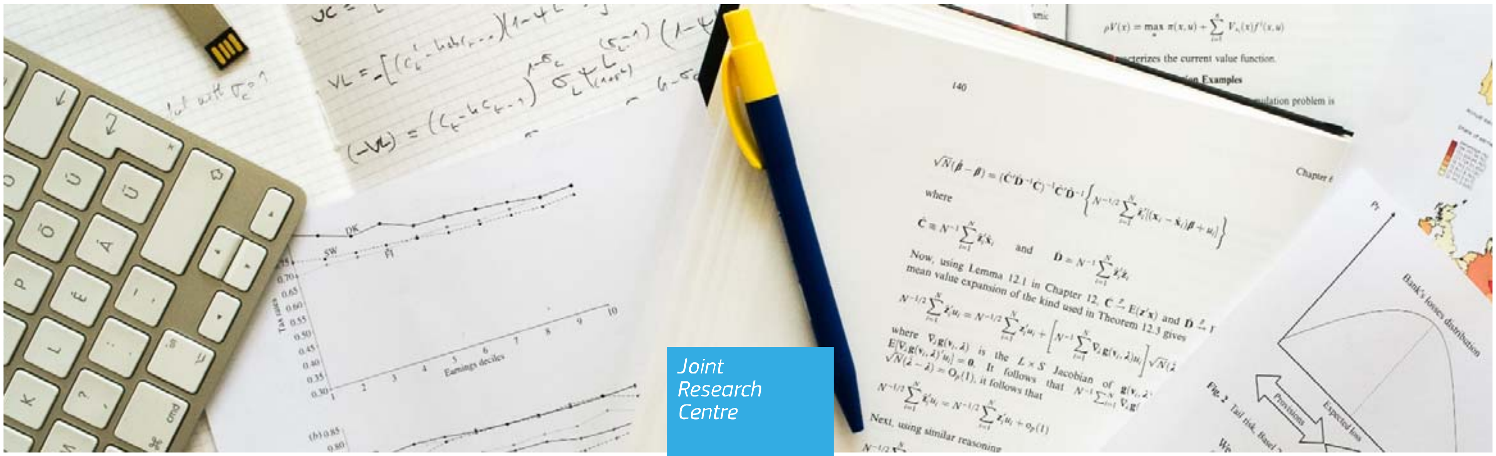

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Exchange rates and the global transmission of equity market shocks

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Abstract

We assess the role played by exchange rates in buffering or amplifying the propagation of shocks across international equity markets. Using copula functions we model the joint dependence between exchange rates and two global equity markets and, from a copula framework, we obtain the conditional expectation and measure the exchange rate contribution to shock propagation between those equity markets. Our estimates for emerging Latin American economies (Argentina, Brazil, Chile and Mexico) and two developed markets (Europe and the USA) document the following: (a) the contribution of exchange rates to the transmission of equity shocks is time varying and asymmetric and differs across countries; and (b) exchange rates diversify shocks from abroad for investors based in emerging economies (particularly Brazil, Chile and Mexico) and echo the effect of shocks from abroad for investors based in developed markets. This evidence has implications for international investors in terms of portfolio and risk management decisions.

Keywords: *Exchange rates; International equity markets; Copulas; Expected shortfall*
JEL code: *C58, F31, G15*

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1 Introduction

Measuring the transmission of shocks across global equity markets is crucial for portfolio and risk management decisions by international investors. The exchange rate is a conduit through which a shock from one global equity market is transmitted to another. However, as a shock transmission mechanism, the exchange rate itself is not neutral. This is because the value of a currency, tied as it is to the value of equity (Hau and Rey 2006), has the capacity to buffer or amplify shock propagation between equity markets.

Our comprehensive empirical study aims to quantify the role of exchange rates in the global transmission of shocks across equity markets. Disentangling the contribution of exchange rates to shock propagation provides essential information to international investors, in that it identifies which portion of a shock coming from abroad originates in foreign equity or currency fluctuations; this enables investors to implement more effective hedging strategies against each type of risk and so increase gains from international portfolio diversification.

Previous empirical studies on co-movement between international equity markets (see, e.g., Christoffersen et al. 2012; Chollete et al. 2011) have analysed global equity market interdependence and international diversification benefits from the perspective of US investors by modelling dependence between domestic US equity returns and foreign returns denominated in USD. However, such analyses preclude having accurate information on the role played by exchange rates in the propagation of shocks between markets and on the real potential and impact of diversification strategies. Interestingly, as the strength of currency dependence differs for each equity market, interdependence between two global equity markets may differ depending on the investors' perspective, i.e., domestic or foreign. Since currency values and equity returns are negatively correlated in developed economies but positively correlated in emerging economies (Cho et al. 2016), co-movement and international diversification opportunities between global equity markets may differ depending on the investor's perspective.

We study dependence between two global equity markets within a trivariate dependence structure that takes into account the exchange rate relationship with each of those global equity markets and then — conditional on that relationship — establishes the nexus between the global equity markets. To capture stylized facts of equity and currency returns data and their dependence, we use flexible copula functions and obtain the conditional copulas from a vine hierarchical dependence structure. Next, from those conditional copulas, we measure the impact of a shock transmitted from one market to another as the conditional expectation of equity returns, which is given by the average returns yielded by one equity market when the other market experiences a shock. This conditional expectation is the expected shortfall (ES), which we draw from a trivariate copula setup assumed to display Markov switching nonlinear dependence features (Chollete et al. 2011). In addition, on the basis of the conditional expectation, we introduce a measure of the exchange rate contribution to shock propagation between equity markets. Finally, we assess how exchange rates can enhance diversification benefits for international portfolios.

We empirically examine the dependence structure for four emerging Latin American equity markets (Argentina, Brazil, Chile and Mexico) and two developed equity markets (USA and EU) taking into account the role of the respective exchange rates. Our empirical results for the period 2002-2020 show that while exchange rates play a key role in transmitting shocks between equity markets, this role is time varying and asymmetric and also varies across currencies; for all the markets except for Argentina, exchange rates make an important contribution to shock transmission that changes across regimes. We also document that exchange rates diversify shocks from abroad for investors based in emerging economies (particularly Brazil, Chile and Mexico) and echo the effect of shocks from abroad for investors based in developed markets.

This research builds on the literature regarding co-movement between international equity markets and international portfolio diversification (see, e.g., Longin and Solnik 1995; Forbes and Rigobon 2002; Ang and Bekaert 2002; Rodriguez 2007; Chollete et al. 2009; Chollete et al. 2011; Christoffersen et al. 2012; Yang et al. 2015). Our particular contribution is that we specifically consider the impact of exchange rates in terms of propagating shocks and asymmetries affecting international portfolio diversification, depending on whether the investor is based in a developed or emerging economy.

Our research is broadly related to the vast theoretical and empirical literature that relates exchanges rates and equity returns. Macroeconomic (Dornbusch and Fischer 1980; Meese and

Rogoff 1983; Frankel 1992; Branson 1981) and portfolio balance (Hau and Rey 2006; Pavlova and Rigobon 2007) theories establish a relationship between currency values and equity returns based on arguments regarding international competitiveness and capital flows to rebalance portfolios. Extant empirical evidence (see, e.g., Ning 2010; Wang et al. 2013; Cho et al. 2016; Reboredo et al. 2016) supports the link between currency values and equity returns in different market circumstances, although evidence on the sign of this dependence is mixed. As a result of return-chasing by investors, Froot et al. (2001); Griffin et al. (2004) and Richards (2005) find a positive relationship between equity returns and local currency values through capital inflows in developing markets. In contrast, using portfolio rebalancing arguments, Hau and Rey (2006) empirically show that currency values and domestic equity returns are negatively correlated for developed economies, whereas Cho et al. 2016 show that these are positively correlated for emerging economies. Using the uncovered equity parity condition, Cenedese et al. (2016) show that the sign and strength of dependence between currency values and equity returns are not clear at the theoretical level, but report empirical evidence of independence between them. Our empirical analysis contributes to this current of the literature by providing copula evidence on dependence between equity returns and currency values and highlighting the role of that dependence in the transmission of shocks between equity markets.

Our study also adds to the systemic risk literature,[1] where ES is a widely used measure, typically computed in a bivariate setting so as to account for the adverse impact of a market downturn on returns (see, e.g., Brownlees and Engle 2016). In order to assess the sensitivity of equity returns to returns in another equity or currency market, we use a trivariate copula-based model to estimate ES that could be useful for assessing systemic risk in a multivariate setting.

Finally, our findings have implications for investment and risk management decisions by international investors, regulatory authorities and policymakers. Firstly, from the perspective of investors in emerging markets, exchange rates offer diversification opportunities for their investments in developed economies, as the developed-country exchange rate moves in the opposite direction to developed-country equity returns, and this has the outcome of buffering extreme downward or upward movements in equity returns. Contrarily, for investors in developed markets, diversification

[1]For a survey of this theoretical and empirical literature see Benoit et al. (2017).

opportunities for their emerging market investments are limited, as the emerging-market exchange rate moves in tandem with equity returns. Secondly, for monetary and supervisory authorities our empirical setup is useful for building tailormade stress-test scenarios that specifically take into account exchange rate and equity dependence in protecting economies against crises, like, e.g., the Turkish currency crisis of 2018. Thirdly, policy makers will find our framework helpful in understanding the impact through exchange rates of equity market distress scenarios on the main economic indicators, e.g., on changes in international investment positions.

The remainder of this paper is laid out as follows: in Section 2 we introduce our empirical methods to characterize multivariate dependence between exchange rates and equity markets, and to quantify the contribution of exchange rates to the propagation of shocks across global equity markets; in Section 3 we describe the data for the studied equity and currency markets; in Section 4 we present and discuss our empirical results, and in Section 5 we discuss the implications of our findings for international investors. Finally, Section 6 concludes the paper.

2 Methodology

This section outlines the modelling approach to characterizing dependence and spillover effects between equity markets in different countries, specifically considering the role of exchange rates in shaping co-movement. We describe conditional copula modelling to compute ES, marginal models and the copula hierarchical dependence structure with Markov switching dynamics.

2.1 Exchange rates and dependence between equity markets

Let r_d and r_f denote domestic (d) and foreign (f) equity returns, and let r_e denote the exchange rate (e) return, with e defined in terms of units of domestic currency per unit of foreign currency. We assume that those returns have continuous distribution functions given by $F_d(r_d) = u_d$, $F_f(r_f) = u_f$ and $F_e(r_e) = u_e$.

Our objective is to characterize dependence between foreign and domestic equity markets by explicitly considering the role played by exchange rates in that dependence. Our motivation is that the impact, on domestic investor portfolios, of price fluctuations in international equity markets is shaped by the size of those fluctuations, by exchange rates, and by the dependence structure between equity markets. First, since the value of foreign log-returns expressed in domestic currency is given by $r_{fe} = r_f + r_e$, the distribution function of r_{fe} is given by the convolution of the distribution of r_f and r_e. This convolution combines marginal and dependence features of both foreign and domestic exchange rates. As a result, exchange rates may amplify or buffer the impact of foreign equity price fluctuations on domestic investor portfolios, while an exchange rate's own fluctuations may also generate shocks in r_{fe}. Second, that impact is also determined by the dependence structure between r_{fe} and r_d. Hence, the spillover and diversification effects of foreign equity markets on domestic investor portfolios requires a good understanding of the dependence structure between foreign equity returns, domestic equity returns and exchange rates.

We model that three-way dependence using copula functions.[2] Copulas offer a flexible way to characterize the multivariate distribution function of random variables by separately modelling marginal and joint dependence features, thus allowing greater flexibility in characterizing complex dependence patterns exhibited by financial data, like asymmetric relationships, joint tail dependence and nonlinearities.[3] From Sklar (1959)'s theorem, the multivariate distribution function, $F(\cdot,\cdot,\cdot)$, for foreign equity returns, domestic equity returns and exchange rates can be obtained from a copula function $C(\cdot,\cdot,\cdot)$ as:

$$F(r_f, r_d, r_e) = C\left(u_f, u_d, u_e\right). \tag{1}$$

Assuming that the copula function and marginal distribution functions are differentiable, the joint density can be decomposed as the product of the marginal densities of each variable, $f_j(\cdot)$ for $j = d, f, e$, and the copula density, $c\left(u_f, u_d, u_e\right)$, that captures dependence between variables:

$$f(r_f, r_d, r_e) = f_f(r_f) f_d(r_d) f_e(r_e) c\left(u_f, u_d, u_e\right). \tag{2}$$

[2] A comprehensive explanation of copula functions can be found in Nelsen (2006) and Joe (1997).

[3] See, for instance, Joe et al. (2010), Nikoloulopoulos et al. (2012), Kim et al. (2013), Reboredo and Ugolini (2016) and Ojea Ferreiro (2020).

We quantify the impact of a foreign equity shock on domestic equity returns (or vice versa) using information from the three-way dependence structure between foreign equity returns, domestic equity returns and exchange rate, as given by the copula function. Specifically, we account for the impact of that shock using the conditional expectation metric, which measures the expected return for domestic equity under the condition that the return for foreign equity is equal to or less than a specific threshold value c: $E\left(r_d | r_f \leq c; r_e\right)$. A usual choice for the threshold c is the value-at-risk (VaR), defined for a level of confidence α as $P(r_f \leq VaR_\alpha(r_f)) = \alpha$. Using the copula function, we can obtain the conditional expectation for domestic equity returns in a distress scenario for the foreign equity market defined by its VaR at the level α as:[4]

$$E\left(r_d | r_f \leq VaR_\alpha(r_f); r_e\right) = \int_0^1 \int_0^1 F_d^{-1}(u_d) \frac{C_{f|d}(C_{f|e}(\alpha|u_e)|C_{d|e}(u_d|u_e))}{\alpha} du_e du_d, \tag{3}$$

where $C_{j|h}(\cdot)$ is the conditional copula or the conditional distribution function of j given h, obtained from the partial derivative of the copula function as:

$$C_{j|h}\left(u_j|u_h\right) = \frac{\partial C_{j,h}\left(u_j, u_h\right)}{\partial u_h}. \tag{4}$$

Likewise, for an upward movement in foreign equity returns above the VaR level at the $1-\alpha$ confidence level, we can obtain the conditional expectation for domestic equity returns as:

$$E\left(r_d | r_f \geq VaR_{1-\alpha}(r_f); r_e\right) = \int_0^1 \int_0^1 F_d^{-1}(u_d) \frac{1 - C_{f|d}(C_{f|e}(1-\alpha|u_e)|C_{d|e}(u_d|u_e))}{\alpha} du_e du_d. \tag{5}$$

Quantifying the impact of shocks from domestic to foreign equity returns is straightforward, i.e., we exchange d and f in Eqs. (3) and (5). Likewise, and following from Eqs. (3) and (5), the impact of downward or upward exchange rate movements on domestic equity returns can be quantified by exchanging e and f.

As shocks from either foreign equity returns or exchange rates may have an impact on the conditional expected value of domestic equity returns, we can assess the contribution of each

[4]The proof of Eqs. (3) and (5) is provided in the Appendix C. Note that the variable after the semicolon, i.e., r_e, in Eqs. (3) and (5) does not imply conditionality. It is merely a way to explicitly show that the exchange rate returns play a pivotal role in the hierarchical dependence structure.

kind of shock to changes in domestic equity returns by considering the difference between their conditional and unconditional expected values. Thus, the contributions to domestic equity returns of a downward movement in foreign equity returns, sharp exchange rate depreciation and sharp exchange rate appreciation are defined, respectively, as:

$$\begin{aligned} \gamma_f(\alpha) &= E\left(r_d | r_f \leq VaR_\alpha(r_f); r_e\right) - E(r_d), \\ \gamma_e^L(\alpha) &= E\left(r_d | r_e \leq VaR_\alpha(r_e); r_f\right) - E(r_d), \\ \gamma_e^U(1-\alpha) &= E\left(r_d | r_e \geq VaR_{1-\alpha}(r_e); r_f\right) - E(r_d). \end{aligned} \tag{6}$$

We can therefore define, for scenarios of sharp currency depreciation or appreciation, the relative contribution of a shock in foreign equity returns to the ES of domestic equity returns as:

$$\begin{aligned} \theta_f^L(\alpha) &= \frac{|\gamma_f(\alpha)|}{|\gamma_f(\alpha)| + |\gamma_e^L(\alpha)|} \\ \theta_f^U(\alpha) &= \frac{|\gamma_f(\alpha)|}{|\gamma_f(\alpha)| + |\gamma_e^U(1-\alpha)|}, \end{aligned} \tag{7}$$

where $\gamma_f(\alpha)$, $\gamma_e^L(\alpha)$ and $\gamma_e^U(\alpha)$ are taken as absolute values, since they may be positive or negative depending on the conditional dependence. We can obtain, in a similar way, the relative contribution of an upward and downward exchange rate shock as $\theta_e^L(\alpha)$ and $\theta_e^U(\alpha)$, respectively, each taking a value between 0 (no contribution) and 1 (maximum contribution). Note that, by construction, $\theta_f^L(\alpha) + \theta_e^L(\alpha) = 1$ and $\theta_f^U(\alpha) + \theta_e^U(\alpha) = 1$.

2.2 Modelling conditional copulas

We now describe how to obtain the conditional copulas necessary to compute the impact of the shocks described above. Those conditional copulas can be derived from a hierarchical dependence structure that decomposes the multivariate copula in Eq. (1) into a cascade of bivariate copulas, in a decomposition called a vine copula.[5] Vine copulas are obtained from decomposition of the joint probability density by iterative conditioning. Thus, the joint density for the three variables, i.e.,

[5]For an introduction to vine copulas, see Joe (1996), Bedford and Cooke (2002) and Aas et al. (2009).

foreign equity returns, domestic equity returns and exchange rates, in Eq. (2) can be factorized recursively as

$$f(r_f, f_d, r_e) = f(r_e)f(r_f|r_e)f(r_d|r_f, r_e).$$

where, using copulas, the first conditional density can be decomposed as

$$f(r_f|r_e) = c_{f,e}(F_f(r_f), F_e(r_e))f_f(r_f),$$

and the second conditional density can be decomposed as

$$f(r_d|r_f, r_e) = c_{f,d|e}\left(F_f(r_f|r_e), F_d(r_d|r_e)\right) f(r_d|r_e),$$

with $f(r_d|r_e) = c_{d,e}(F_d(r_d), F_e(r_e))f_d(r_d)$ and $F_k(r_k|r_l) = C_{k|l}\left(F_k(r_k)|F_l(r_l)\right)$, where $C_{k|l}(u_k|u_l)$ is defined by Eq. (4). Hence, the joint density of the three variables can be written as a function of their marginals and bivariate copulas as:

$$f(r_f, r_d, r_e) = \underbrace{c_{f,d|e}\left(F_f(r_f|r_e), F_d(r_d|r_e)\right) c_{f,e}(F_f(r_f), F_e(r_e))c_{d,e}(F_d(r_d), F_e(r_e))}_{c(u_f,u_d,u_e)} f(r_f)f(r_d)f(r_e). \tag{8}$$

The main appeal of the decomposition in Eq. (8) is that each bivariate copula can be selected independently from different copula types, ensuring, thus, greater flexibility in capturing multivariate dependence than the use of a trivariate copula as in Eq. (2). Furthermore, this density decomposition can be graphically represented by a hierarchical structure between f, d and e, whether given by a C-vine copula, where e is the pivotal variable, or by a D-vine copula, where e is the central node. Figure 1 represents the graph-based tree structure of the copula decomposition for the three variables, showing the hierarchical construction under a C-vine copula (left panel) and under a D-vine copula (right panel); note that the copula structure chosen for both is the same.

[Insert Figure 1 here]

Interestingly, from the bivariate or pair copulas in Eq. (8) we can obtain the conditional copulas as per Eq. (4) that are necessary to compute the conditional ES in Eqs. (3) and (5).

As essential information for the computation of spillover effects, we model bivariate dependence using different copula specifications to capture the main dependence features in time series, including tail independence and symmetric and asymmetric tail dependence. Specifically, we consider: (a) the Gaussian copula, which does not present tail dependence and allows for positive association and negative association; (b) the student-t copula, which (like the Gaussian) allows for positive association and negative association but presents symmetric tail dependence; (c) the Gumbel and Clayton copulas, which allow for positive asymmetric association with lower tail dependence and upper tail independence, and lower tail dependence and upper tail independence, respectively; and (d) the BB1 copula which allows for positive asymmetric association with lower and upper tail dependence. Table 1 summarizes the main features of the bivariate copulas we use in our empirical analysis.

[Insert Table 1 here]

We further take into account that the dependence structure changes over time by using a regime-switching model with two states (as in Pelletier (2009), Rodriguez (2007), Garcia and Tsafak (2011), Chollete et al. (2009) and Ojea Ferreiro (2019)), namely, state 1 and state 2. Each state has an economic interpretation that depends on the strength and sign of the average and tail dependence observed within that state. In state 1 the relationship between two variables is represented by elliptic copulas, whereas the relationship in state 2 is represented by copulas exhibiting different forms of tail dependence. Those two states are not directly observable, but can be identified during estimation of the copula parameters. Thus, the dependence structure is assumed to depend on an unobserved latent binary variable s_t indicating the regime at time t ($s_t = 1$ or $s_t = 2$) and following a Markov chain with the following transition probability matrix:

$$P = \begin{bmatrix} p_{11} & 1 - p_{11} \\ 1 - p_{22} & p_{22} \end{bmatrix}, \tag{9}$$

where $p_{ij} = P(s_t = j | s_{t-1} = i)$ refers to the probability of moving from state i at time $t-1$ to state j at time t, with $\sum_{j=1}^{2} p_{ij} = 1$ for $i = 1, 2$. As in Chollete et al. (2009), we consider that the regime only affects the dependence structure, so the joint density conditional on being in regime

j ($j = 1, 2$) is given by:

$$f(r_f, r_d, r_e | s_t = j) = c^{(j)}_{f,d|e}\left(u_f|u_e, u_d|u_e; \theta^{(j)}_{f,d|e}\right) c^{(j)}_{f,e}(u_f, u_e; \theta^{(j)}_{f,e}) c^{(j)}_{d,e}(u_d, u_e; \theta^{(j)}_{d,e}) f(r_f) f(r_d) f(r_e), \tag{10}$$

where $\theta^{(j)}_{(\cdot)}$ denotes the set of copula parameters in state j.

2.3 Modelling marginal densities

We model the marginal densities of d, f and e returns in Eq. (2) by considering that their means and variances display dynamic behaviour characterized, respectively, by an autorregressive moving average (ARMA) model and by a Glosten-Jagannathan-Runkle generalized autoregressive conditional heteroskedasticity (GJR-GARCH) model. Specifically, the returns for asset h ($h = d, f, e$) at time t can be expressed as:

$$r_{h,t} \quad = \quad \mu_{h,t} + \sigma_{h,t}\varepsilon_{h,t}, \tag{11}$$

where the mean returns are $\mu_{h,t} = \phi_{h,0} + \sum_{k=1}^{p} \phi_{h,k} r_{h,t-k} + \sum_{l=1}^{q} \psi_{h,l}\sigma_{h,t-l}\varepsilon_{h,t-l}$, with p and q denoting the number of lags of the AR and MA structures, respectively. $\varepsilon_{h,t}$ is an $i.i.d.$ random variable with zero mean and unit variance that is assumed to follow a Hansen (1994)'s skewed-t distribution, capturing higher moments such as skewness and kurtosis. The skewed-t distribution is given by:

$$F_h(\varepsilon_{h,t}|\eta_h, \lambda_h) = \begin{cases} bc(1 + \frac{1}{\eta_h - 2}(\frac{b\varepsilon_{h,t}+a}{1-\lambda_h})^2)^{-(\eta_h+1)/2} & \varepsilon_{h,t} < -a/b \\ bc(1 + \frac{1}{\eta_h - 2}(\frac{b\varepsilon_{h,t}+a}{1+\lambda_h})^2)^{-(\eta_h+1)/2} & \varepsilon_{h,t} \geq -a/b \end{cases}, \tag{12}$$

where $2 < \eta_h < \infty$ and $-1 < \lambda_h < 1$. The constants a, b and c are given by:

$$a = 4c\lambda_h \left(\frac{\eta_h - 2}{\eta_h - 1}\right), b = \sqrt{1 + 3\lambda_h^2 - a^2}, c = \frac{\Gamma(\frac{\eta_h+1}{2})}{\sqrt{\pi(\eta_h - 2)}\Gamma(\frac{\eta_h}{2})}.$$

Note that, for $\lambda_h = 0$, Eq. (12) reduces to the standard Gaussian distribution as $\eta_h \to \infty$, while, for $\lambda_h = 0$ and η_h finite, Eq. (12) is the standardized symmetric-t distribution. Finally, the dynamics of the return variance, $\sigma^2_{h,t}$, is given by:

$$\sigma^2_{h,t} = \omega_h + \beta_h \sigma^2_{h,t-1} + (\alpha_h + \gamma_h \mathbb{1}_{\epsilon_{h,t-1}<0})\epsilon^2_{h,t-1}, \tag{13}$$

where ω_h is a constant, β_h and α_h are the parameters of the generalized and autoregressive conditional heteroskedasticity effects; and $\mathbb{1}_{\epsilon_{h,t-1}<0}$ is an indicator function that is valued at 1 if $\epsilon_{h,t-1} < 0$ and 0 otherwise. Thus, γ_h captures leverage effects; in other words, negative shocks have more impact on variance than positive shocks. When $\gamma_h = 0$ we have the usual GARCH model.

2.4 Estimation

We estimate the parameters of the copula and marginal models using a two-step procedure called inference function for margins (IFM), whereby marginal distributions and copulas are estimated separately (see, e.g., Oakes 1994; Genest et al. 1995; Shih and Louis 1995). In a first step, marginal model parameters are estimated using maximum likelihood, while in a second step, copula parameters are estimated from the pseudo-observations obtained from the estimated marginals. The pseudo-likelihood to be maximized in the second step is given by $\sum_t L_t(\hat{u}_{f,t}, \hat{u}_{e,t}, \hat{u}_{d,t})$, with $\hat{u}_{h,t}$ $(h = d, e, f)$, computed at each time t as $\hat{F}_h\left(\frac{r_{h,t}-\hat{\mu}_{h,t}}{\hat{\sigma}_{h,t}}\right)$. The likelihood value at time t is given by a mixture of two copulas, with weights determined by the likelihood of being in each state, calculated as:

$$\begin{aligned} L_t(\hat{u}_{f,t}, \hat{u}_{e,t}, \hat{u}_{d,t}; I_{t-1}, \Theta) &= c(\hat{u}_{f,t}, \hat{u}_{c,t}, \hat{u}_{d,t}|\Theta_{s_t=1}, I_{t-1})P(s_t = 1|I_{t-1}) \\ &\quad + c(\hat{u}_{f,t}, \hat{u}_{c,t}, \hat{u}_{d,t}|\Theta_{s_t=2}, I_{t-1})P(s_t = 2|I_{t-1}), \end{aligned} \tag{14}$$

where Θ includes the set of copula parameters that characterize dependence in both states, i.e., $\Theta_{s_t=j} = [\theta^{(j)}_{f,d|e}, \theta^{(j)}_{f,e}, \theta^{(j)}_{d,e}]'$, and where $P(s_t = j|I_{t-1})$ is the probability of being in state j at $t+1$ given the set of information I_{t-1} available at $t-1$. Trivariate copulas in Eq. (14) can be decomposed into bivariate copulas as in Eq. (8).

Joe and Xu (1996) show that the parameters estimated using the IFM approach are consistent and asymptotically normal. However, since those estimates are less efficient than the full estimates

(Joe 2005, Patton (2006); Patton 2012), we use a Monte Carlo procedure to compute the covariance matrix, consisting of simulating and re-estimating the model N times in order to obtain the distribution of the estimated parameters.

Finally, we choose the most suitable copula function using the Akaike information criterion corrected for small-sample bias (AICc),[6]

$$AICc = 2k\frac{T}{T-k-1} - 2\log(\hat{L}),$$

where T is the sample size, k is the number of estimated parameters and $\hat{L}$ is the log-likelihood value. The minimum AICc value indicates the best copula fit.

3 Data

We take equity data for Argentina, Brazil, Chile and Mexico, as key Latin American economies in terms of GDP, and for the USA and the EU, given the close trade and financial relationships with the above-mentioned countries. We also take exchange rates for the USD and EUR against each of the Latin American currencies (Argentine peso, Brazilian real, Chilean peso and Mexican peso).

Equity returns are represented by (log) changes in stock market indices for each market: S&P MERVAL for Argentina; BOVESPA for Brazil; S&P CLX IGPA for Chile; S&P/BMV IPC for Mexico; STOXX EUROPE 600 for the EU; and S&P 500 COMPOSITE for the USA. Exchange rates are defined in terms of developed-market units of currency per unit of emerging-country currency, with an increase in the exchange rate meaning depreciation (appreciation) of the currency of the developed (emerging) market against the currency of the emerging (developed) market.

Data, sourced from Datastream, covers the period 11 January 2002 to 28 February 2020, with the starting date determined by the end of exchange rate pegging of the Argentine peso to the USD.[7] To avoid time zone differences, daily returns data was aggregated to a weekly frequency

[6]This criteria has been previously used to select the best copula fit in the conditional risk measure literature (see, e.g., Brechmann and Schepsmeier (2013), Reboredo and Ugolini (2015a), Reboredo and Ugolini (2015b), Reboredo and Ugolini (2016), Rodriguez (2007), Ojea Ferreiro (2019), Reboredo (2011) and Ojea Ferreiro (2020)).

[7]On 6 January 2002 the Convertibility Law was partially derogated, eliminating currency conversion operations

(Friday-Friday). The sample period includes several crises, including the global financial crisis and European debt crisis from 2008, with large oscillations in equity and currency values that might impact on their interdependence.

Figure 2 depicts temporal dynamics for the equity market indices in emerging and developed economies (values expressed in their different currencies). Visual inspection reveals that the intensity of co-movement between indices differs depending on the investor's perspective. While all the Latin American markets co-move with the two developed markets when equity market indices are expressed in their respective currencies, co-movement for emerging-market investors is considerably lower than co-movement for developed-market investors (indices denominated in the emerging-market currency and in the developed-market currency, respectively). Pairwise correlation analysis and Table 2 confirm this graphical intuition. In Table 2, panel A shows that correlations between the Latin American and the EU and US equity market returns expressed in their respective currencies are relatively high, while panel B shows that correlations also remain relatively high from the perspective of developed-market investors, i.e., when emerging market returns are converted to EUR or USD. However, panel C in Table 2 shows that, from the perspective of emerging-market investors, correlations between returns for the emerging markets and the developed markets expressed in the emerging-market currencies are considerably reduced, most especially for Brazil. Diversification benefits, therefore, vary for domestic and foreign investors operating in the same markets.

[Insert Figure 2 here]

[Insert Table 2 here]

Table 3 presents correlation evidence for equity returns and currency values. Panel A reports correlations for emerging markets, documenting a positive and high linear dependence between emerging-market equity returns and currency values against the EUR and USD. An exception is Argentina, where there is no linear association between equity and currency returns, which might be explained by the particular monetary and debt conditions of this country during the sample period Galindo et al. (2003), and by the large number of highly internationalized companies included in the

between the Argentine peso and the USD.

MERVAL index. The correlation evidence for emerging economies is consistent with the empirical results reported by Cho et al. (2016), even though correlation is not universally positive for all those countries (e.g., not for Argentina). Panel B reports correlations for developed markets, documenting a negative linear association that is consistent with theoretical results reported by Hau and Rey (2006). The fact that the sign of the correlations between currency values and equity returns differs depending on the investor's perspective has implications for the role played by exchange rates in transmitting shocks between international equity markets, as quantified below.

[Insert Table 3 here]

Table 4 presents descriptive statistics for equities and currencies. Panel A contains descriptive statistics for equity returns for each market, showing average annualized returns of 3.3% in developed markets versus 13.6% in emerging markets, with average annual standard deviations of 17.5% and 23.6%, respectively. Returns distributions are not normal and exhibit negative skewness and fat tails. Also evident is a wider average interquartile range for returns for emerging markets than for developed markets. All equity return series are heteroskedastic and show autocorrelation, while the null of normality is rejected. Panel B contains descriptive statistics for exchange rates, showing negative average returns and documenting Argentine peso and Brazilian real values that are more volatile than the values of other currencies. All currency returns show negative skewness and fat tails, but especially the Argentine peso. Normality is rejected, and heteroskedasticity and autocorrelation are common across all currency series.

[Insert Table 4 here]

4 Results

4.1 Marginal and copula model results

Table 5 presents marginal model parameter estimates according to Eqs. (11)-(13) for equity returns and exchange rates. Lag parameters in the mean and variance equations were chosen so as to minimize the AICc values. Panel A in Table 5, referring to equity returns, shows that average returns display no serial correlation and (as is commonly found in the literature) volatility is persistent, with positive leverage effects that are larger in developed markets than in emerging markets. Likewise, we find consistent evidence of asymmetries and fat tails in the distribution functions for equity returns. Goodness-of-fit tests of model residuals indicate that there is no remaining correlation or heteroskedasticity in the model residuals, and that the skewed-t distribution adequately accounts for returns features, as the standardized model residuals are uniform (0,1) according to the Kolmogorov-Smirnov (KS) and Anderson-Darling (AD) tests.

[**Insert Table 5 here**]

Panel B in Table 5, referring to exchange rates, shows that most exchange rates display no serial correlation and that volatility persistence for the emerging-market currencies is higher against the USD than against the EUR. Likewise, empirical estimates are consistent with positive leverage effects in exchange rate volatility that are of a smaller size than for equity returns. Exchange rates are well characterized by an asymmetric distribution (with the exception of the Argentine and Chilean pesos against the EUR) with fat tails. Goodness-of-fit tests of model residuals indicate that the null hypothesis of correct specification of serial correlation, ARCH effects and the distribution model could not be rejected at the 1% level.

Parameter estimates of the Markov switching paired copulas for the four Latin American countries with the EU and USA are presented in Table 6 (panels A to D, reporting empirical evidence for Argentina, Brazil, Chile and Mexico, respectively), showing results for the best copula fit according to the AICc. Panel A in Table 6 reports dependence estimates for Argentina that show that the value of the EUR against the Argentine peso is negatively correlated with equity returns in Argentina and the EU in state 1, while average dependence is low in state 2. Likewise, we find no evidence of tail dependence in state 1 between exchange rates and equity returns. In contrast, the value of the USD against the Argentine peso is independent of equity returns in both states, with no evidence of tail dependence. As for dependence between equity returns conditional on exchange rates, we find evidence of positive dependence between equity returns in Argentina and the EU that is stronger in state 1 than in state 2, and evidence of tail dependence as given by the student-t copula and the BB1 copula in states 1 and 2, respectively. Likewise, the link between equity returns in Argentina and the USA is significantly positive and stronger in state 1 than in state 2, with weak evidence of tail dependence. Finally, transition probabilities show high persistence, while the dynamics of smooth probabilities of each state differ between Argentina with the EU and Argentina with the USA, being more volatile for the USA, as shown in Panel A of Figure 3.

[**Insert Table 6 here**]

[**Insert Figure 3 here**]

Panel B in Table 6 reports dependence estimates for Brazil that show that the value of the EUR against the Brazilian real is positively correlated with Brazilian and EU equity returns in states 1 and 2, although we find tail independence in state 1 and some evidence of tail dependence (mainly upper tail dependence) in state 2. Evidence is similar for the relationship between the USD against the Brazilian real, although the dependence is higher in states 1 and 2 for the USD than for the EUR. As for dependence between equity markets conditional on exchange rates, our results indicate that conditional dependence is stronger in state 1 than in state 2 for both the Brazil-EU and Brazil-USA pairs, and also that there is consistent evidence of tail independence. Transition probabilities are persistent and the dynamics of smoothed probabilities, as shown in Panel B of Figure 3, show more persistence for the Brazil-EU pair than for the Brazil-USA pair.

Panel C in Table 6 reports dependence estimates for Chile that show that the value of the EUR against the Chilean peso is associated with equity returns in Chile and the EU; however, there is evidence of tail independence between the exchange rate and the equity markets in the EU and Chile. Empirical evidence is also consistent with a positive link between the USD exchange rate against the Chilean peso with equity returns in Chile and the USA, with an intensity that depletes in state 2. In addition, evidence on dependence between equity markets conditional on exchange rates indicates that this dependence is positive and greater for the link between the Chilean and US equity markets than for the link between the Chilean and EU equity markets, with dependence in state 2 increasing for the latter and reducing for the former. Transition probabilities show high persistence in both regimes, while plots of smoothed probabilities in Panel C of Figure 3 show an abrupt transition between states for both EU-Chile and USA-Chile.

Panel D in Table 6 reports dependence estimates for Mexico, showing that EUR and USD exchange rates against the Mexican peso are positively correlated with equity returns in the EU and the USA, respectively. Moreover, this correlation is greater in state 1 than in state 2, while evidence of tail dependence is weak, except for the nexus between the USD exchange rate and US equity returns. Likewise, empirical evidence is that dependence between the Mexican equity market and the EU and US equity markets is strongly positive. Transition probabilities for both regimes are highly persistent, while smoothed probabilities, as plotted in Panel D of Figure 3, show that regime changes are more frequent for USA-Mexico than for EU-Mexico.

Overall, our dependence results from pair-copulas point to the following: (a) with the exception of the Argentine peso, emerging-market currency values move in tandem with emerging-market equity returns, but not developed-market currency values with developed-market equity returns; (b) dependence between exchange rates and equity returns changes through states, being lower or negligible in state 2; (c) developed and emerging equity markets show positive dependence, with intensities that differ depending on the state; and finally (d) there is mixed evidence of tail dependence that varies across markets and states. This evidence on dependence between exchange rates and equity markets has implications in terms of shock transmission that are quantified below.

4.2 Expected shortfall and relative contribution to shock transmission

This subsection presents estimates of the expected domestic (foreign) equity returns conditional on distress scenarios in the foreign (domestic) equity market or in exchange rates, along with assessments of their relative contributions to conditional expectation. We compute, at each time t, the impact of each shock using the conditional expectation, following Eq. (3), for a confidence level of 10% ($\alpha = 0.1$), and the relative contribution of an equity shock, following Eq. (7), considering extreme currency appreciation or depreciation scenarios. For each pair formed by a Latin American emerging economy (Argentina, Brazil, Chile, Mexico) and a developed market (EU, USA), we present results on the size and relative contribution of shocks in states 1 and 2 (Figures 4 to 11) using smoothed probabilities from Kim (1994). In Figures 4-11, the A panels refer to the EU market and the B panels to the US market.

4.2.1 Argentina

Panel A in Figure 4 depicts the temporal dynamics of shocks from/to Argentina to/from the EU using the conditional expectation. The first row of graphs show the dynamics of the conditional expected returns, indicating that the impact of a shock from/to the Argentinian equity market to/from the EU equity market in states 1 and 2 is sizeable with respect to the unconditional expected value, but mainly in state 1. The differences in the size of the impact in both states are consistently explained by the fact that the Argentinian and EU equity markets show greater integration in state 1 than in state 2. The dynamics of the conditional expectation also reflect the impact of the global financial crisis of 2008 and, to a lesser degree, the impact of the European sovereign debt crisis of 2010-2011. The additional impact of market uncertainty originating in elections in Argentina in the last quarter of 2019 is reflected in an abrupt drop in the value of the conditional expectation of the Argentinian equity market in both states. The second row of graphs shows the impact of a downside movement in exchange rates, i.e., the impact on equity returns of extreme appreciation (depreciation) in the EUR (Argentinian peso). The fact that the size of that shock differs across states and countries is consistent with the dependence structures reported in Panel A of Table 6. More specifically, appreciation (depreciation) of the EUR (Argentinian peso) has a positive effect on equity returns in state 1 in both markets (although more intense in the Argentinian equity market), whereas in state 2 in contrast, the impact on the EU market is negative and on the Argentinian market is negligible. Finally, the third row of graphs depicts the temporal dynamics of conditional expectation for an upward movement in the exchange rate, i.e., extreme depreciation (appreciation) of the EUR (Argentinian peso), showing reduced equity returns in the EU and Argentina in state 1 in response to extreme EUR depreciation, i.e., a negative effect; in state 2, in contrast, the effect is positive for the EU and negligible for Argentina. Overall, the evidence on the transmission of equity and exchange rate shocks between the Argentinian and EU markets drastically changes across markets and regimes as a result of changes in the dependence structure between states 1 and 2. The relative contributions of equity and exchange rate shocks, as depicted in Panel A of Figure 5, support those findings. The impact of an Argentinian equity market distress scenario on the EU equity market remains stable across time, for an average size of 74% in state 1, reduced in state 2. Note that the contribution reaches maximum values at times when the correlation between exchange rates and equity moves from negative values (state 1) to zero or positive values (state 2). The average contribution is high in state 1 during 2006-2014 and is reduced for the remaining sample period. Regarding shock transmission in the reverse direction (EU to Argentina), average values are low during 2006-2014, at around 90% in state 2 and around 63% in state 1. Differences in the contribution across states and periods indicate that optimal diversification strategies should change considerably across countries and time periods.

[**Insert Figure 4 here**]

[**Insert Figure 5 here**]

Panel B in Figure 4 depicts the temporal dynamics of shocks from/to Argentina to/from the USA using the conditional expectation. The evidence on shock transmission in this case offers a different picture. Although the temporal dynamics of the conditional expectation shows that the effects of a shock are quite similar to those commented previously, the impact changes drastically. In particular, given the evidence on the lack of dependence between exchange rates and equity markets in both regimes, downward movement in exchange rates, i.e., extreme appreciation (depreciation) of the USD (Argentinian peso), has negligible effects on the equity markets in states 1 and 2, while upward movement has no impact on the US equity market and a negligible impact on the Argentinian equity market. As for relative contributions, as depicted in panel B of Figure 5, values are high (low) for the contribution of equity market (exchange rate) shocks, at above 90% in both regimes, with clear implications for international portfolio risk management in terms of the usefulness of hedging against exchange rate movements.

4.2.2 Brazil

Panel A of Figure 6 depicts the dynamics of equity returns for the EU (Brazil) conditional on a distress scenario for the Brazilian (EU) equity market or exchange rate. The first row of graphs shows that the conditional expectation of the Brazilian and EU equity markets for stock-related scenarios is significant, and especially so in state 1, where dependence between equity markets is tighter than in state 2. Moreover, the size of the average impact of a shock from Brazil to the EU is lower than vice versa, because of the smaller difference between unconditional and conditional expected returns for the EU compared to Brazil. Note that the temporal evolution of the conditional expectation reflects the impact of the global and European sovereign debt crises and the oil glut in mid-2014. Regarding the impact of exchange rate shocks, the second row of graphs display the impact on equity returns of a downside movement in exchange rates, i.e., of extreme appreciation (depreciation) of the EUR (Brazilian real). Our estimates indicate a similar impact on the EU equity market of EUR appreciation in both states, while in the Brazilian equity market, the impact in state 2 is slightly greater than in state 1. The last row of graphs shows similar responses, but with the opposite sign, conditional on extreme depreciation (appreciation) of the EUR (Brazilian real). Interestingly, our results indicate that appreciation in the EUR and the corresponding depreciation in the Brazilian real are associated with falls in both EU equity and Brazilian equity returns. Our results indicate that appreciation in the EUR is associated with downward movement in the EU equity market, while the corresponding depreciation in the Brazilian real is associated with downward movement in the Brazilian equity market. Hence, there is an inverse relationship between the value of the EUR and changes in the EU equity market and a direct relationship between the value of the Brazilian real and changes in the Brazilian equity market. This finding is consistent with the correlation evidence reported in Table 3. The implications for the risk diversification strategies of international investors, depending on where they are based, are straightforward. Relative contributions, as displayed in Panel A of Figure 7, show that around 64% of the total shock received by the EU market from Brazil is explained by equity price changes in Brazil in state 1, with contributions reduced in state 2 for an intensity conditional on the exchange rate scenario. Looking at the contribution of EU equity shocks to the Brazilian equity market, the contribution is stable over time, but with a greater impact in state 1 (around 64%) than in state 2.

[Insert Figure 6 here]

[Insert Figure 7 here]

Panel B in Figure 6 shows the results of shock transmission between Brazil and the USA, indicating that the Brazilian equity market is more sensitive to swings in the US equity market than vice versa (in line with findings for Brazil and the EU) and also that the size of shocks is greater in state 1 than in state 2. The impact of exchange rate shocks between Brazil and the USA differs from that between Brazil and the EU. Equity returns in the Brazilian and the US markets fall in state 1 given a scenario where there is extreme appreciation (depreciation) of the USD (Brazilian real, while the same scenario produces an upward (downward) movement in the US (Brazilian) equity market in state 2. Equity returns respond positively to extreme depreciation (appreciation) of the USD (Brazilian real) in state 1, while the same scenario triggers US equity losses and Brazilian equity gains in state 2. This occurs because of the shift in the dependence structure between US equity returns and exchange rates, which switches from positive to negative between states 1 and 2. Accordingly, the USD moves in the opposite direction to the US equity market in state 1 and in tandem in state 2, whereas the Brazilian real moves in tandem with Brazilian equity returns in both states. Relative contributions, as depicted in panel B of Figure 7, reflect that between 50% and 60% of the shocks to US equity from Brazil are explained by changes in the value of Brazilian equity, with peaks of around 90% explained by a positive to negative change in dependence between the US equity market and the USD-Brazilian real exchange rate. Similarly, the impact of shocks from the US to Brazilian equity markets changes, depending on exchange rate movements and also movement between states, with contributions of about 55% (between 28% and 50%) for appreciation (depreciation) of the Brazilian real.

4.2.3 Chile

Panel A in Figure 8 presents the evolution of the conditional mean EU (Chilean) equity returns given a shock from Chile (EU). It can be observed from the first row that both equity markets are more sensitive to shocks in state 2 than in state 1 because of stronger dependence. The impact of shocks in both states is more intense in periods of turmoil (during the global financial and European sovereign debt crises), while impact differences between states are greater in the EU than in Chile. The second row provides evidence on the impact of a downside movement in exchange rates, i.e., extreme appreciation (depreciation) of the EUR (Chilean peso). Dependence between exchange rates and equity markets is more intense for the EU than for Chile, with the resulting greater impact on the EU equity market. The third row leads to the same conclusion, as intensity can be extrapolated for a scenario where the EUR experiences strong depreciation. This finding (as for Brazil) points to an inverse relationship between the EUR and EU equity market movements and a direct relationship between the Chilean peso and Chilean equity market movements. This conditional expectation result is consistent with the correlation analysis in Table 3 and the copula estimates in Table 6. Panel A in Figure 9 shows that the relative contributions of Chilean equity shocks to the EU equity market differ in size depending on the state, being greater in state 2 ($\approx$ 73%) than in state 1 ($\approx$ 40%). Shocks in the opposite direction have greater intensity in state 2 than in state 1, with differences depending on the direction of exchange rate movement: for appreciation (depreciation) of the Chilean peso, the contribution is 84% (72%) in state 2 and 72% in state 1. Consequently, there is little gain for a Chilean investor hedging an equity portfolio of EU investments against exchange rate fluctuations, most especially in state 2.

[**Insert Figure 8 here**]

[**Insert Figure 9 here**]

Panel B in Figure 8 presents evidence on shock transmission between Chile and the USA. The first row shows that the impact of equity market shocks from/to Chile to/from the USA is similar in size, with no great difference in intensity across states. Conditional expectation estimates for the Chile-USA equity markets point to greater sensitivity to extreme movements in the exchange rate than in the Chile-EU equity markets. While losses occur in both states when the USD (Chilean peso) appreciates (depreciates) in value, those losses are higher in the US equity market than in the Chilean equity market. Likewise, gains accrue when the opposite occurs, i.e., extreme depreciation (appreciation) of the USD (Chilean peso); in state 2 the exchange rate movement produces no effect on the equity market because dependence is low (given by a Clayton copula, which, by construction, presents upper tail independence). Overall, the conditional expectation regarding equity in both states indicates that the Chilean peso and Chilean equity market move in the same direction, while the USD and the US equity market move in opposite directions. Panel B in Figure 9 presents the relative contributions. The relative contribution of an equity shock from Chile is around 55% in both states for USD appreciation, and 75% in state 2 and 55% in state 1 for USD depreciation. The relative contribution of a shock from the US equity market is about 70% (52%) in state 2 (state 1) when the USD appreciates, and 90% (55%) in state 2 (state 1) when the USD depreciates. Average contributions are highly volatile, in line with the behaviour of smoothed probabilities.

4.2.4 Mexico

Panel A of Figure 10 presents evidence on the conditional expectation dynamics for shocks from/to Mexico to/from the EU. The first row shows that the EU and Mexican equity markets receive and transmit sizeable impacts in both states. The size of the impact from Mexico to the EU is similar across states, while that from the EU to Mexico is larger in state 1 than in state 2. The impact of exchange rate shocks on equity markets differs. The second row shows, for extreme appreciation (depreciation) of the EUR (Mexican peso), that there is no difference in impact across states for the EU equity market, whereas there is a greater impact in state 1 than in state 2 for the Mexican equity market (in line with the weaker Kendall tau in the latter), as shown by panel D of Table 6. The final row shows conditional expectation of the equity market of a similar size as previously mentioned, but for extreme depreciation (appreciation) of the EUR (Mexican peso). As for Brazil and Chile, an inverse relationship holds between the EUR and EU equity market values and a direct relationship holds between the Mexican peso and Mexican equity values. Panel A of Figure 11 indicates that the relative contribution of an equity shock from Mexico is around 66% for EUR appreciation or depreciation in state 1, reduced to around 56% in state 2. The contribution of EU equity shocks to changes in Mexican equity returns is higher when the Mexican peso appreciates (around 69% in state 1 and 79% in state 2) than when the Mexican peso depreciates (between 67% and 70% in states 1 and 2, respectively).

[Insert Figure 10 here]

[Insert Figure 11 here]

Panel B of Figure 10 indicates that shock transmissions from/to Mexico to/from the USA are similar across states and in intensity. Extreme appreciation (depreciation) of the USD evokes almost no response in the Mexican equity market in state 2. Extreme depreciation (appreciation) of the USD (Mexican peso) triggers gains in both equity markets in state 1, but has no effect on the Mexican equity market in state 2 (this is explained by the lower dependence between equity and exchange rates in Mexico when moving from state 1 to state 2). Hence, there is an inverse relationship between the USD-Mexican peso exchange rate and the US equity market, while the relationship between the Mexican equity market and the Mexican peso is positive. Panel B of Figure 11 shows that the relative contributions of total shocks received by the US equity market from Mexico differ in size across states, standing at 85% (52%) in state 1 (state 2) for USD appreciation, and at 76% (56%) in state 1 (state 2) for USD depreciation. The Mexican equity market is, in contrast, more strongly affected by US equity shocks than by exchange rates (90% in state 1 and around 55% in state 2). Average contributions show volatile behaviour in line with the smoothed probabilities.

5 Implications for international investors

Our findings point to an inverse relationship and a direct relationship between exchange rates and equity market returns for developed markets and emerging markets, respectively, a finding in line with the flight-to-quality foreign capital movements observed in periods of crisis (i.e., capital flight from emerging to developed economies). In periods of turbulence, equity markets typically face large losses, with foreign investment in emerging economies often repatriated, thereby depreciating the emerging economy's currency and appreciating the developed economy's currency. A finding that has consequence for hedging strategies is that, consistently, the relative contribution of equity shocks from emerging markets to developed markets is generally higher than is the contribution of exchange rate shocks.

In this section we quantify the implications of our findings for the value of foreign investments. As for a domestic investor, i.e., based in a developed market, the returns on a foreign investment are given by $r_{fe} = r_f + r_e$. The impact of a shock from the foreign equity market or exchange rate on the foreign investment returns can be computed in terms of the conditional expectation as:

$$\begin{aligned} E[r_{fe}|r_f < VaR_\alpha(r_f)] &= E[r_f|r_f < VaR_\alpha(r_f)] + E[r_e|r_f < VaR_\alpha(r_f)], \\ E[r_{fe}|r_e < VaR_\alpha(r_e)] &= E[r_f|r_e < VaR_\alpha(r_e)] + E[r_e|r_e < VaR_\alpha(r_e)], \\ E[r_{fe}|r_e > VaR_{1-\alpha}(r_e)] &= E[r_f|r_e > VaR_{1-\alpha}(r_e)] + E[r_e|r_e > VaR_{1-\alpha}(r_e)]. \end{aligned} \quad (15)$$

Note that for a foreign investor based in an emerging market, the conditional expected returns in Eq. (15) are computed in a similar way, except that the value of the conditional expectation of the exchange rate returns (for the exchange rate definition given above) is multiplied by -1.

Figures 12 to 15 (Argentina, Brazil, Chile and Mexico, respectively, with panels A and B referring to the EU and USA, respectively) show the decomposition of the expected foreign investment returns conditional on distress scenarios for the foreign equity market or exchange rate, computed for a level of confidence of 10% and considering the location of the investor (emerging-market and developed-market investors in the left and right columns, respectively). Panel A in Figure 12, illustrating the temporal evidence for Argentinian investors in the EU and EU investors in Argentina, shows that, for the Argentinian investor, a shock in the EU market has little effect on exchange rates, so the main impact received is from the downward movement in equity itself. Likewise, extreme depreciation or appreciation of the Argentinian peso has a minor effect on EU equity, so the main impact, again, is from the currency shock itself. From the EU investors' perspective, the evidence is similar regarding Argentinian equity shocks, while, during 2006-2014, there is some impact for currency shocks for Argentinian equity returns: when the Argentinian peso depreciates (appreciates), Argentinian equity returns increase (decrease), compensating EU investors for Argentinian peso losses. Panel B of Figure 12, illustrating evidence for Argentinian investors in the USA and US investors in Argentina, indicates that Argentinian and US investors are only affected by shocks transmitted by the US equity market or the exchange rate, and also shows that there is no interaction between equity and currency markets.

[**Insert Figure 12 here**]

Figures 13 to 15 display the same kind of information for Brazil, Chile and Mexico, showing the diversification role afforded by currencies in buffering the impact of shocks on investment positions abroad. For the developed markets, in contrast, currencies have an amplifying effect. Panel A in Figure 13 shows that, in response to a downward shock in the EU equity market, the EUR increases in value against the Brazilian real. Therefore, while Brazilian investors can use exchange rates to compensate for part of their losses, this is not possible for EU investors, as the EUR appreciates when Brazilian equity returns fall. In addition, when the Brazilian real abruptly appreciates (depreciates), EU equity returns increase (decrease), offsetting the loss of Brazilian investors; in contrast, for EU investors, when the EUR appreciates (depreciates), Brazilian equity returns decrease (increase), enhancing thus the negative (positive) impact of the change in currency value on the foreign investment position of EU investors. Similar evidence is reported in Panel B of Figure 13 for Brazilian and US investors.

[Insert Figure 13 here]

Figures 14 and 15 for Chile and Mexico show similar evidence as reported above for Brazil, although pointing to different intensities. Thus, the Chilean peso and Mexican peso both buffer the impact of EU and US shocks to Chile- and Mexico-based investors, whereas the EUR and USD are unable to cushion the impact of Chilean or Mexican shocks transmitted to EU- and US-based investors

[Insert Figure 14 here]

[Insert Figure 15 here]

By way of a summary, Table 7 reports average shock effects over the sample period for investors based in emerging and in developed markets, as reported in Figures (12)-(15 .

[Insert Table 7 here]

Finally, we report the diversification benefits of a portfolio comprised of domestic and foreign assets. Let r_p^d and r_p^f denote the returns of an international portfolio denominated in domestic and foreign currencies, respectively, given by:

$$
\begin{aligned}
r_p^d &= (1-\omega)\, r_d + \omega\, (r_f + r_e)\,, \\
r_p^f &= (1-\omega)\, (r_d - r_e) + \omega r_f,
\end{aligned}
\tag{16}
$$

where ω $(1-\omega)$ denotes the amount invested in the foreign (domestic) market. The diversification benefits that accrue to domestic (foreign) investors from including foreign (domestic) equities in a portfolio can be computed in terms of the ES (see Christoffersen et al. 2012) as $\Delta_{r_p^d}(\alpha)$ $(\Delta_{r_p^f}(\alpha))$:

$$
\begin{aligned}
\Delta_{r_p^d}(\alpha) &= \frac{ES_\alpha(r_f + r_e)\omega + ES_\alpha(r_d)(1-\omega) - ES_\alpha(r_p^d)}{ES_\alpha(r_f + r_e)\omega + ES_\alpha(r_d)(1-\omega) - VaR_\alpha(r_p^d)}, \\
\Delta_{r_p^f}(\alpha) &= \frac{ES_\alpha(r_f)\omega + ES_\alpha(r_d - r_e)(1-\omega) - ES_\alpha(r_p^f)}{ES_\alpha(r_f)\omega + ES_\alpha(r_d - r_e)(1-\omega) - VaR_\alpha(r_p^f)},
\end{aligned}
\tag{17}
$$

where $VaR_\alpha(r_p^d)$ $(VaR_\alpha(r_p^f))$ denotes the α-VaR of portfolio p denominated in the domestic (foreign) currency, which is the lower bound of the portfolio ES, and where $\Delta_{r_p^k}(\alpha)$ for $k = d, f$ takes values in the interval $[0, 1]$, with 0 indicating no diversification benefits, and 1 denoting maximum diversification benefits.[8] Figure 16 depicts temporal dynamics for portfolio diversification benefits – from the perspective of Latin American and EU investors (panel A) and from the perspective of Latin American and US investors (panel B) – considering an equally-weighted portfolio and a 10% confidence level. Panel A and panel B point to similar evidence: that investors can attain portfolio benefits by including foreign assets in their portfolios and that those benefits remain relatively stable over the sample period and are greater for domestic than for foreign investors. The relationship between developed-market exchange rates and equity markets are such that they amplify the losses of an EU or US investor who has a portfolio in any of the studied Latin American countries. In contrast, an investor in any of the studied Latin American countries would find that the exchange rate works as a shock-absorber of potential losses in EU or US equity markets. This result means that developed-market investors would incur higher losses, i.e., a more negative ES,

[8]The risk measures for the portfolio are obtained from numerical integration using the cumulative distribution function of the portfolio returns: see Appendix, available online.

from investing all their portfolio in emerging markets than would happen in reverse; in other words, the advantages of building an international portfolio are greater for developed-market investors, as confirmed by the higher value in the diversification index. Overall, this finding corroborates previous evidence on the diversification benefits of international portfolios, which we have expressed in terms of downside risk as given by the ES.

[**Insert Figure 16 here**]

6 Conclusion

Cross-border portfolio investment has been widely studied in the economic literature, not only for the potential opportunities and diversification benefits for investors, but also because of the systemic risk implications as a risk-sharing channel (Poncela et al. 2019). An international portfolio can potentially help investors disengage from the financial cycle associated with their base of operations, stabilizing consumer welfare and reducing the risks associated with crises. To that end, understanding the transmission of shocks between global equity markets is crucial for portfolio design and risk management decisions. We have analysed the relationship between equity markets in emerging and developed markets while also considering the role of exchange rates. Dependence among equity markets and exchange rates is structured in a multivariate vine copula setup that accounts for specific marginal and dependence features such as time-varying mean and variance and tail dependence. Furthermore, time-varying dependence is considered in terms of a Markov switching model that captures potential nonlinearities and changes in tail dependence over time. Computed from this multivariate dependence structure is the conditional expectation (the ES) to measure the mean response of financial variables to shocks and to assess the tail features of international portfolios. Our findings for emerging Latin American countries (Argentina, Brazil, Chile and Mexico) and two developed markets (EU and USA) indicate that the contribution of exchange rates to the transmission of equity shocks is time varying and asymmetric and differs across countries; in addition, exchange rates diversify shocks from abroad for investors based in emerging economies (particularly Brazil, Chile and Mexico), while they echo the effect of shocks from abroad for investors based in developed markets. This evidence has particular implications for investment and risk management decisions by international investors. In particular, in times of market stress when capital flows usually experience flight-to-quality, investors based in developed markets would face an extra cost of repatriation because of currency depreciation for the emerging market. To reduce such losses, the investor would try to secure a first-mover advantage of repatriating their foreign investment sooner in order to lower the associated costs. Such dynamics could pose a potential systemic risk, leading to instabilities in international markets. Our results are consistent with capital movements in international markets and exchange rate fluctuations experienced during crises, e.g., during the current COVID-19 crisis (Eguren Martin et al. 2020), an analysis we leave for future research.

References

Aas, K., C. Czado, A. Frigessi, and H. Bakken (2009). Pair-copula constructions of multiple dependence. *Insurance: Mathematics and Economics 44*(2), 182–198.

Ang, A. and G. Bekaert (2002). International asset allocation with regime shifts. *The review of financial studies 15*(4), 1137–1187.

Bedford, T. and R. M. Cooke (2002). Vines: A new graphical model for dependent random variables. *Annals of Statistics*, 1031–1068.

Benoit, S., J. Colliard, C. Hurlin, and C. Pérignon (2017). Where the risks lie: A survey on systemic risk. *Review of Finance 21*(1), 109–152.

Branson, W. H. (1981). Macroeconomic determinants of real exchange rates. Technical report, National Bureau of Economic Research.

Brechmann, E. and U. Schepsmeier (2013). CDVine: Modeling dependence with C-and D-vine copulas in R. *Journal of Statistical Software 52*(3), 1–27.

Brownlees, C. T. and R. Engle (2016). Srisk: A conditional capital shortfall measure of sytemic risk. *Review of Financial Studies 30*(1), 48–79.

Cenedese, G., R. Payne, L. Sarno, and G. Valente (2016). What do stock markets tell us about exchange rates? *Review of Finance 20*(3), 1045–1080.

Cherubini, U., F. Gobbi, and S. Mulinacci (2016). *Convolution Copula Econometrics*. Springer.

Cho, J.-W., J. H. Choi, T. Kim, and W. Kim (2016). Flight-to-quality and correlation between currency and stock returns. *Journal of Banking and Finance 62*, 191–212.

Chollete, L., V. de la Peña, and C.-C. Lu (2011). International diversification: A copula approach. *Journal of Banking and Finance 35*(2), 403–417.

Chollete, L., A. Heinen, and A. Valdesogo (2009). Modeling international financial returns with a multivariate regime-switching copula. *Journal of financial econometrics 7*(4), 437–480.

Christoffersen, P., V. Errunza, K. Jacobs, and H. Langlois (2012). Is the potential for international diversification disappearing? a dynamic copula approach. *Review of Financial Studies 25*(12), 3711–3751.

Dornbusch, R. and S. Fischer (1980). Exchange rates and the current account. *The American Economic Review 70*(5), 960–971.

Eguren Martin, F., M. Joy, C. Maurini, A. Moro, V. Nispi Landi, A. Schiavone, and C. van Hombeeck (2020). Capital flows during the pandemic: lessons for a more resilient international financial architecture. *Bank of England Financial Stability Paper* (45).

Forbes, K. J. and R. Rigobon (2002). No contagion, only interdependence: Measuring stock market comovements. *Journal of Finance 57*(5), 2223–2261.

Frankel, J. A. (1992). Monetary and portfolio-balance models of exchange rate determination. In *International economic policies and their theoretical foundations*, pp. 793–832. Elsevier.

Froot, K. A., P. G. O'connell, and M. S. Seasholes (2001). The portfolio flows of international investors. *Journal of financial Economics 59*(2), 151–193.

Galindo, A., U. Panizza, and F. Schiantarelli (2003). Debt composition and balance sheet effects of currency depreciation: a summary of the micro evidence. *Emerging Markets Review 4*(4), 330–339.

Garcia, R. and G. Tsafak (2011). Dependence structure and extreme comovements in international equity and bond markets. *Journal of Banking and Finance 38*(8), 1954–1970.

Genest, C., K. Ghoudi, and L.-P. Rivest (1995). A semiparametric estimation procedure of dependence parameters in multivariate families of distributions. *Biometrika 82*(3), 543–552.

Griffin, J. M., F. Nardari, and R. M. Stulz (2004). Are daily cross-border equity flows pushed or pulled? *Review of Economics and Statistics 86*(3), 641–657.

Hansen, B. E. (1994). Autoregressive conditional density estimation. *International Economic Review*, 705–730.

Hau, H. and H. Rey (2006). Exchange rates, equity prices, and capital flows. *The Review of Financial Studies 19*(1), 273–317.

Joe, H. (1996). Families of m-variate distributions with given margins and m (m-1)/2 bivariate dependence parameters. *Lecture Notes-Monograph Series*, 120–141.

Joe, H. (1997). *Multivariate models and multivariate dependence concepts*. CRC Press.

Joe, H. (2005). Asymptotic efficiency of the two-stage estimation method for copula-based models. *Journal of Multivariate Analysis 94*(2), 401–419.

Joe, H., H. Li, and A. K. Nikoloulopoulos (2010). Tail dependence functions and vine copulas. *Journal of Multivariate Analysis 101*(1), 252–270.

Joe, H. and J. J. Xu (1996). The estimation method of inference functions for margins for multivariate models. Technical report, Department of Statistics, University of British Columbia.

Kim, C. (1994). Dynamic linear models with Markov-switching. *Journal of Econometrics 60*(1-2), 1–22.

Kim, D., J.-M. Kim, S.-M. Liao, and Y.-S. Jung (2013). Mixture of D-vine copulas for modeling dependence. *Computational Statistics & Data Analysis 64*(C), 1–19.

Kupiec, P. (1995). Techniques for verifying the accuracy of risk measurement models. *The Journal of Derivatives 3*(2), 73–84.

Longin, F. and B. Solnik (1995). Is the correlation in international equity returns constant: 1960–1990? *Journal of international money and finance 14*(1), 3–26.

Meese, R. and K. Rogoff (1983). Empirical exchange rate models of the seventies: do they fit out-of-sample? *Journal of International Economics 14*(2), 3–24.

Nelsen, R. B. (2006). *An introduction to copulas*. Springer.

Nikoloulopoulos, A. K., H. Joe, and H. Li (2012). Vine copulas with asymmetric tail dependence and applications to financial return data. *Computational Statistics & Data Analysis 56*(11), 3659–3673.

Ning, C. (2010). Dependence structure between the equity market and the foreign exchange market–a copula approach. *Journal of International Money and Finance 29*(5), 743–759.

Oakes, D. (1994). Multivariate survival distributions. *Journal of Nonparametric Statistics 3*(3-4), 343–354.

Ojea Ferreiro, J. (2019). Structural change in the link between oil and the European stock market: implications for risk management. *Dependence Modeling 7*(1), 53–125.

Ojea Ferreiro, J. (2020). Disentangling the role of the exchange rate in oil-related scenarios for the european stock market. *Energy Economics*, 104776.

Patton, A. J. (2006). Estimation of multivariate models for time series of possibly different lengths. *Journal of Applied Econometrics 21*(2), 147–173.

Patton, A. J. (2012). A review of copula models for economic time series. *Journal of Multivariate Analysis 110*, 4–18.

Pavlova, A. and R. Rigobon (2007). Asset prices and exchange rates. *The Review of Financial Studies 20*(4), 1139–1180.

Pelletier, D. (2009). Regime-switching for dynamic correlation. *Journal of Econometrics 131*, 445–473.

Poncela, P., M. Nardo, and F. M. Pericoli (2019). A review of international risk sharing for policy analysis. *East Asian Economic Review 23*(3), 227–260.

Reboredo, J. C. (2011). How do crude oil prices co-move?: A copula approach. *Energy Economics 33*(5), 948–955.

Reboredo, J. C., M. A. Rivera-Castro, and A. Ugolini (2016). Downside and upside risk spillovers between exchange rates and stock prices. *Journal of Banking & Finance 62*, 76–96.

Reboredo, J. C. and A. Ugolini (2015a). A vine-copula Conditional Value-at-Risk approach to systemic sovereign debt risk for the financial sector. *The North American Journal of Economics and Finance 32*(C), 98–123.

Reboredo, J. C. and A. Ugolini (2015b). Downside/upside price spillovers between precious metals: A vine copula approach. *The North American Journal of Economics and Finance 34*(C), 84–102.

Reboredo, J. C. and A. Ugolini (2016). Quantile dependence of oil price movements and stock returns. *Energy Economics 54*(C), 33–49.

Richards, A. (2005). Big fish in small ponds: The trading behavior and price impact of foreign investors in asian emerging equity markets. *Journal of Financial and quantitative Analysis 40*(1), 1–27.

Rodriguez, J. C. (2007). Measuring financial contagion: A copula approach. *Journal of empirical finance 14*(3), 401–423.

Shih, J. H. and T. A. Louis (1995). Inferences on the association parameter in copula models for bivariate survival data. *Biometrics*, 1384–1399.

Sklar, M. (1959). Fonctions de repartition an dimensions et leurs marges. *Publ. Inst. Statist. Univ. Paris 8*, 229–231.

Wang, Y.-C., J.-L. Wu, and Y.-H. Lai (2013). A revisit to the dependence structure between the stock and foreign exchange markets: A dependence-switching copula approach. *Journal of Banking & Finance 37*(5), 1706–1719.

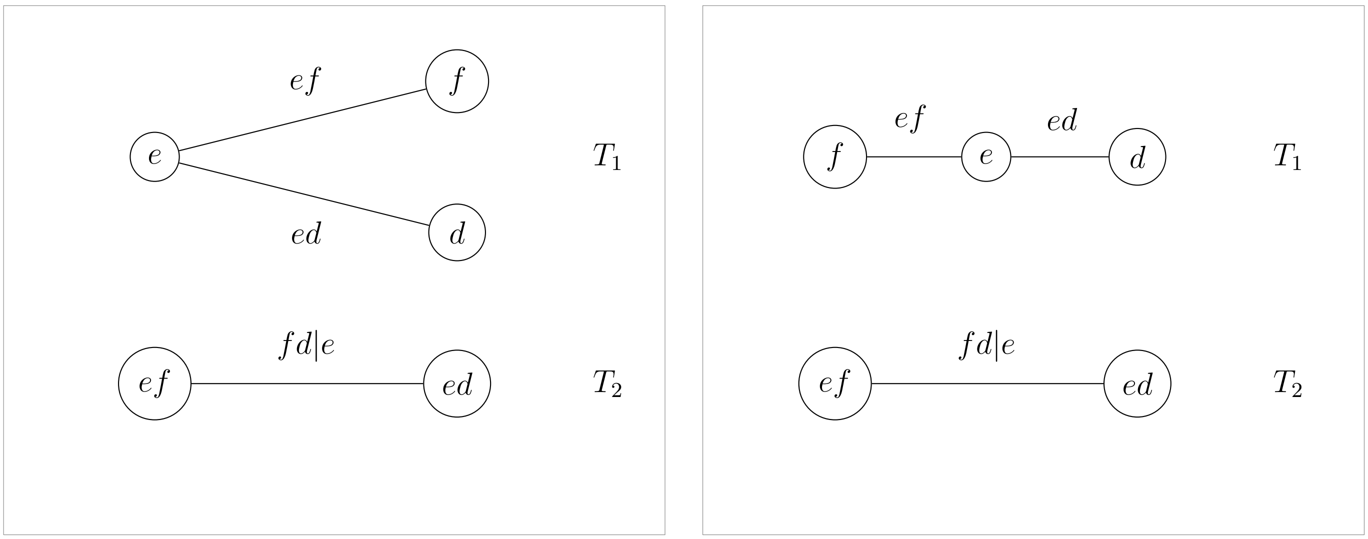
Yang, L., X. J. Cai, M. Li, and S. Hamori (2015). Modeling dependence structures among international stock markets: Evidence from hierarchical archimedean copulas. *Economic Modelling 51*, 308–314.

Appendices

A Figures

Figure 1: Hierarchical dependence structure of C- and D-vine copula models.

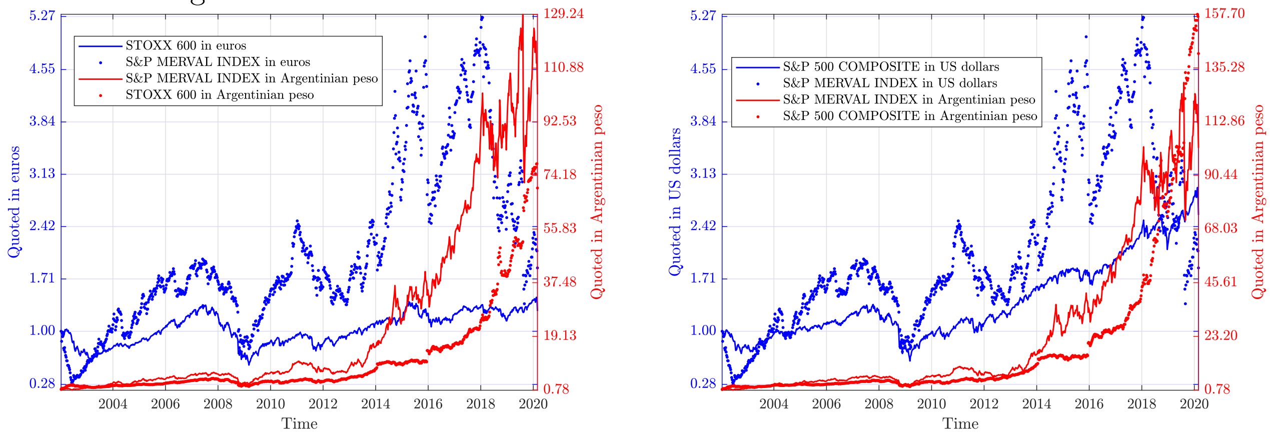
C-Vine tree-structure D-Vine tree-structure



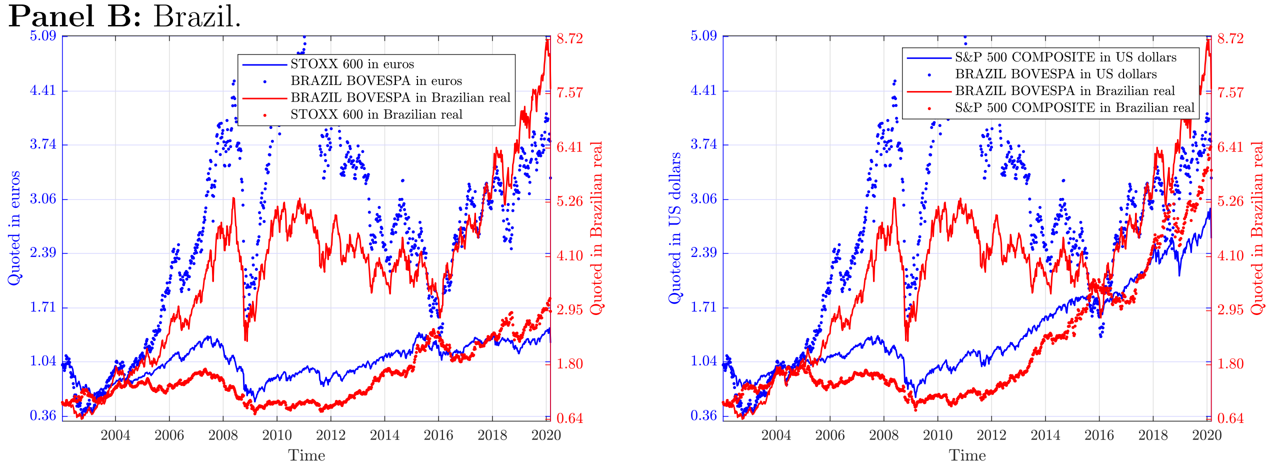
This figure shows the structure of hierarchical dependence for domestic equity, foreign equity and exchange rate returns using a C-vine (left panel) or a D-vine (right panel). Each node corresponds to domestic equity (d), foreign equity (f) or exchange rate returns (e), and the edge indicates dependence between two nodes. In the first layer (T_1), dependence between exchange rates, domestic equity returns and foreign equity returns is modelled with bivariate copulas. In the second layer (T_2), dependence between domestic equity returns and foreign equity returns conditional on exchange rate returns is modelled using a bivariate copula. Note that both hierarchical dependence structures are the same for dependence between the three variables.

Figure 2: Time series plot of weekly equity market indices in different currencies.

Panel A: Argentina.



Panel B: Brazil.



Panel C: Chile.

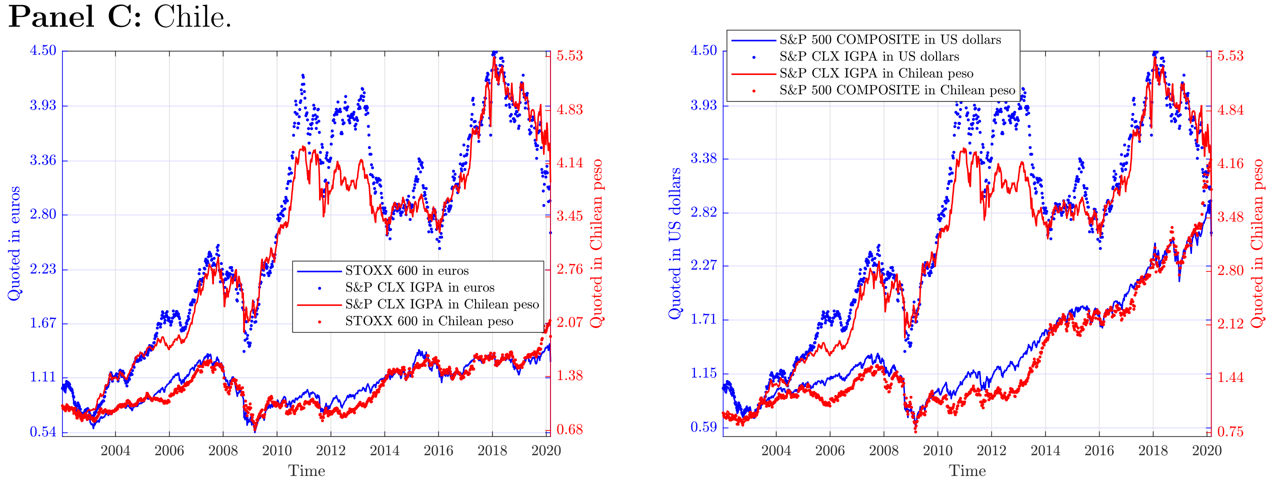
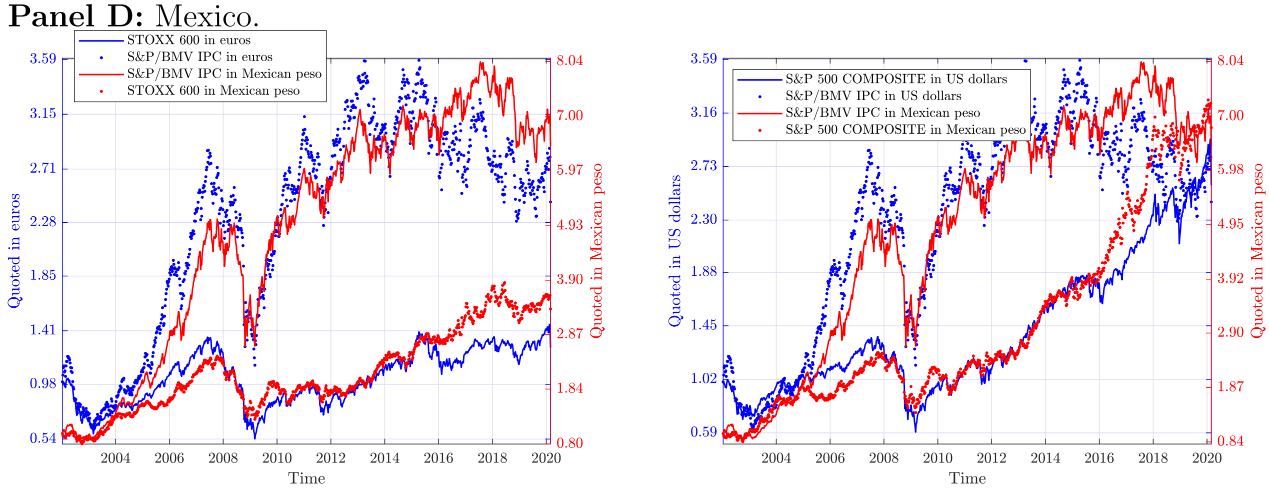


Figure 2 (Cont.): Time series plot of weekly equity market indices in different currencies

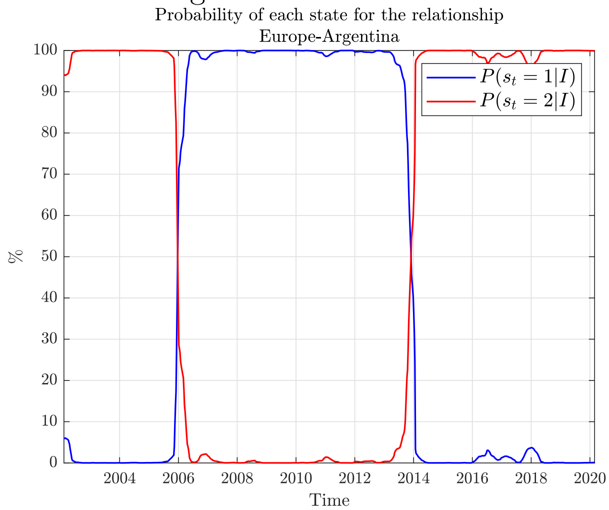
Panel D: Mexico.



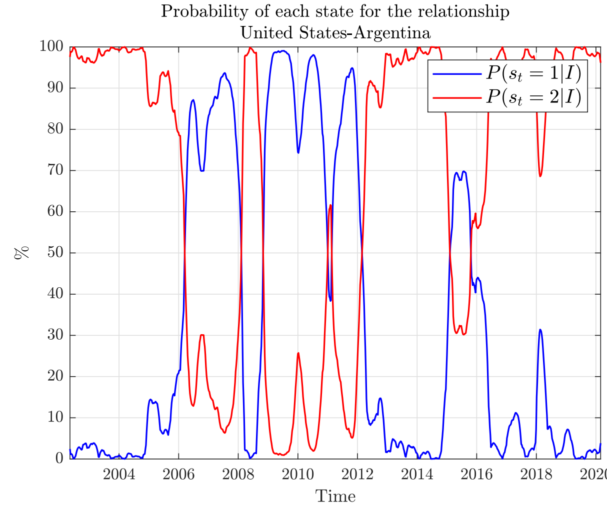
This figure depicts the time series for weekly stock data for the S&P MERVAL INDEX, BRAZIL BOVESPA, S&P CLX IGPA, S&P/BMV IPC, STOXX EUROPE 600 and S&P 500 COMPOSITE indices for Argentine, Brazil, Chile, Mexico, the EU and the USA. The left axis indicates stock quotes in EUR (left column) or in USD (right column), whereas the right axis indicates stock quotes in the emerging-market currency, i.e., Argentine peso (panel A), Brazilian real (panel B), Chilean peso (panel C) and Mexican peso (panel D). The weekly stock markets are set to the value one at the beginning of the sample period to make time series in the same currency visually comparable.

Figure 3: Smoothed probabilities of each state for the dependence structure.

Panel A: Argentina.

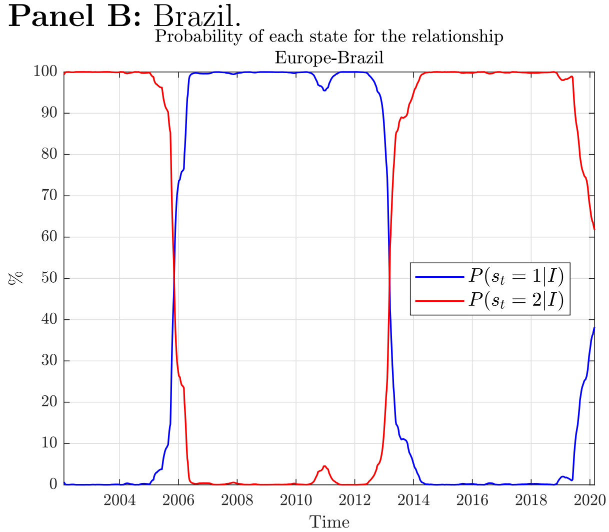


(a) Argentina-Europe

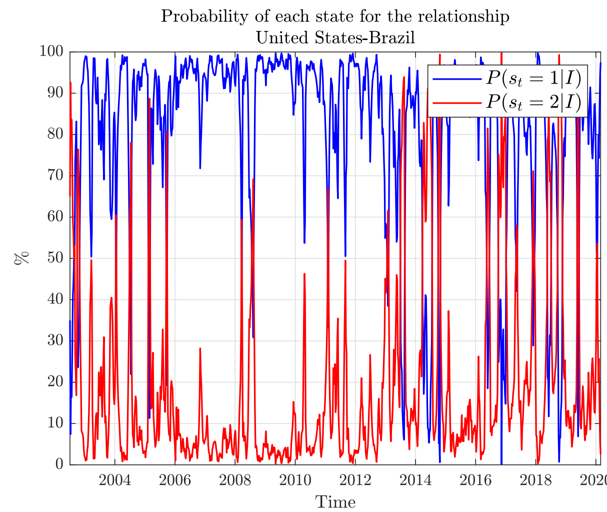


(b) Argentina-United States

Panel B: Brazil.

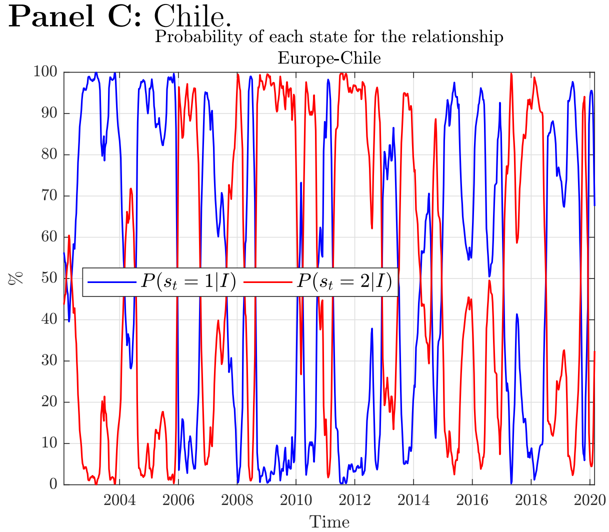


(c) Brazil-Europe

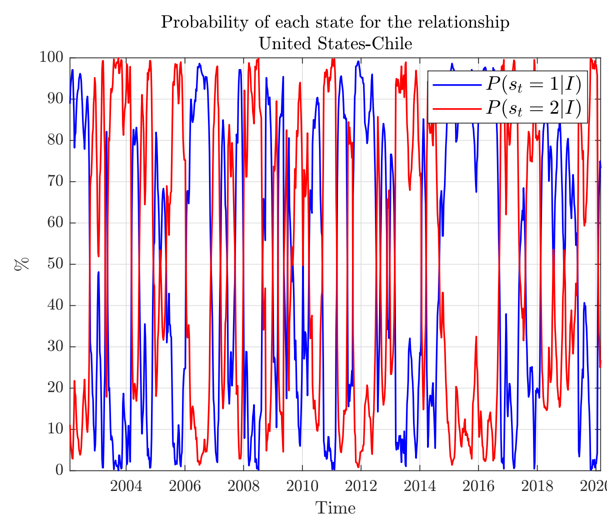


(d) Brazil-United States

Panel C: Chile.



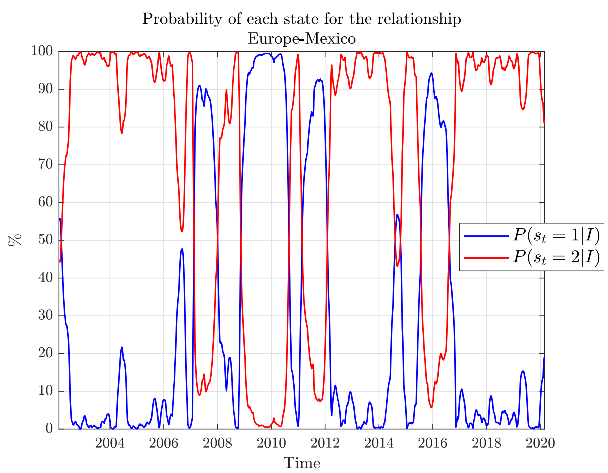
(e) Chile-Europe



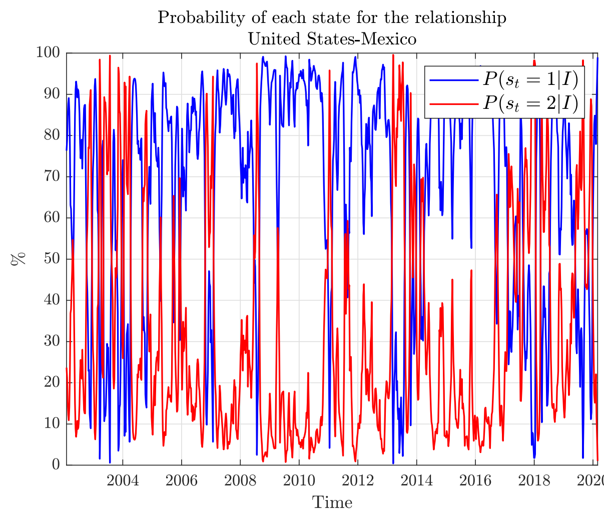
(f) Chile-United States

Figure 3 (Cont.): Smoothed probabilities of each state for the dependence structure.

Panel D: Mexico.



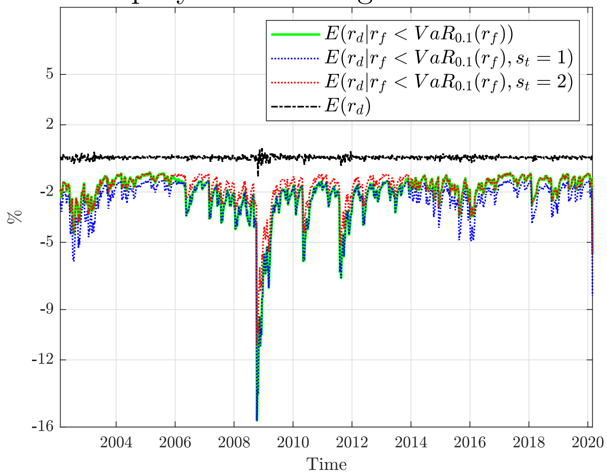
(a) Mexico-Europe



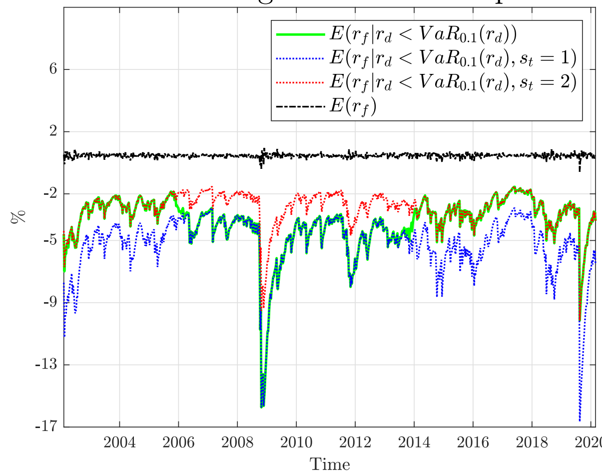
(b) Mexico-United States

Figure 4: Equity and exchange rate shock transmission between Argentina and developed markets.

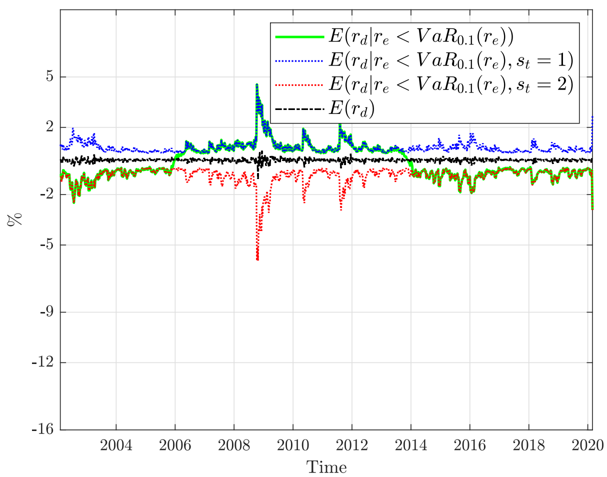
Panel A. Equity and exchange rate shock transmission between Argentina and Europe.



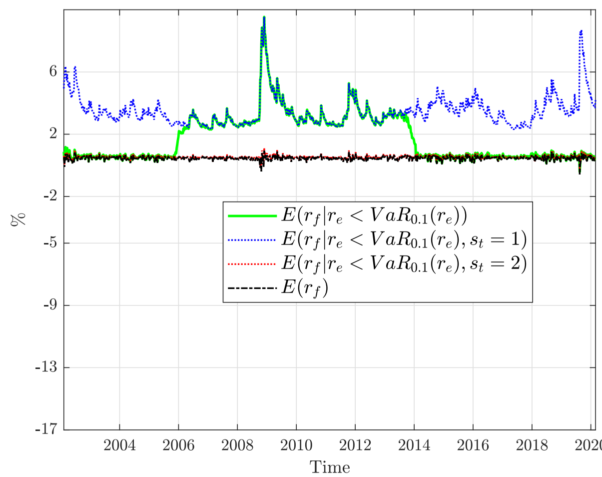
(a) Equity shocks from Argentina (r_f) to Europe (r_d)



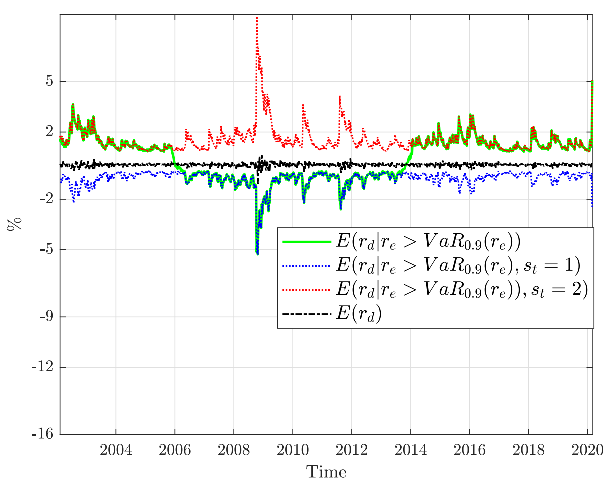
(b) Equity shocks from Europe (r_d) to Argentina (r_f)



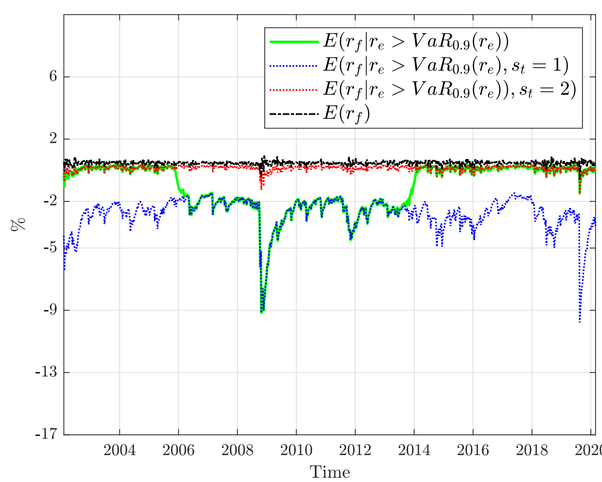
(c) Euro appreciation shocks (e) to European equity (r_d)



(d) Euro appreciation shocks (e) to Argentinian equity (r_f)



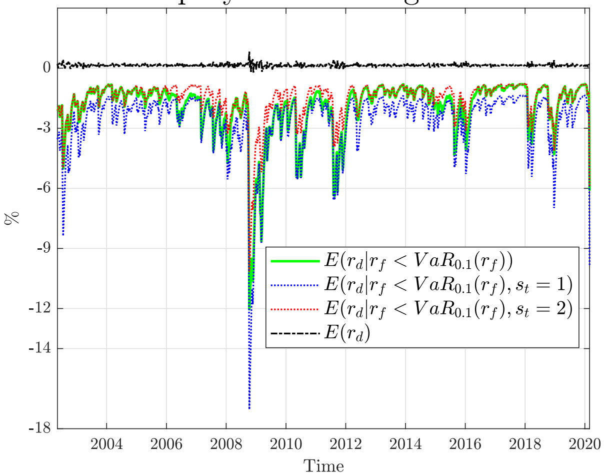
(e) Euro depreciation shocks (e) to European equity (r_d)



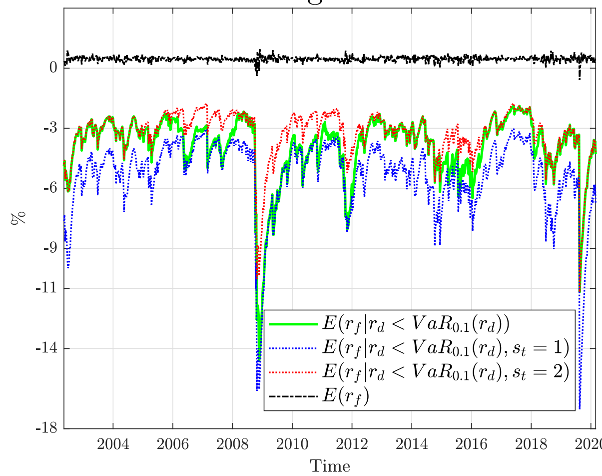
(f) Euro depreciation shocks (e) to Argentinian equity (r_f)

Figure 4 (Cont.): Equity and exchange rate shock transmission between Argentina and developed markets.

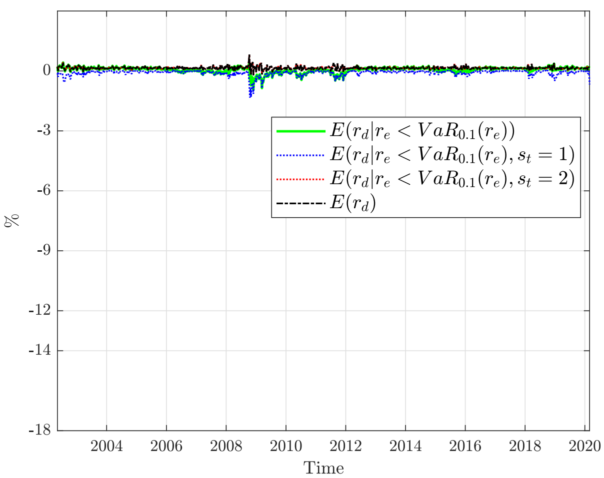
Panel B. Equity and exchange rate shock transmission between Argentina and the USA.



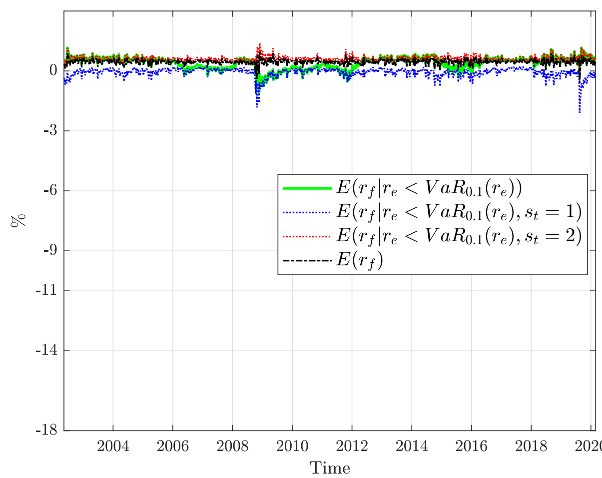
(a) Equity shocks from Argentina (r_f) to the USA (r_d)



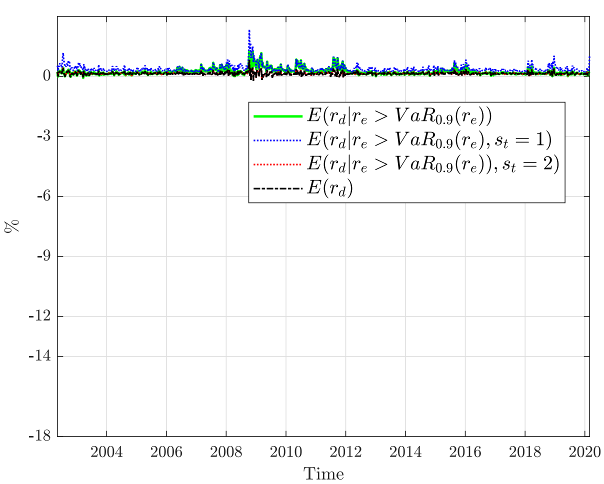
(b) Equity shocks from the USA (r_d) to Argentina (r_f)



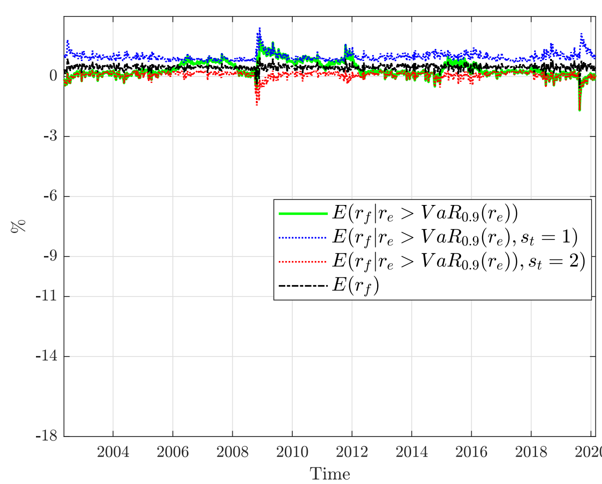
(c) USD appreciation shocks (e) to the USA equity (r_d)



(d) USD appreciation shocks (e) to the Argentinian equity (r_f)



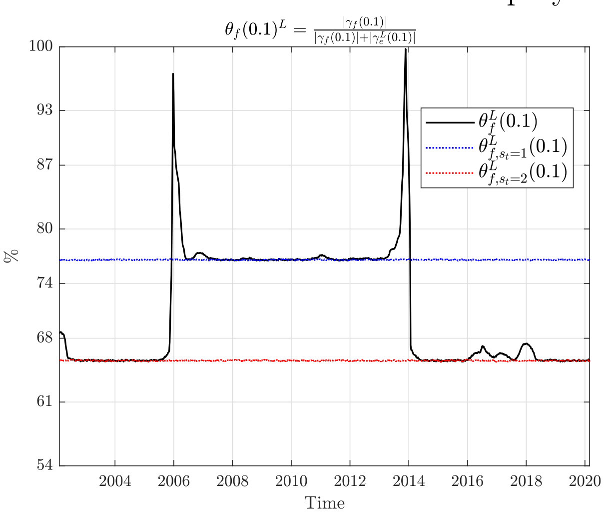
(e) USD depreciation shocks (e) to the USA equity (r_d)



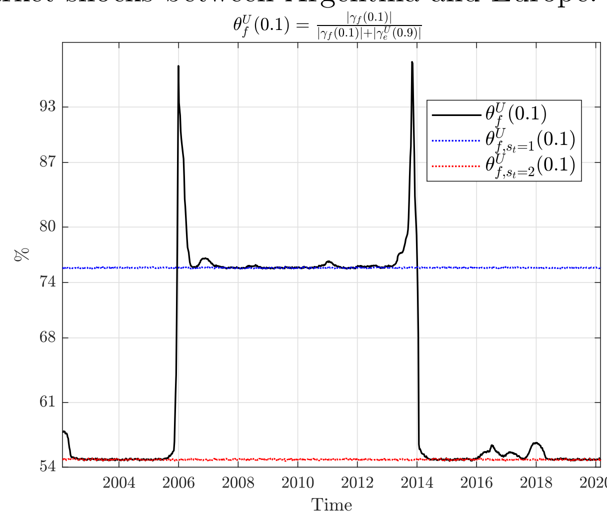
(f) USD depreciation shocks (e) to the Argentinian equity (r_f)

Figure 5: Relative contribution of equity market shocks between Argentina and developed markets.

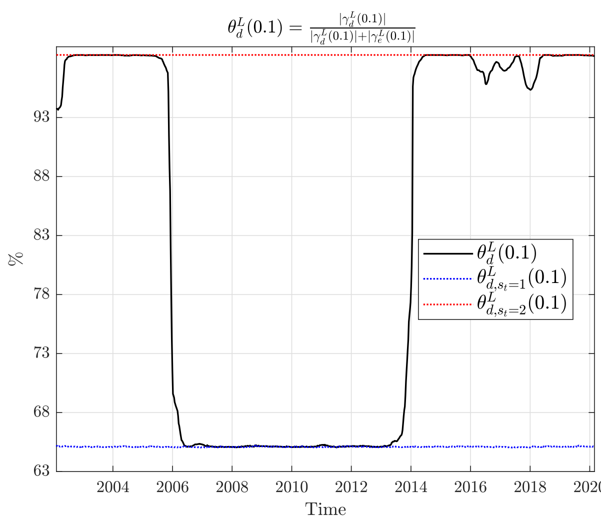
Panel A. Relative contribution of equity market shocks between Argentina and Europe.



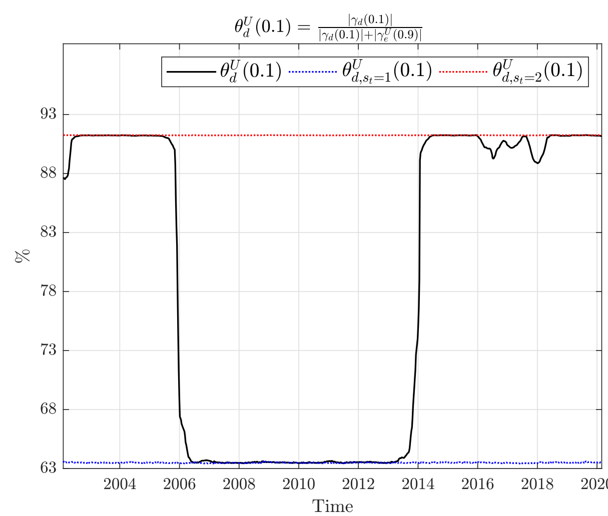
(a) Euro appreciation to Europe



(b) Euro depreciation to Europe



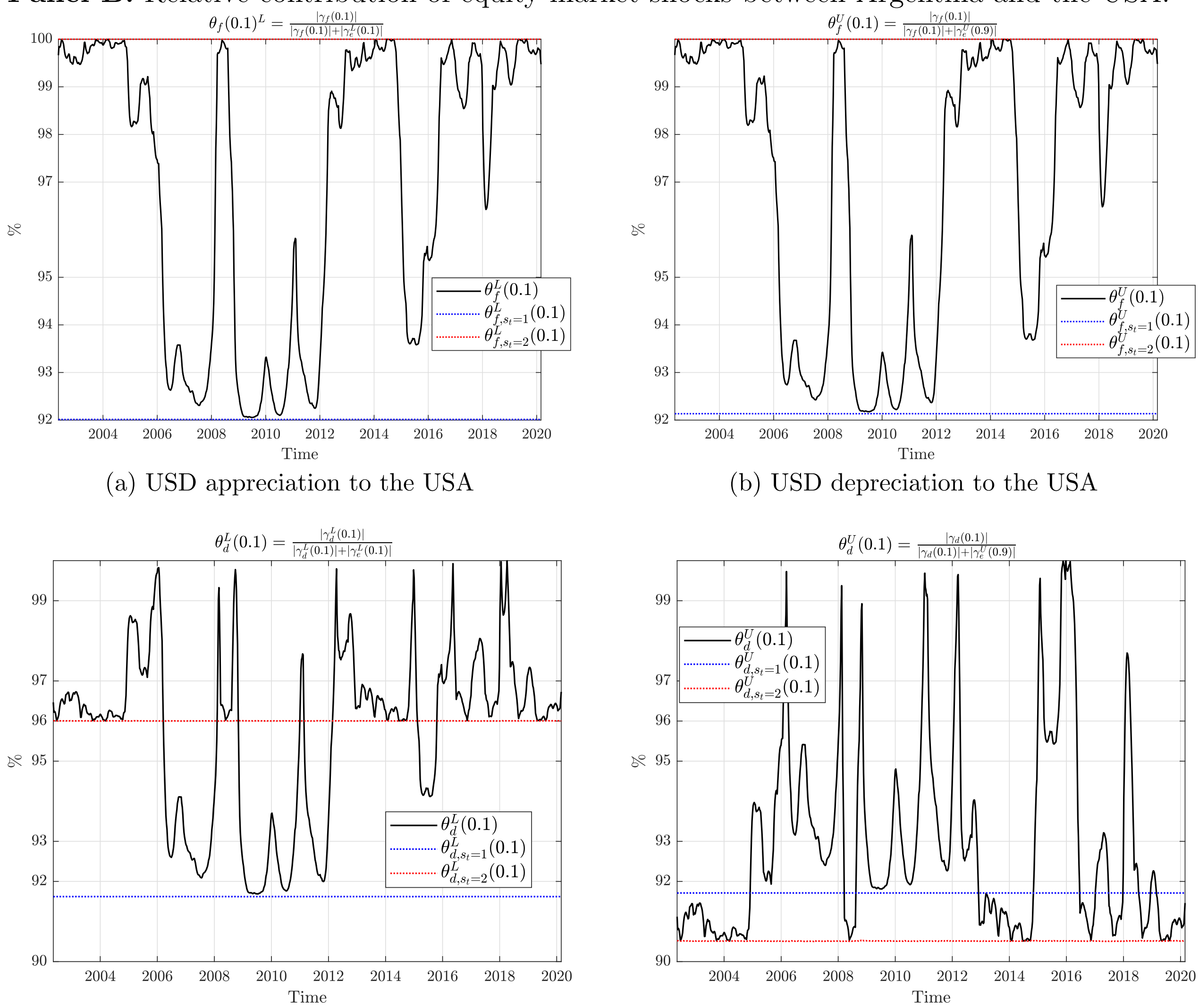
(c) Euro appreciation to Argentina



(d) Euro depreciation to Argentina

Figure 5 (Cont.): Relative contribution of equity market shocks between Argentina and developed markets.

Panel B. Relative contribution of equity market shocks between Argentina and the USA.



(a) USD appreciation to the USA

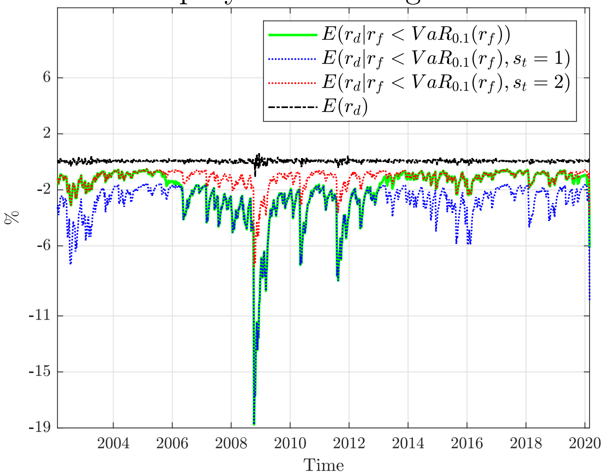
(b) USD depreciation to the USA

(c) USD appreciation to Argentina

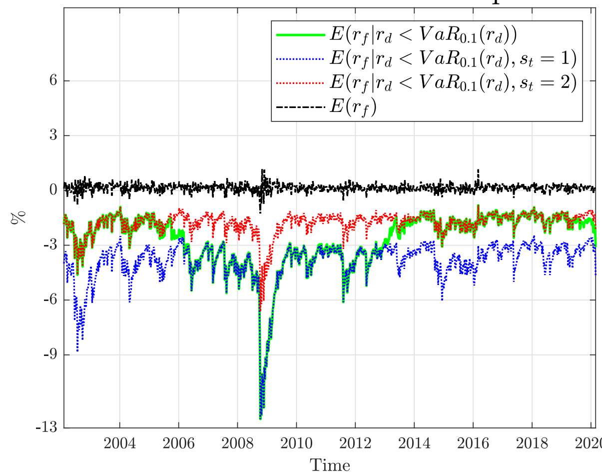
(d) USD depreciation to Argentina

Figure 6: Equity and exchange rate shock transmission between Brazil and developed markets.

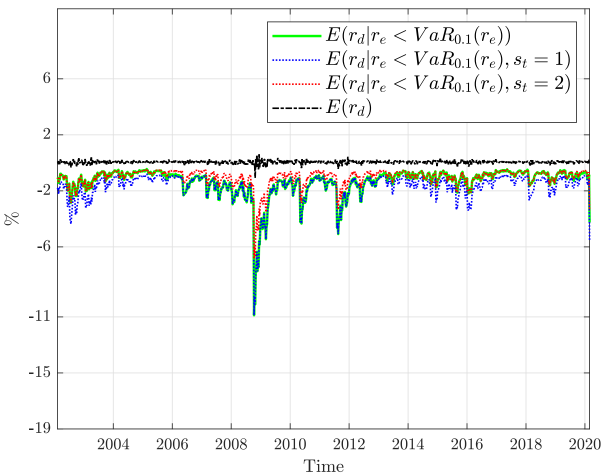
Panel A. Equity and exchange rate shock transmission between Brazil and Europe.



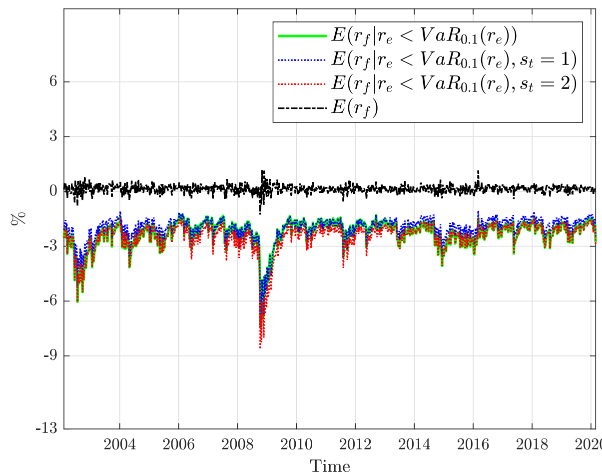
(a) Equity shocks from Brazil (r_f) to Europe (r_d)



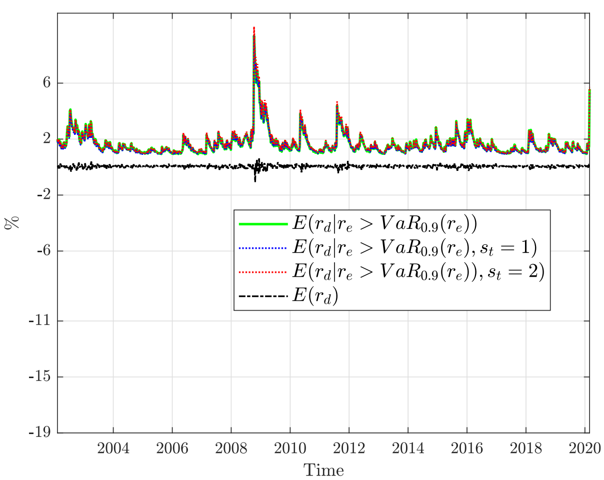
(b) Equity shocks from Europe (r_f) to Brazil (r_d)



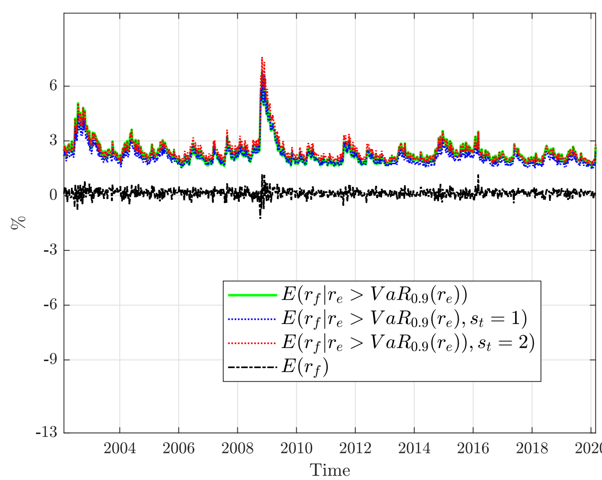
(c) Euro appreciation shocks (e) to European equity (r_d)



(d) Euro appreciation shocks (e) to Brazilian equity (r_f)



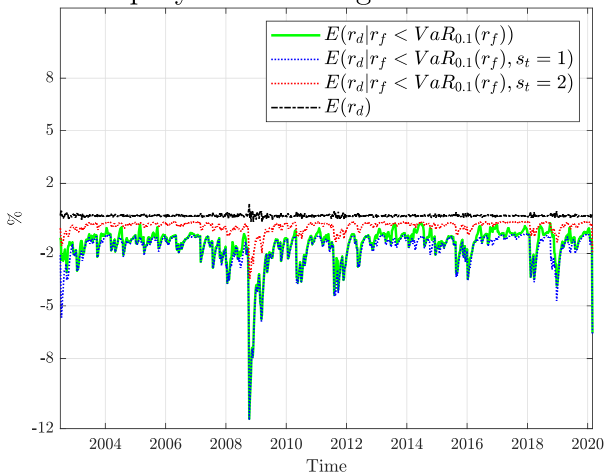
(e) Euro depreciation shocks (e) to European equity (r_d)



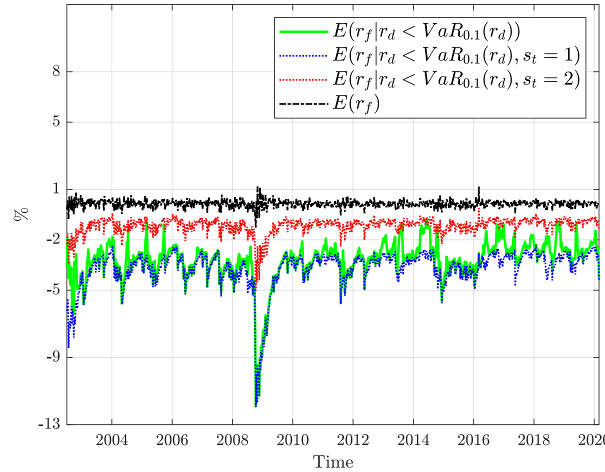
(f) Euro depreciation shocks (e) to Brazilian equity (r_f)

Figure 6 (Cont.): Equity and exchange rate shock transmission between Brazil and developed markets.

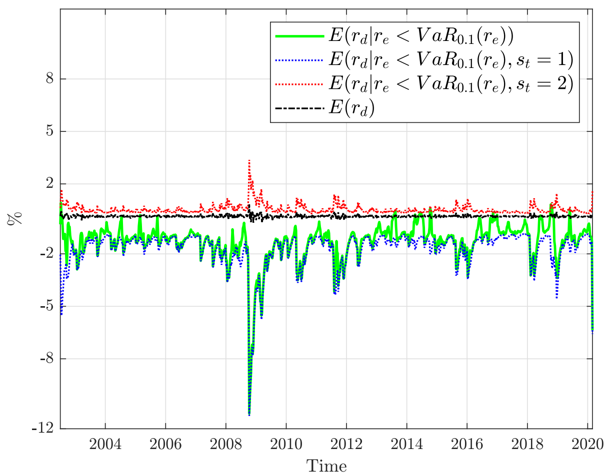
Panel B. Equity and exchange rate shock transmission between Brazil and the USA.



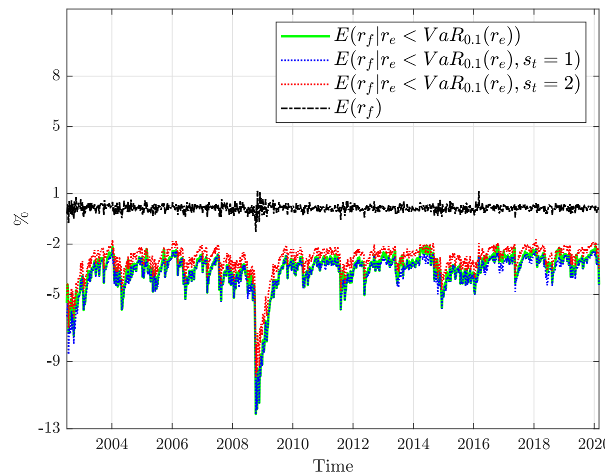
(a) Equity shocks from Brazil (r_f) to the USA (r_d)



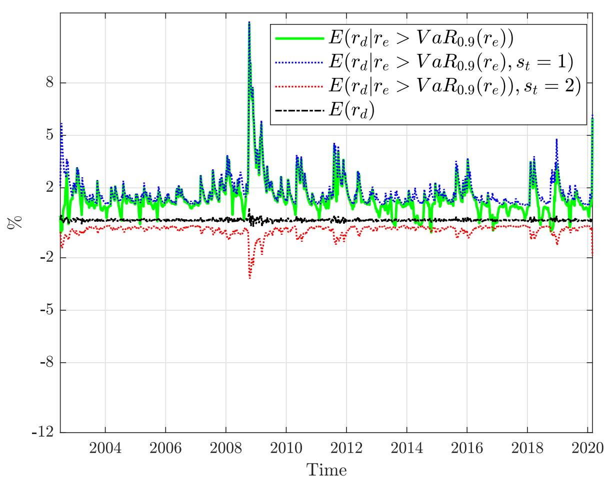
(b) Equity shocks from the USA (r_d) to Brazil (r_d)



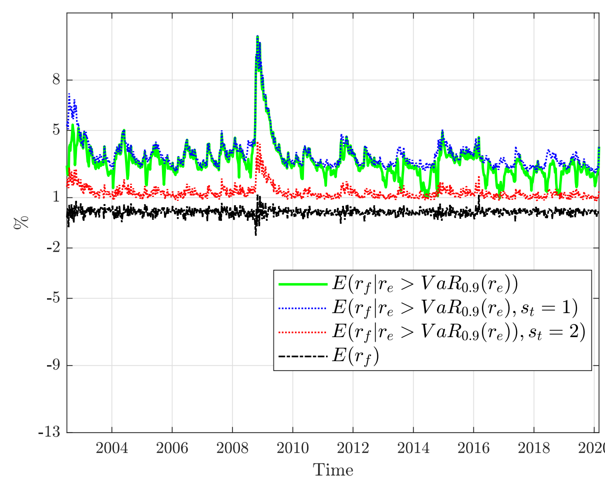
(c) USD appreciation shocks (e) to the US equity (r_d)



(d) USD appreciation shocks (e) to the Brazilian equity (r_f)



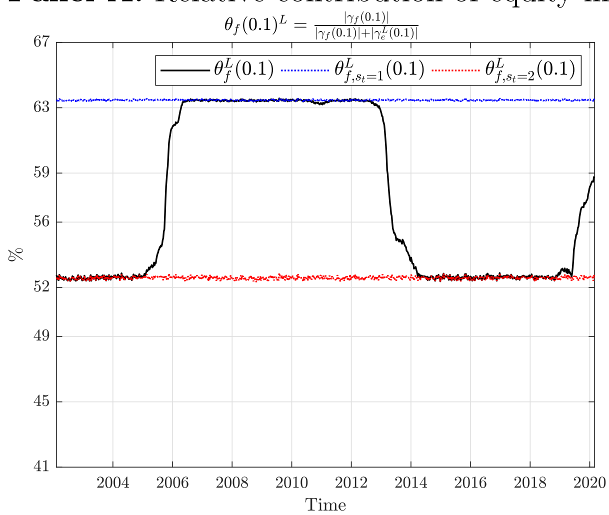
(e) USD depreciation shocks (e) to the US equity (r_d)



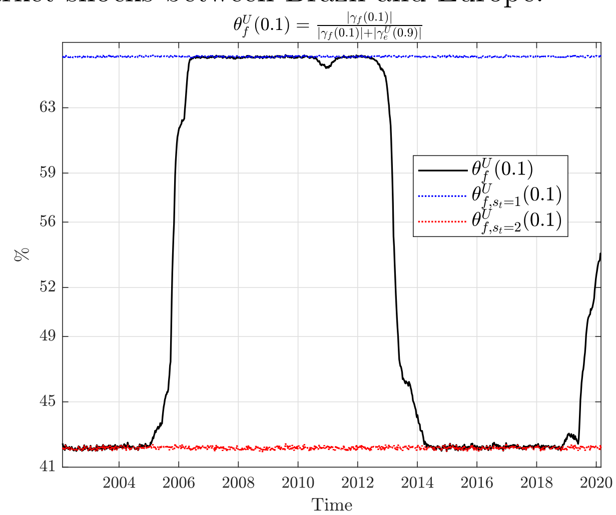
(f) USD depreciation shocks (e) to the Brazilian equity (r_f)

Figure 7: Relative contribution of equity market shocks between Brazil and developed markets.

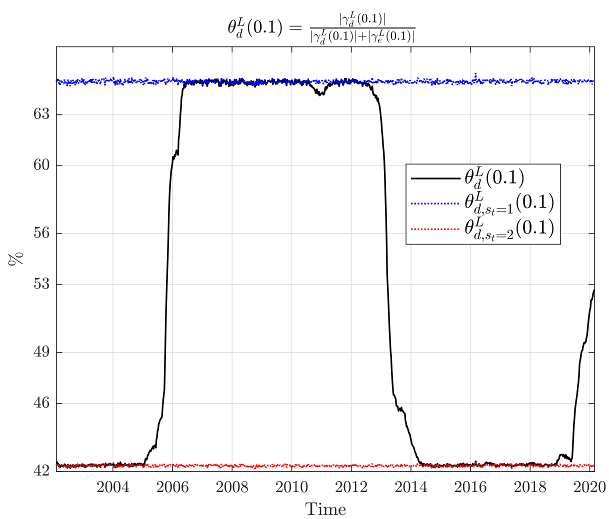
Panel A. Relative contribution of equity market shocks between Brazil and Europe.



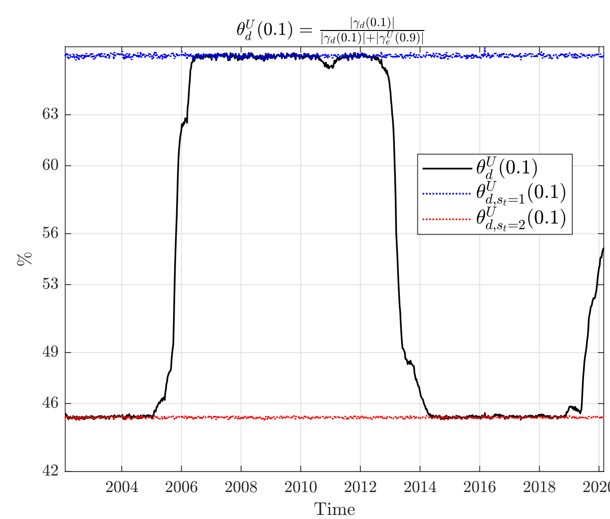
(a) Euro appreciation to Europe



(b) Euro depreciation to Europe



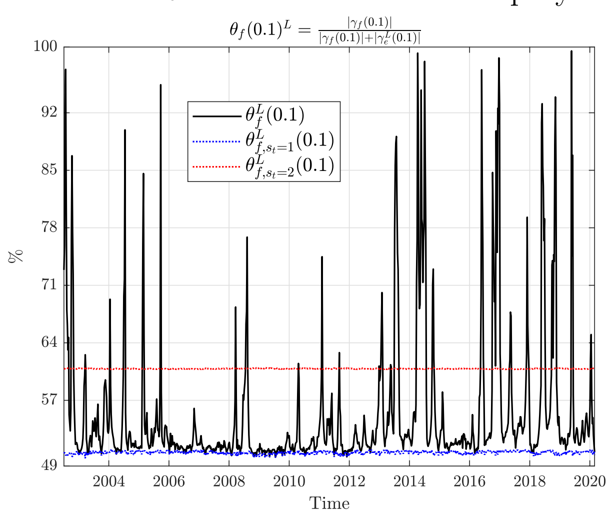
(c) Euro appreciation to Brazil



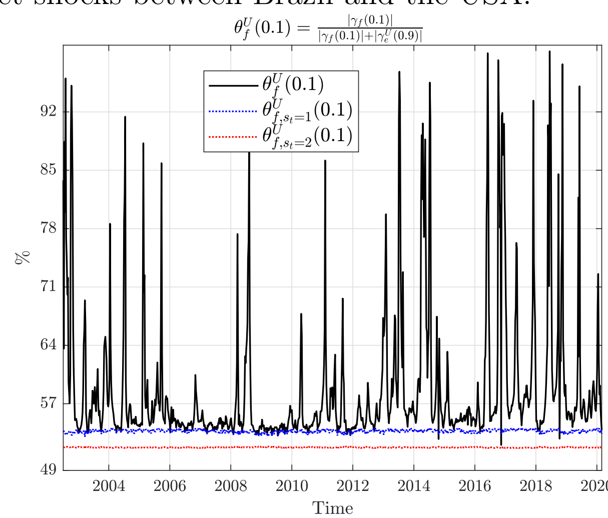
(d) Euro depreciation to Brazil

Figure 7 (Cont.): Relative contribution of equity market shocks between Brazil and developed markets.

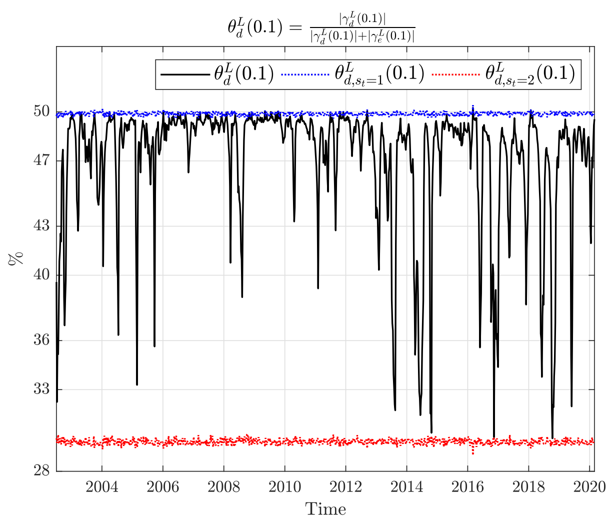
Panel B. Relative contribution of equity market shocks between Brazil and the USA.



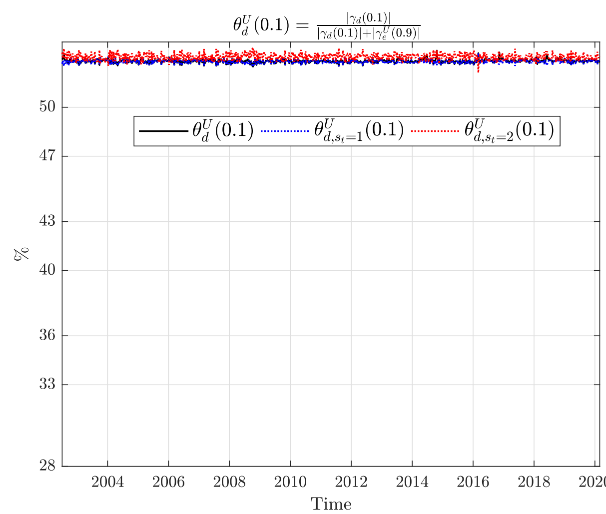
(a) USD appreciation to the USA



(b) USD depreciation to the USA



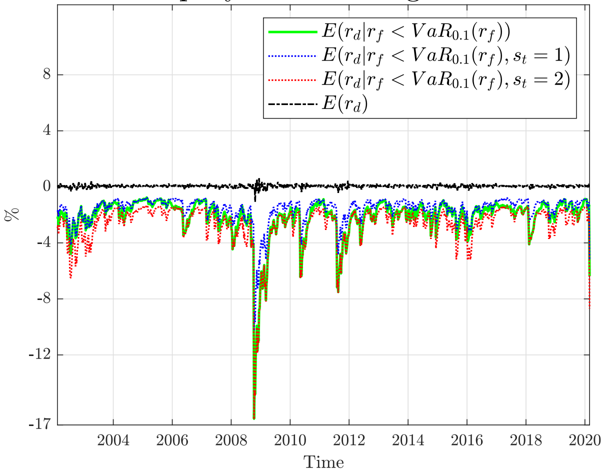
(c) USD appreciation to the Brazil



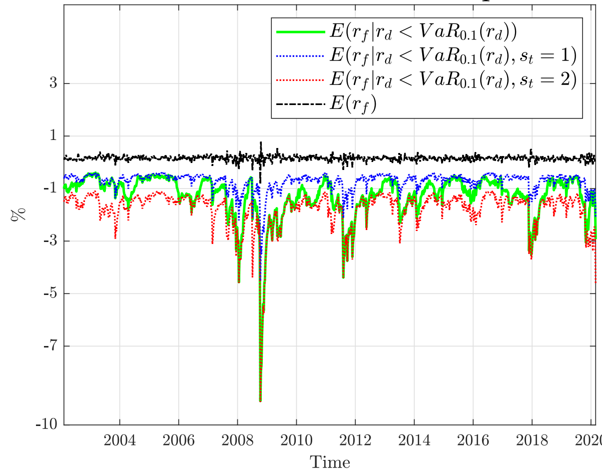
(d) USD depreciation to the Brazil

Figure 8: Equity and exchange rate shock transmission between Chile and developed markets.

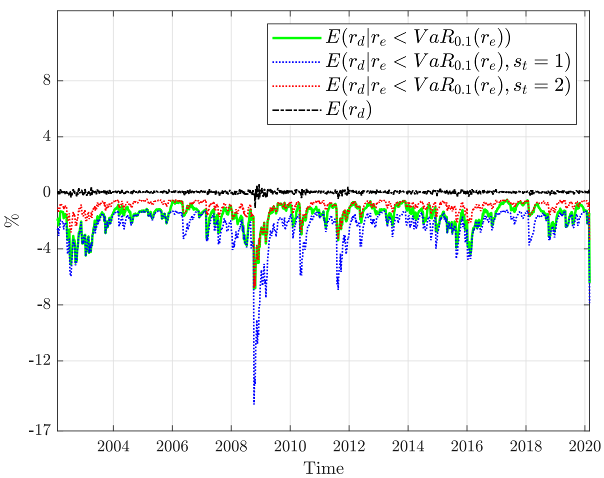
Panel A. Equity and exchange rate shock transmission between Chile and Europe.



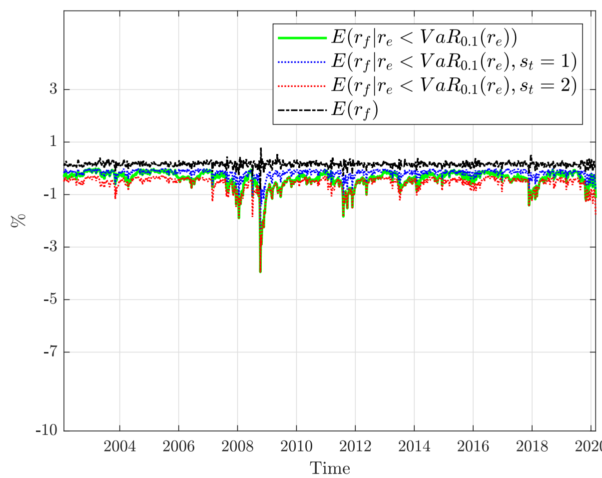
(a) Equity shocks from Chile (r_f) to Europe (r_d)



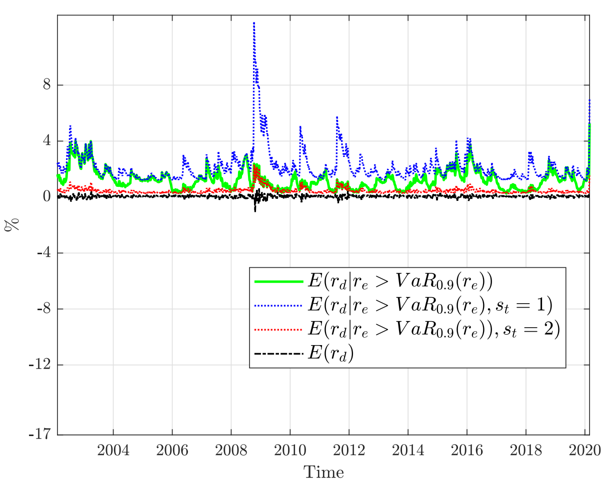
(b) Equity shocks from Europe (r_d) to Chile (r_f)



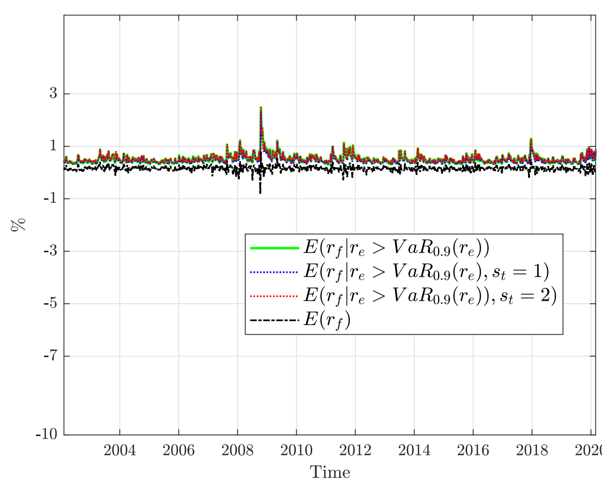
(c) Euro appreciation shocks (e) to European equity (r_d)



(d) Euro appreciation shocks (e) to Chilean equity (r_f)



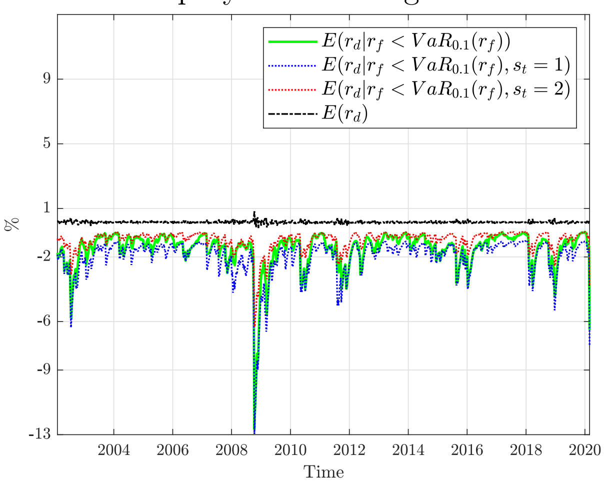
(e) Euro depreciation shocks (e) to European equity (r_d)



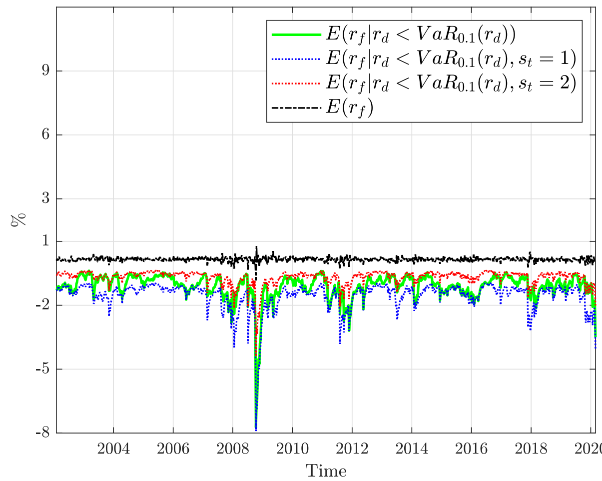
(f) Euro depreciation shocks (e) to Chilean equity (r_f)

Figure 8 (Cont.): Equity and exchange rate shock transmission between Chile and developed markets.

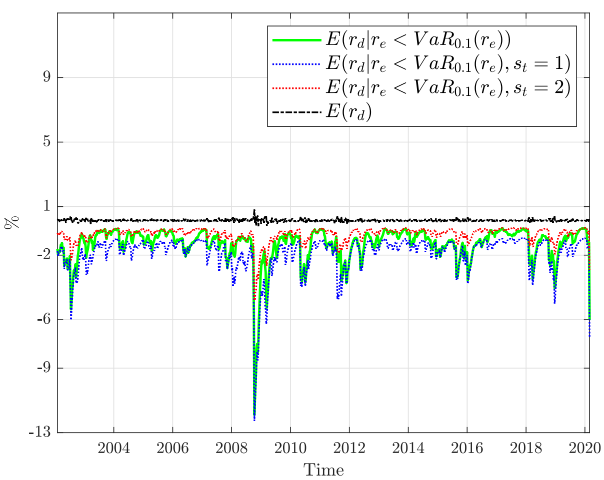
Panel B. Equity and exchange rate shock transmission between Chile and the USA.



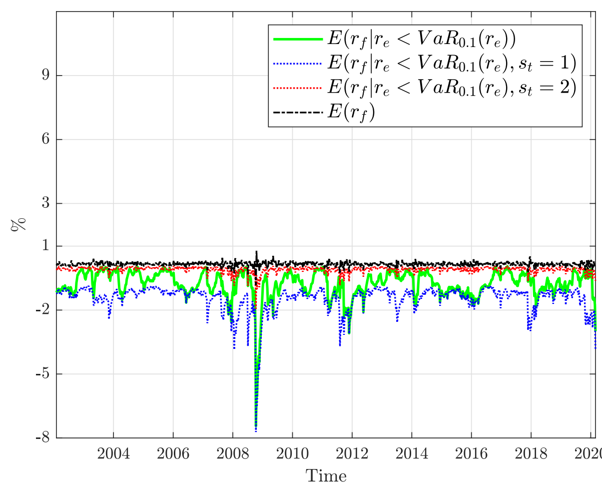
(a) Equity shocks from Chile (r_f) to the USA (r_d)



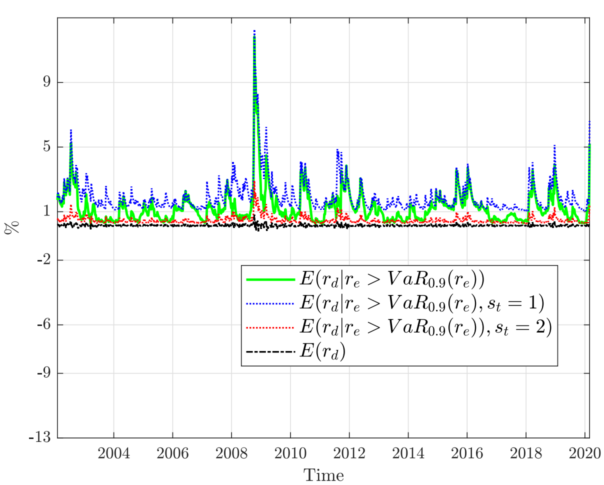
(b) Equity shocks from the USA (r_d) to Chile (r_f)



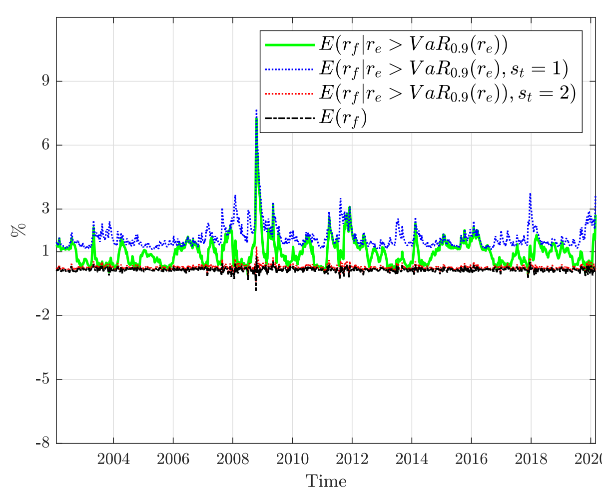
(c) USD appreciation shocks (e) to the US equity (r_d)



(d) USD appreciation shocks (e) to the Chilean equity (r_f)



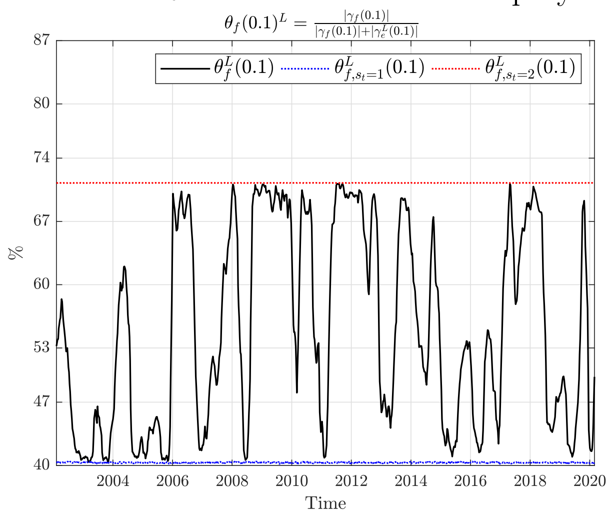
(e) USD depreciation shocks (e) to the US equity (r_d)



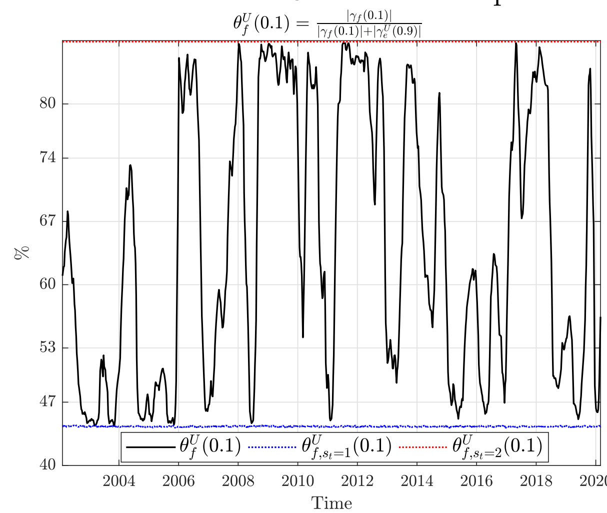
(f) USD depreciation shocks (e) to the Chilean equity (r_f)

Figure 9: Relative contribution of equity market shocks between Chile and developed stock markets.

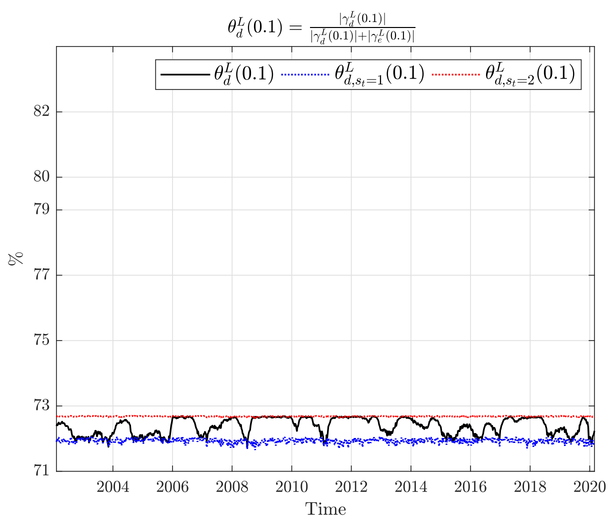
Panel A. Relative contribution of equity market shocks between Chile and Europe.



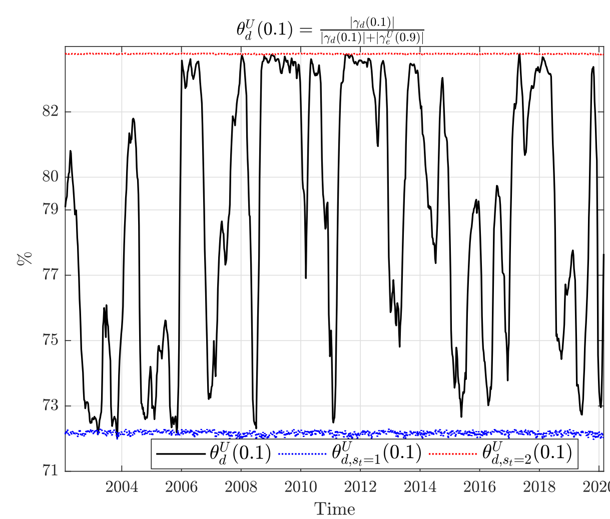
(a) Euro appreciation to Europe



(b) Euro depreciation to Europe



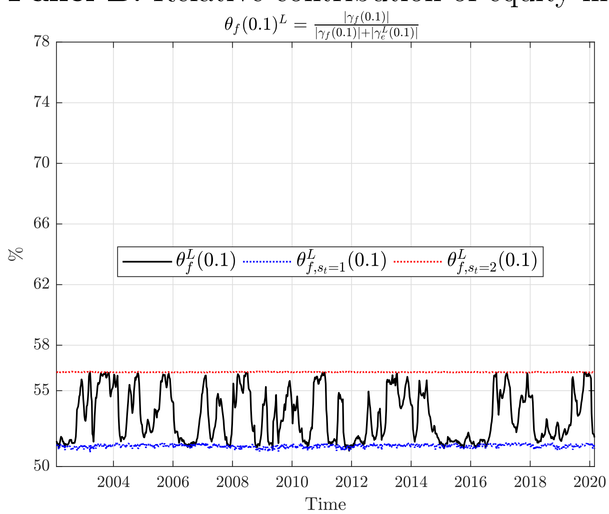
(c) Euro appreciation to Chile



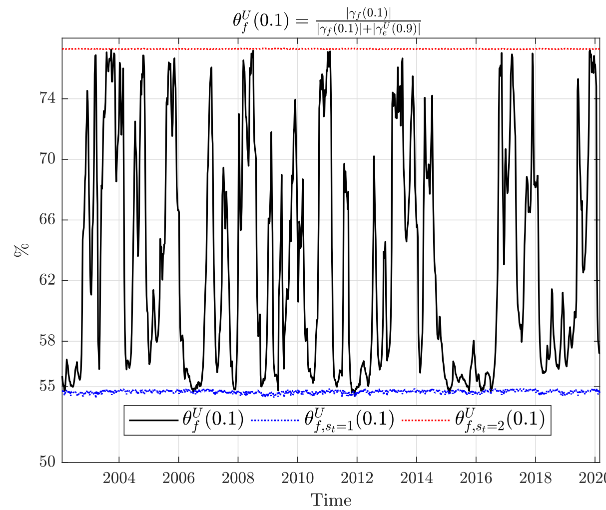
(d) Euro depreciation to Chile

Figure 9 (Cont.): Relative contribution of equity market shocks between Chile and developed stock markets.

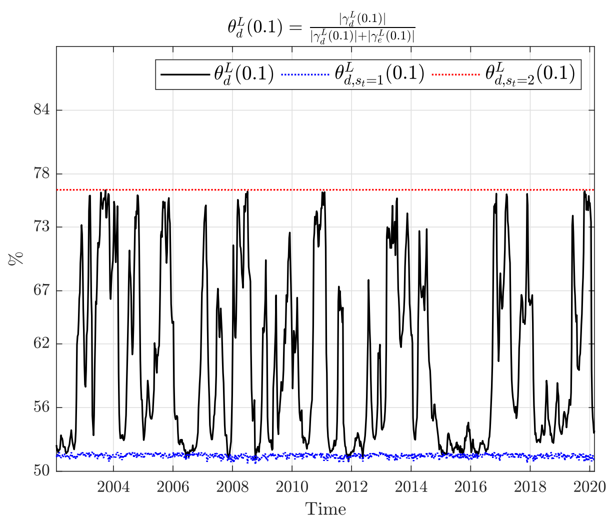
Panel B. Relative contribution of equity market shocks between Chile and the USA.



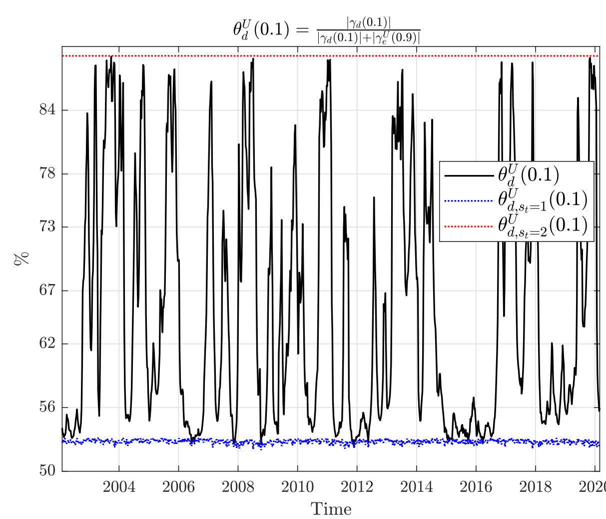
(a) USD appreciation to the USA



(b) USD depreciation to the USA



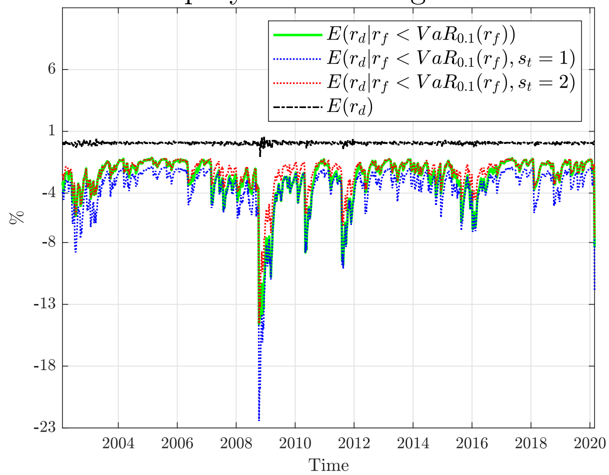
(c) USD appreciation to the Brazil



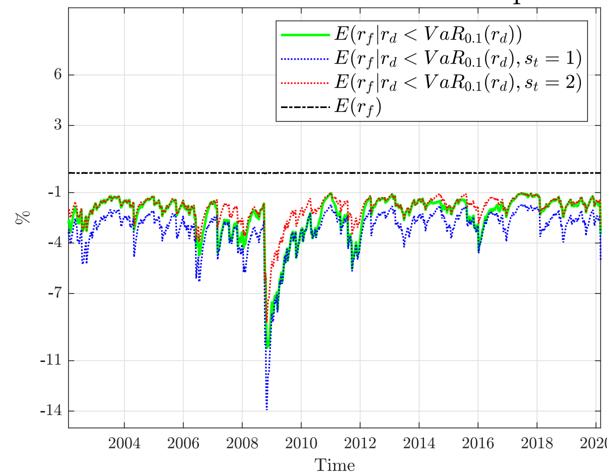
(d) USD depreciation to the Brazil

Figure 10: Equity and exchange rate shock transmission between Mexico and developed markets.

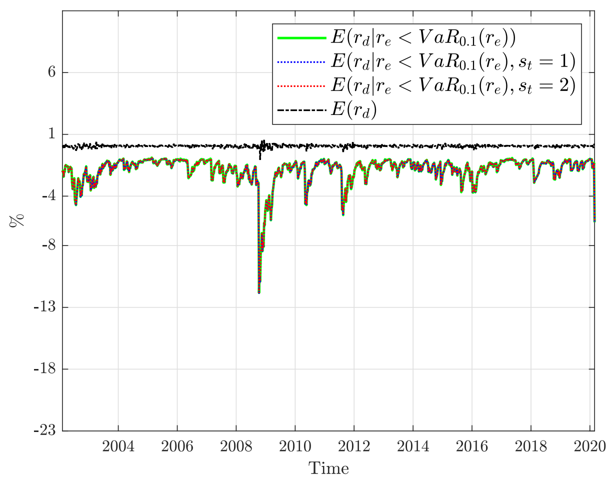
Panel A. Equity and exchange rate shock transmission between Mexico and Europe.



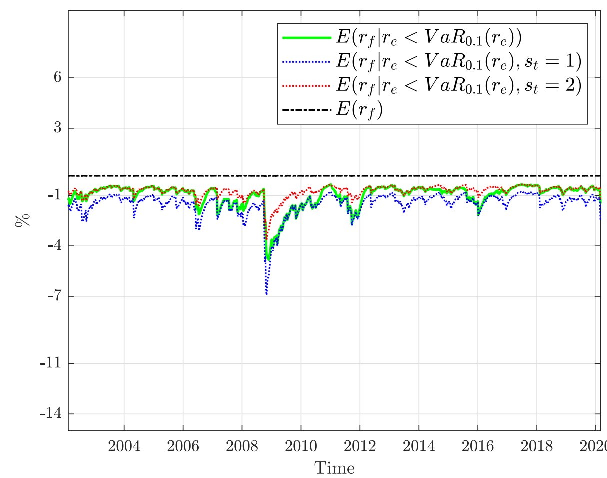
(a) Equity shocks from Mexico (r_f) to Europe (r_d)



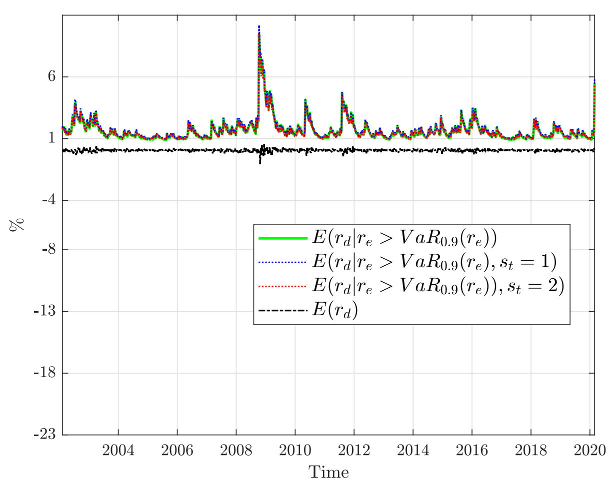
(b) Equity shocks from Europe (r_d) to Mexico (r_f)



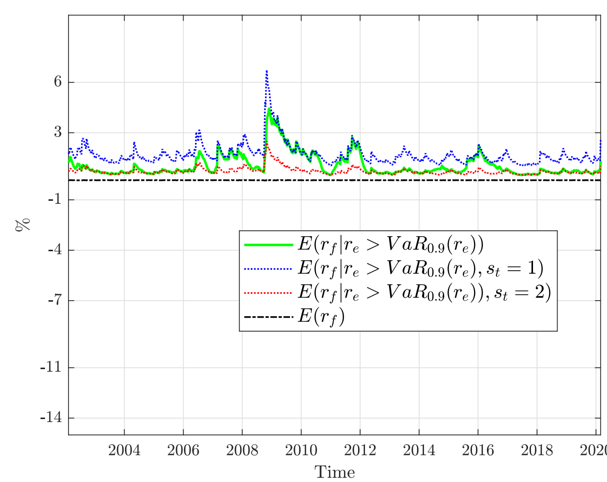
(c) Euro appreciation shocks (e) to European equity (r_d)



(d) Euro appreciation shocks (e) to Mexican equity (r_f)



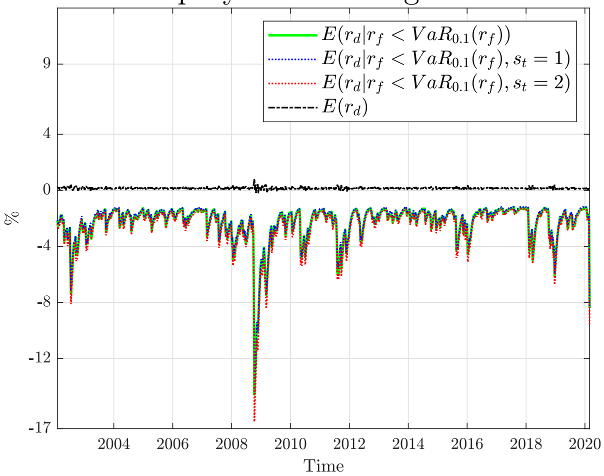
(e) Euro depreciation shocks (e) to European equity (r_d)



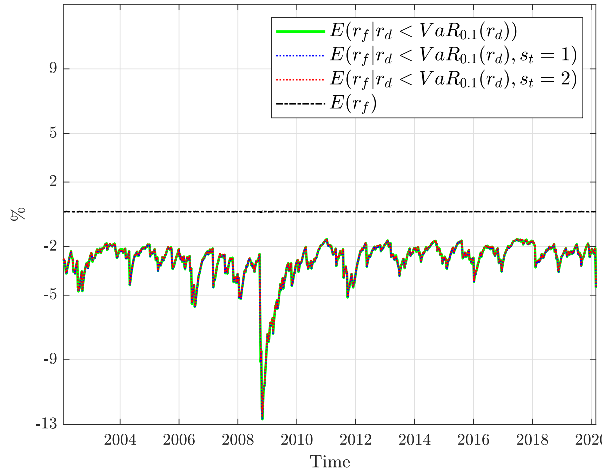
(f) Euro depreciation shocks (e) to Mexican equity (r_f)

Figure 10 (Cont.): Equity and exchange rate shock transmission between Mexico and developed markets.

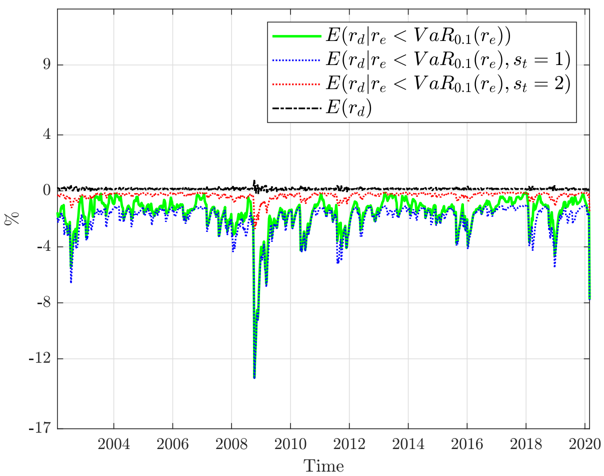
Panel B. Equity and exchange rate shock transmission between Mexico and the USA.



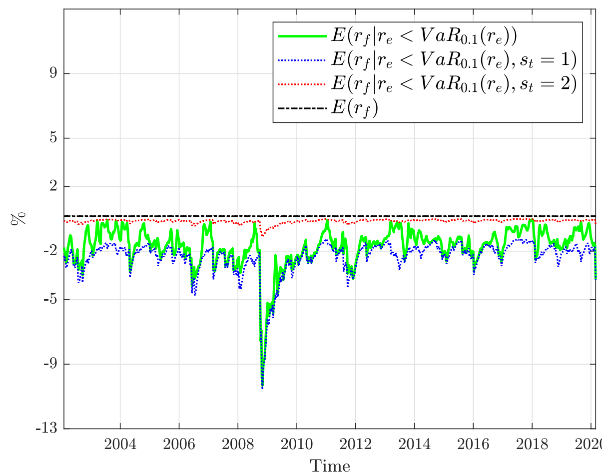
(a) Equity shocks from Mexico (r_f) to the USA (r_d)



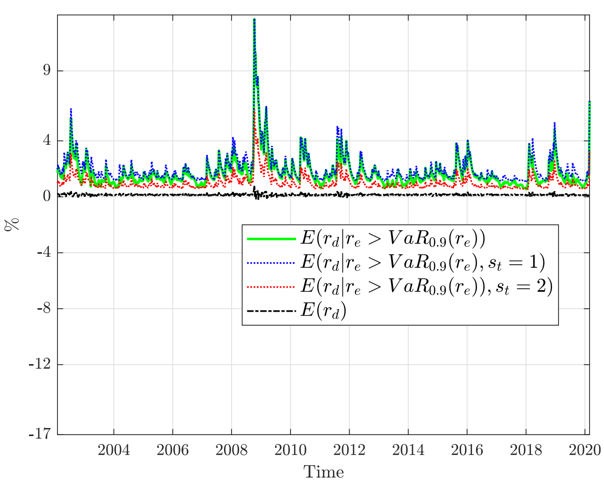
(b) Equity shocks from the USA (r_d) to Mexico (r_f)



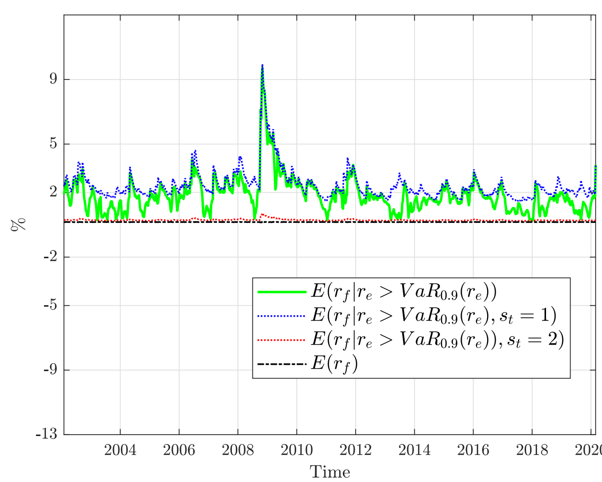
(c) USD appreciation shocks (e) to the US equity (r_d)



(d) USD appreciation shocks (e) to the Mexican equity (r_f)



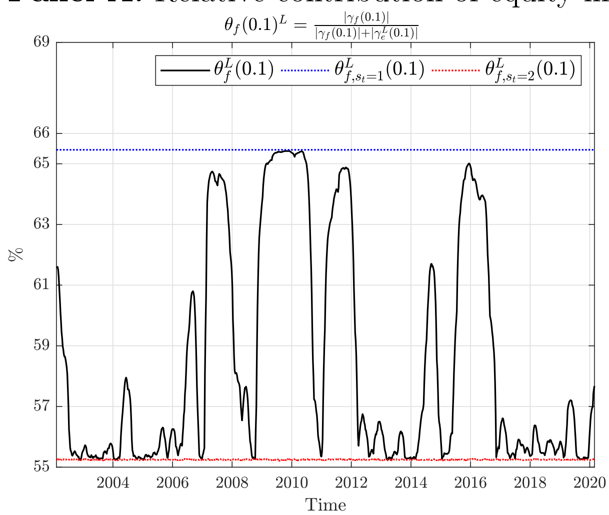
(e) USD depreciation shocks (e) to the US equity (r_d)



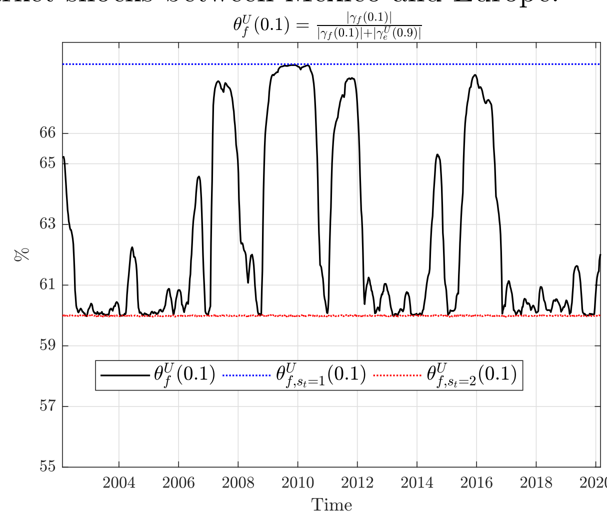
(f) USD appreciation shocks (e) to the Mexican equity (r_f)

Figure 11: Relative contribution of equity market shocks between Mexico and developed markets.

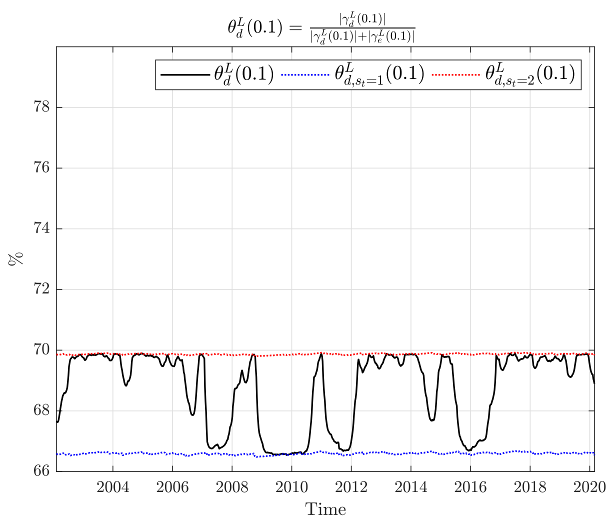
Panel A. Relative contribution of equity market shocks between Mexico and Europe.



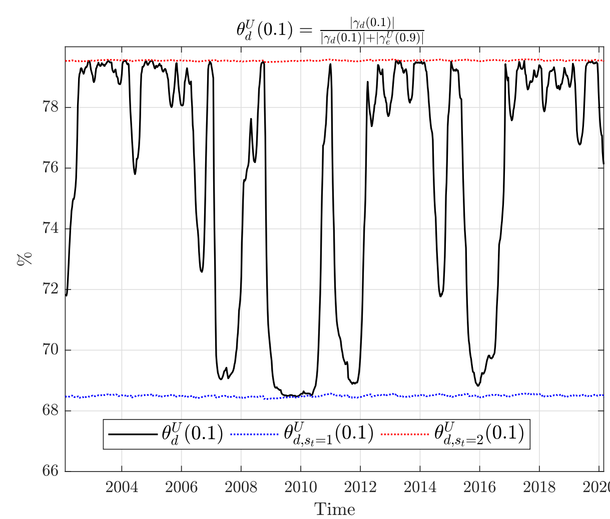
(a) Euro appreciation to Europe



(b) Euro depreciation to Europe



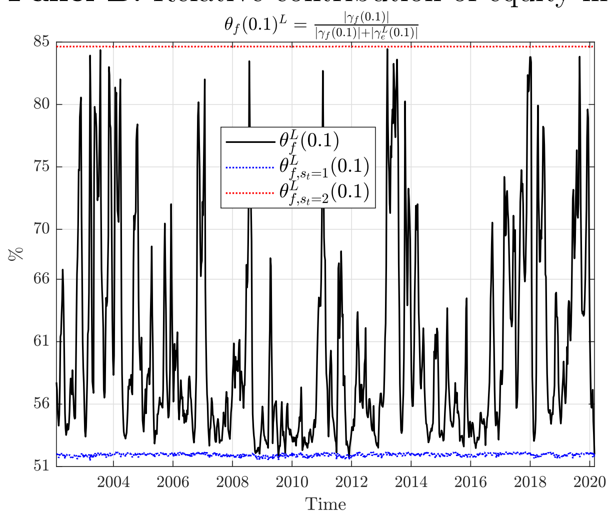
(c) Euro appreciation to Mexico



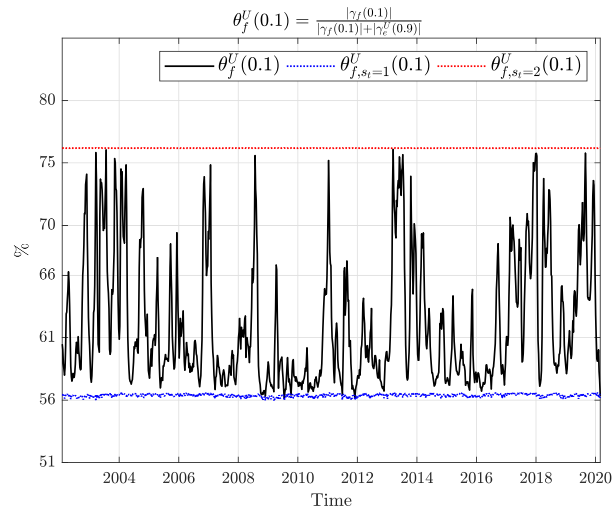
(d) Euro depreciation to Mexico

Figure 11 (Cont.): Relative contribution of equity market shocks between Mexico and developed markets.

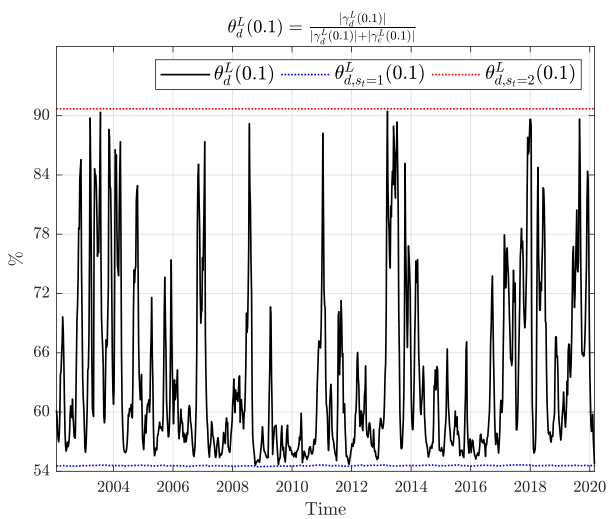
Panel B. Relative contribution of equity market shocks between Mexico and the USA.



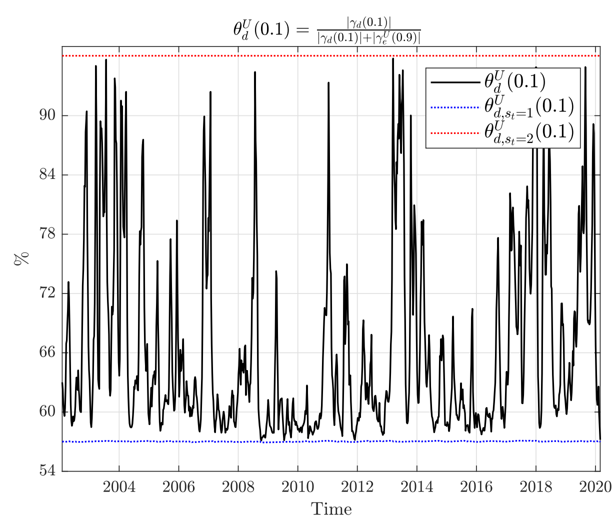
(a) USD appreciation to the USA



(b) USD depreciation to the USA



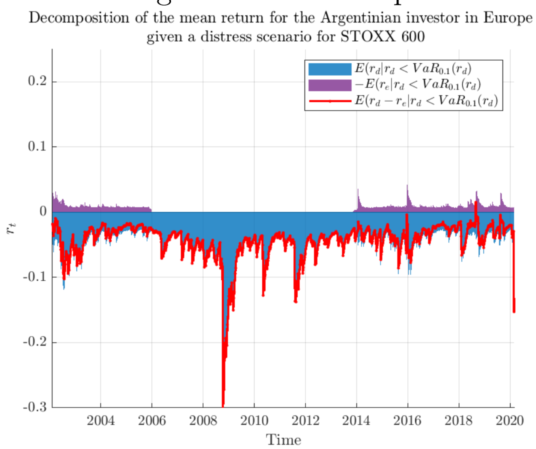
(c) USD appreciation to Mexico



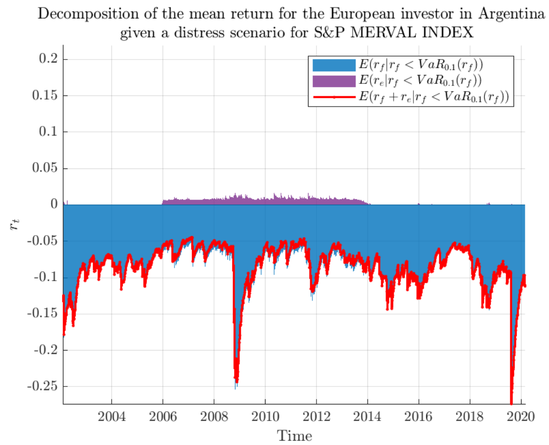
(d) USD depreciation to Mexico

Figure 12: Decomposition of international returns: Argentina and developed markets.

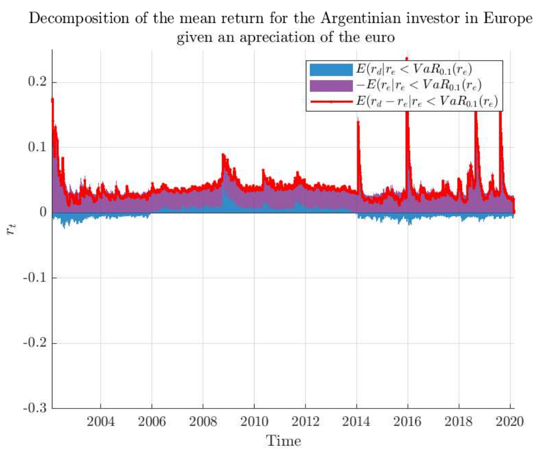
Panel A. Argentina and Europe.



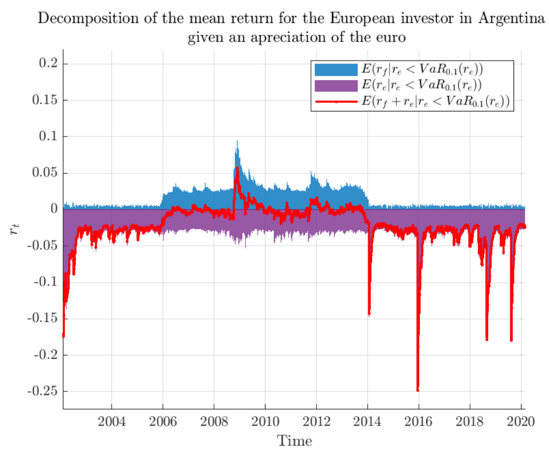
(a) Argentinian investment in European equity ($r_d - r_e$) under a distress scenario for the European stock market (r_d)



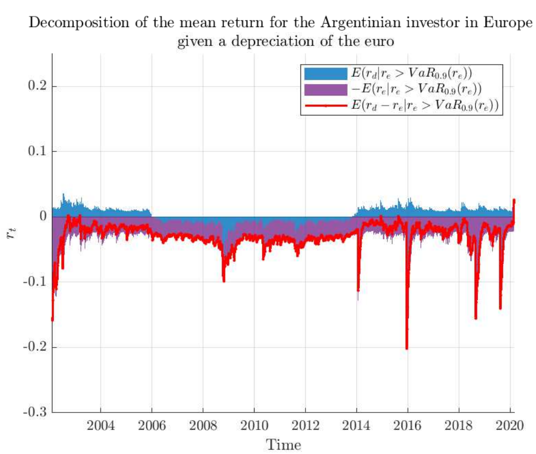
(b) European investment in Argentinian equity ($r_f + r_e$) under a distress scenario for the Argentinian stock market (r_f)



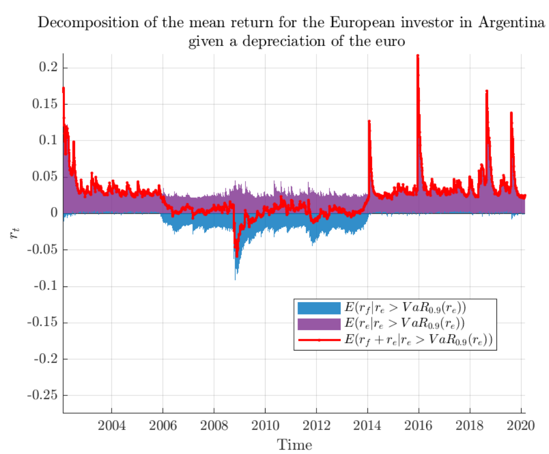
(c) Argentinian investment in European equity ($r_d - r_e$) under a EUR appreciation shocks (r_e)



(d) European investment in Argentinian equity ($r_f + r_e$) under a EUR appreciation shocks (r_e)



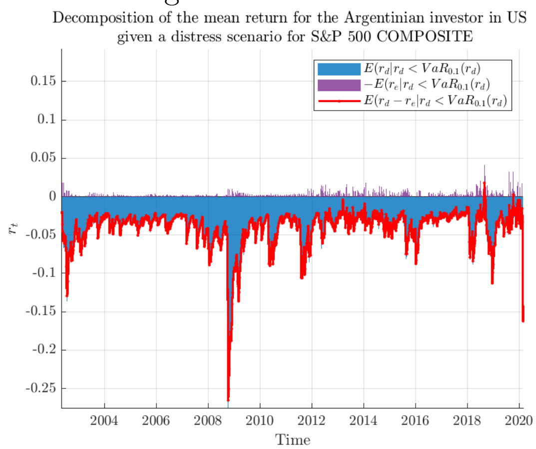
(e) Argentinian investment in European equity ($r_d - r_e$) under a EUR depreciation shocks (r_e)



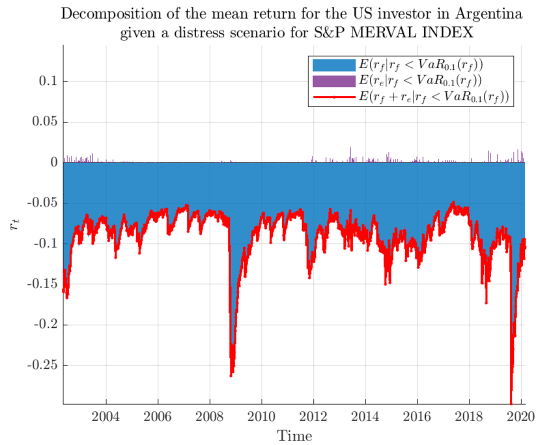
(f) European investment in Argentinian equity ($r_f + r_e$) under a EUR depreciation shocks (r_e)

Figure 12 (Cont.): Decomposition of international returns: Argentina and developed markets.

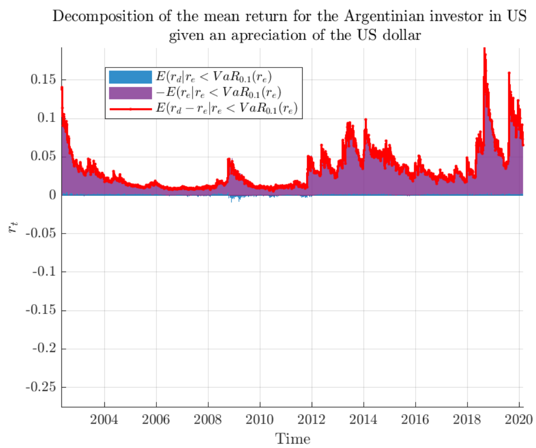
Panel B. Argentina and USA.



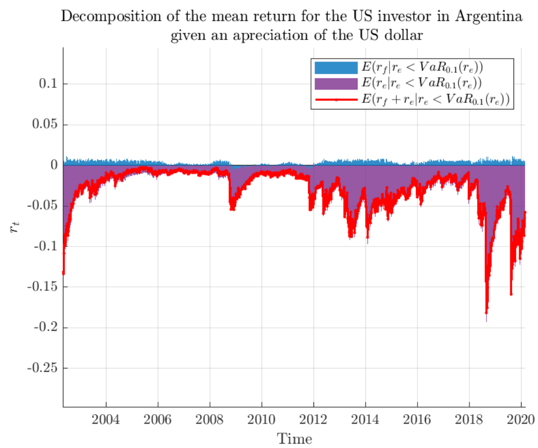
(a) Argentinian investment in US equity $(r_d - r_e)$ under a distress scenario for the US stock market (r_d)



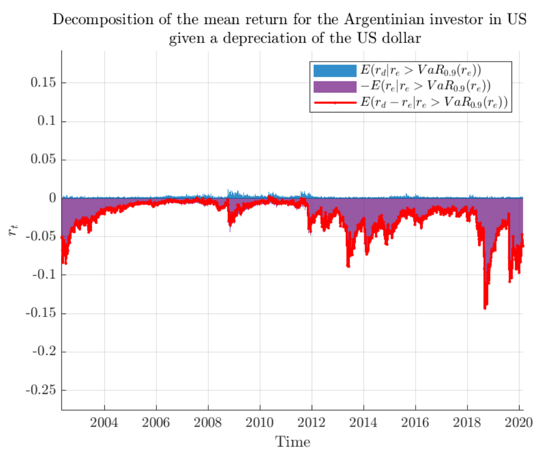
(b) US investment in Argentinian equity $(r_f + r_e)$ under a distress scenario for the Argentinian stock market (r_f)



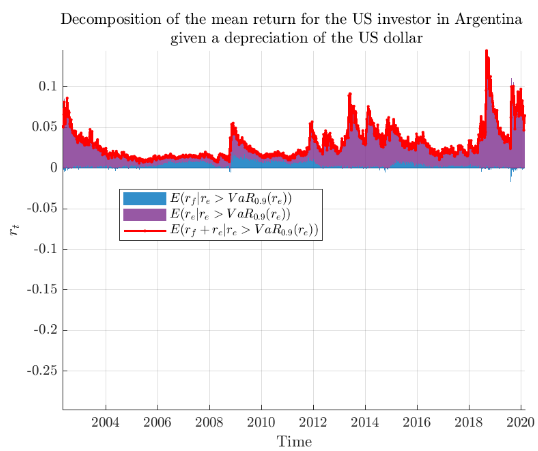
(c) Argentinian investment in US equity $(r_d - r_e)$ under a USD appreciation shocks (r_e)



(d) US investment in Argentinian equity $(r_f + r_e)$ under a USD appreciation shocks (r_e)



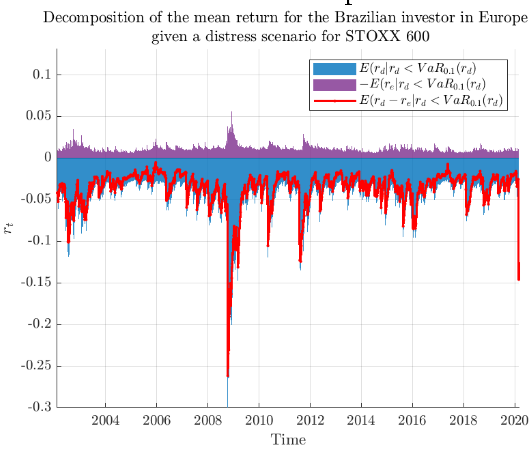
(e) Argentinian investment in US equity $(r_d - r_e)$ under a USD depreciation shocks (r_e)



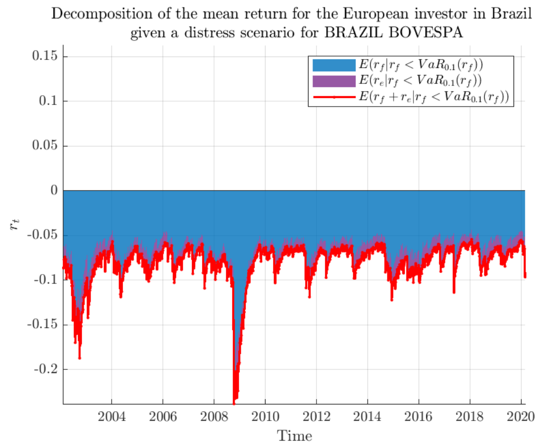
(f) US investment in Argentinian equity $(r_f + r_e)$ under a USD depreciation shocks (r_e)

Figure 13: Decomposition of international returns: Brazil and developed markets.

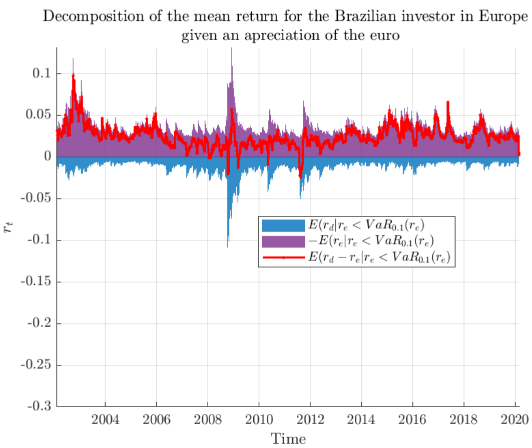
Panel A. Brazil and Europe.



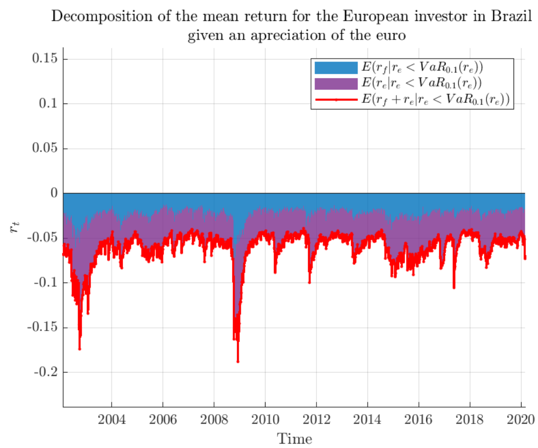
(a) Brazilian investment in European equity ($r_d - r_e$) under a distress scenario for the European stock market (r_d)



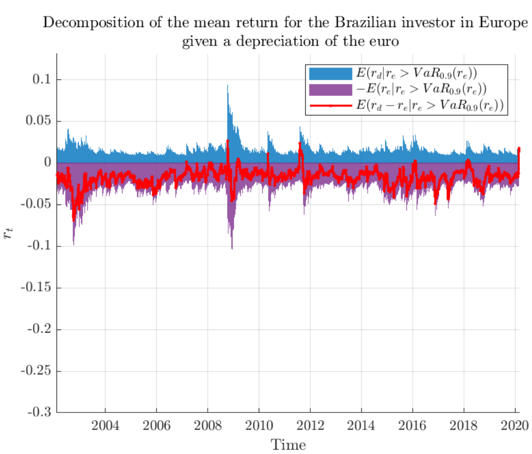
(b) European investment in Brazilian equity ($r_f + r_e$) under a distress scenario for the Brazilian stock market (r_f)



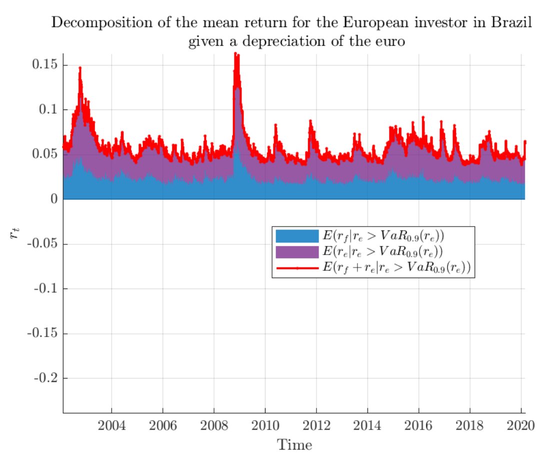
(c) Brazilian investment in European equity ($r_d - r_e$) under a EUR appreciation shocks (r_e)



(d) European investment in Brazilian equity ($r_f + r_e$) under a EUR appreciation shocks (r_e)



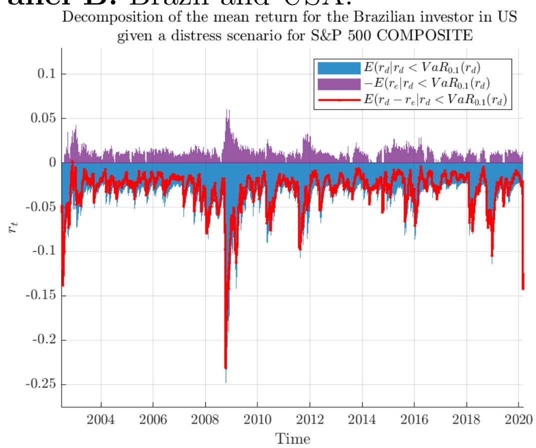
(e) Brazilian investment in European equity ($r_d - r_e$) under a EUR depreciation shocks (r_e)



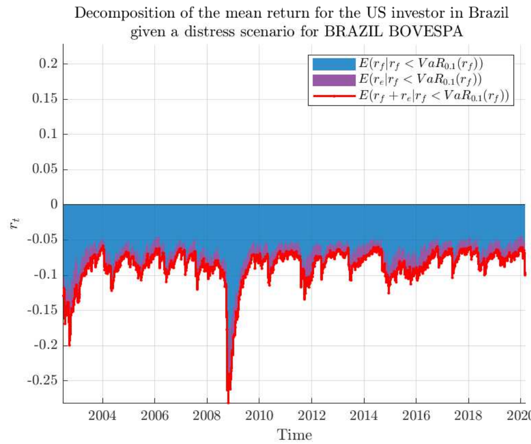
(f) European investment in Brazilian equity ($r_f + r_e$) under a EUR depreciation shocks (r_e)

Figure 13 (Cont.): Decomposition of international returns: Brazil and developed markets.

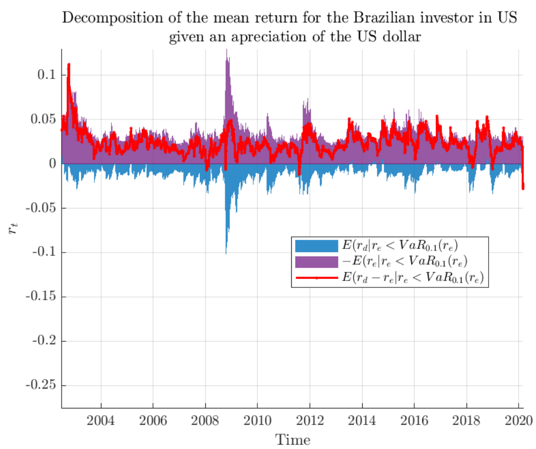
Panel B. Brazil and USA.



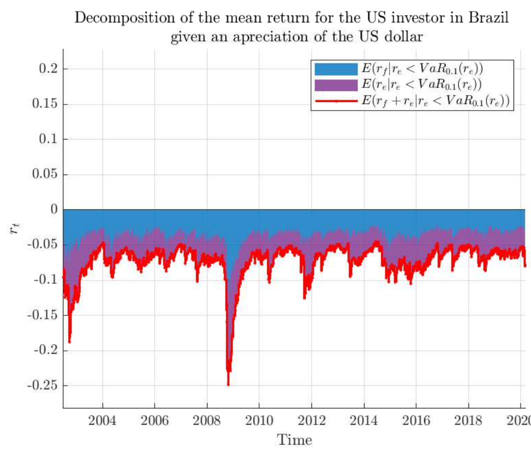
(a) Brazilian investment in US equity ($r_d - r_e$) under a distress scenario for the US stock market (r_d)



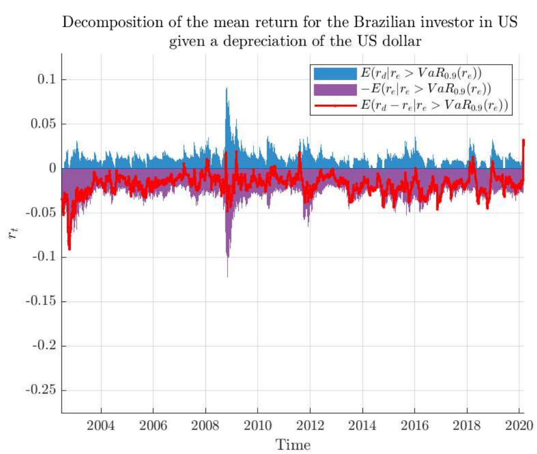
(b) US investment in Brazilian equity ($r_f + r_e$) under a distress scenario for the Brazilian stock market (r_f)



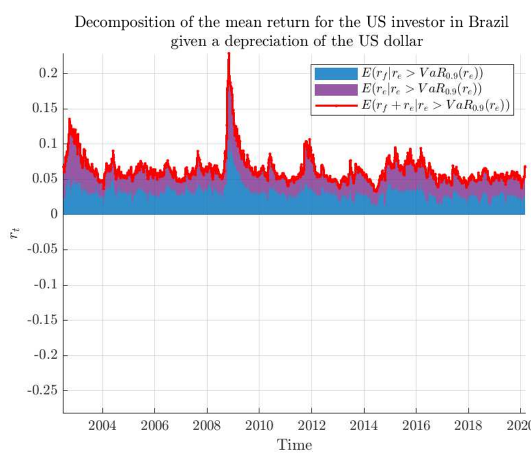
(c) Brazilian investment in US equity ($r_d - r_e$) under a USD appreciation shocks (r_e)



(d) US investment in Brazilian equity ($r_f + r_e$) under a USD appreciation shocks (r_e)



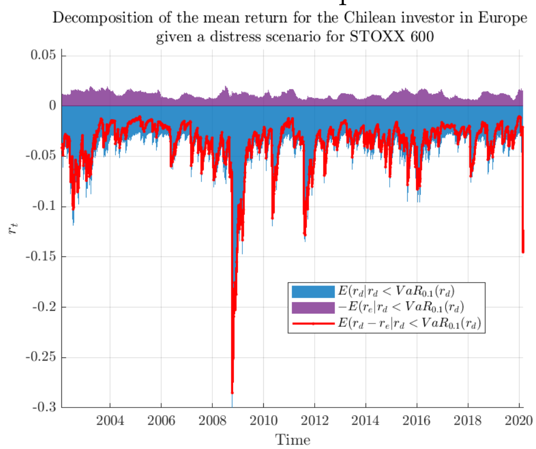
(e) Brazilian investment in US equity ($r_d - r_e$) under a USD depreciation shocks (r_e)



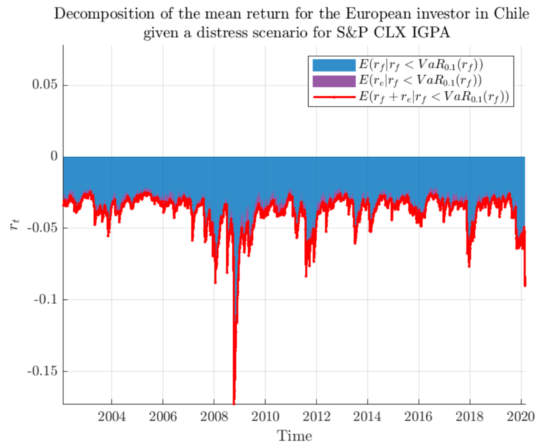
(f) US investment in Brazilian equity ($r_f + r_e$) under a USD depreciation shocks (r_e)

Figure 14: Decomposition of international returns: Chile and developed markets.

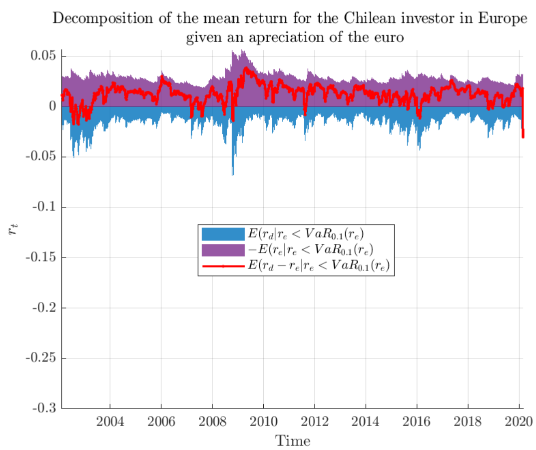
Panel A. Chile and Europe.



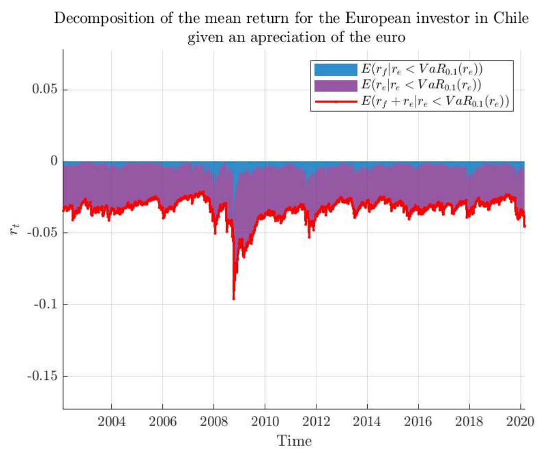
(a) Chilean investment in European equity $(r_d - r_e)$ under a distress scenario for the European stock market (r_d)



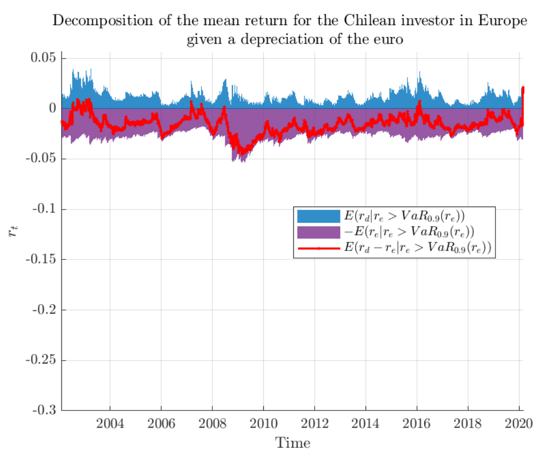
(b) European investment in Chilean equity $(r_f + r_e)$ under a distress scenario for the Chilean stock market (r_f)



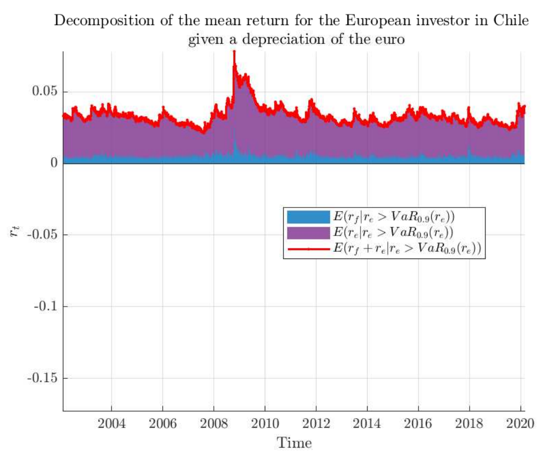
(c) Chilean investment in European equity $(r_d - r_e)$ under a EUR appreciation shocks (r_e)



(d) European investment in Chilean equity $(r_f + r_e)$ under a EUR appreciation shocks (r_e)



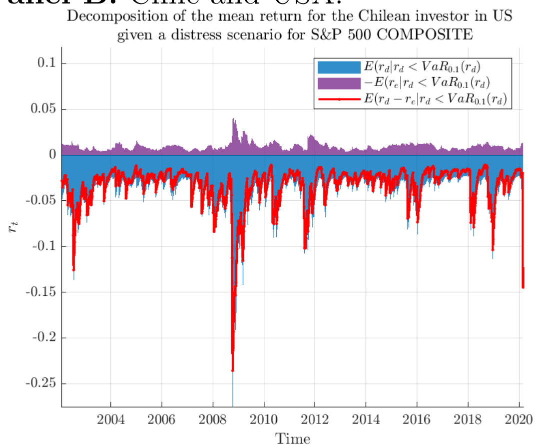
(e) Chilean investment in European equity $(r_d - r_e)$ under a EUR depreciation shocks (r_e)



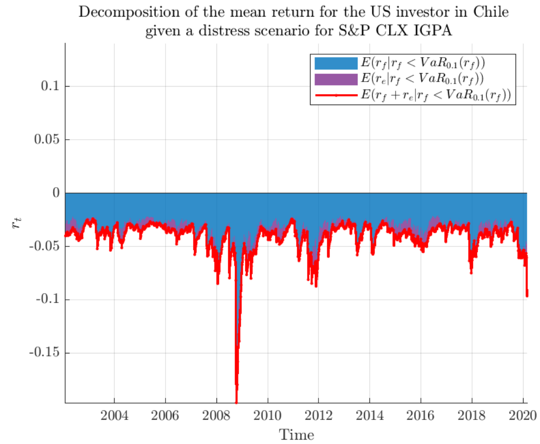
(f) European investment in Chilean equity $(r_f + r_e)$ under a EUR depreciation shocks (r_e)

Figure 14 (Cont.): Decomposition of international returns: Chile and developed markets.

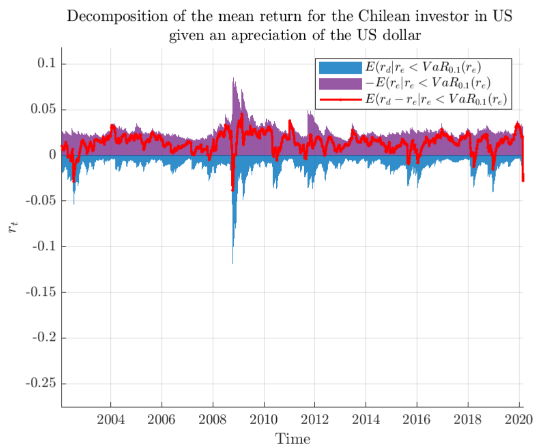
Panel B. Chile and USA.



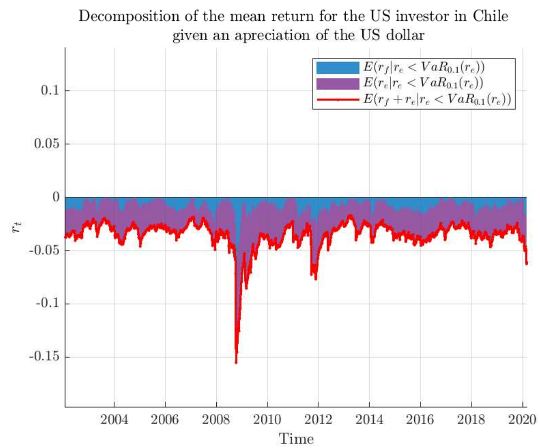
(a) Chilean investment in US equity $(r_d - r_e)$ under a distress scenario for the US stock market (r_d)



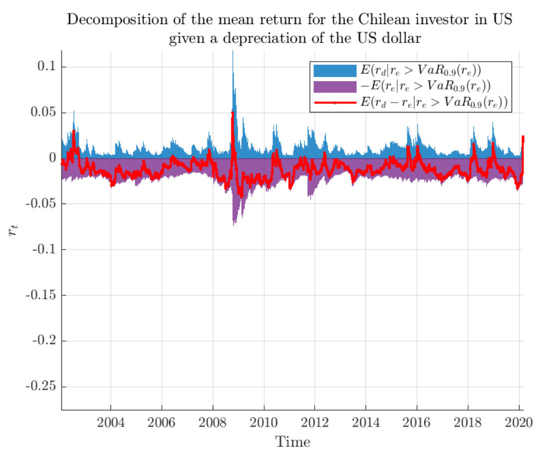
(b) US investment in Chilean equity $(r_f + r_e)$ under a distress scenario for the Chilean stock market (r_f)



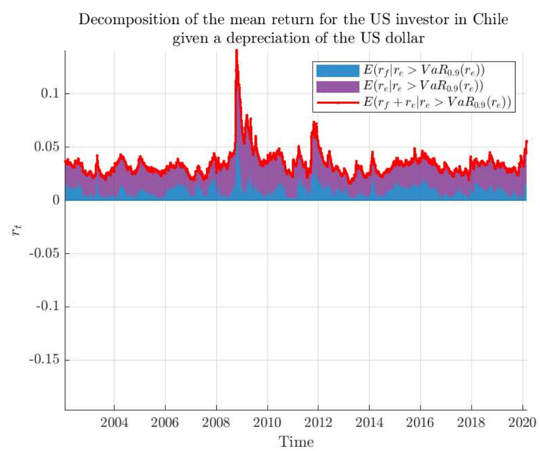
(c) Chilean investment in US equity $(r_d - r_e)$ under a USD appreciation shocks (r_e)



(d) US investment in Chilean equity $(r_f + r_e)$ under a USD appreciation shocks (r_e)



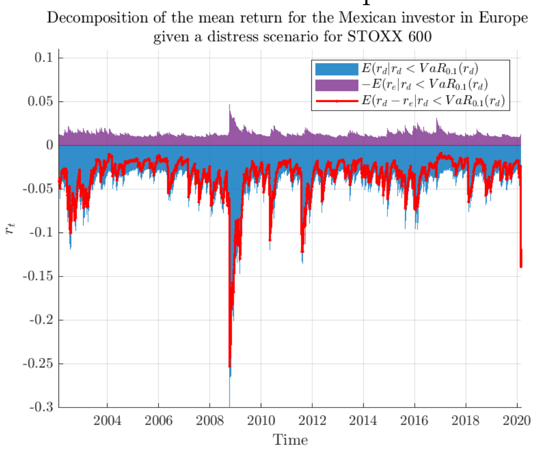
(e) Chilean investment in US equity $(r_d - r_e)$ under a USD depreciation shocks (r_e)



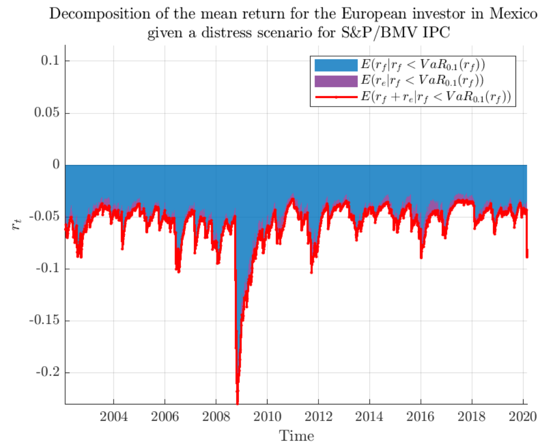
(f) US investment in Chilean equity $(r_f + r_e)$ under a USD depreciation shocks (r_e)

Figure 15: Decomposition of international returns: Mexico and developed markets.

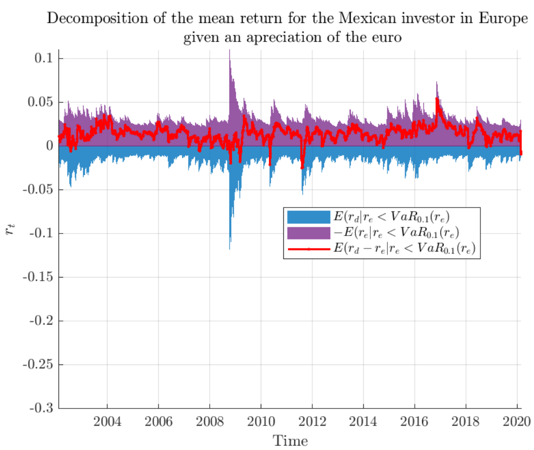
Panel A. Mexico and Europe.



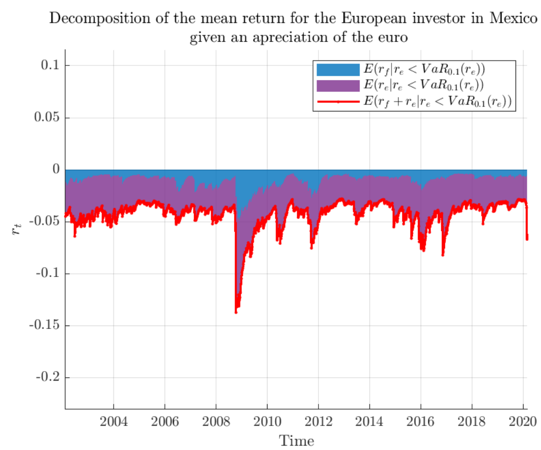
(a) Mexican investment in European equity ($r_d - r_e$) under a distress scenario for the European stock market (r_d)



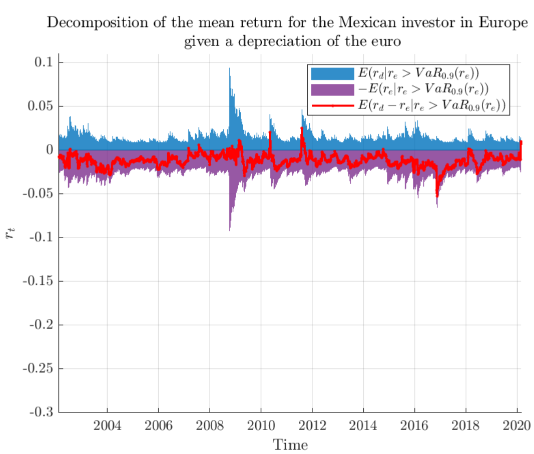
(b) European investment in Mexican equity ($r_f + r_e$) under a distress scenario for the Mexican stock market (r_f)



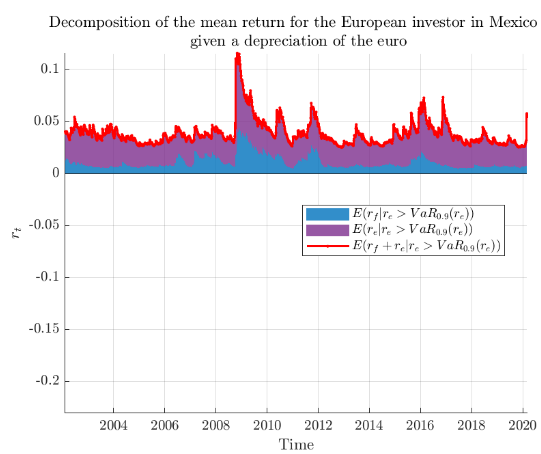
(c) Mexican investment in European equity ($r_d - r_e$) under a EUR appreciation shocks (r_e)



(d) European investment in Mexican equity ($r_f + r_e$) under a EUR appreciation shocks (r_e)



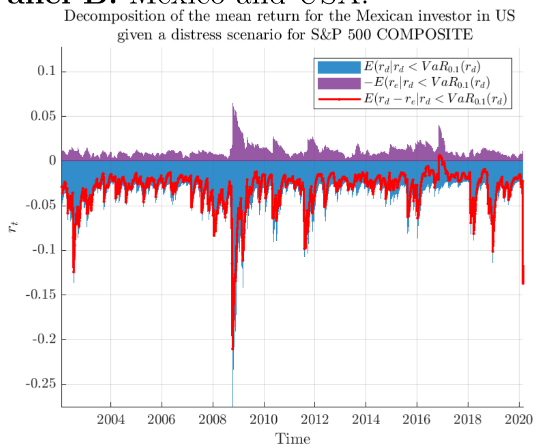
(e) Mexican investment in European equity ($r_d - r_e$) under a EUR depreciation shocks (r_e)



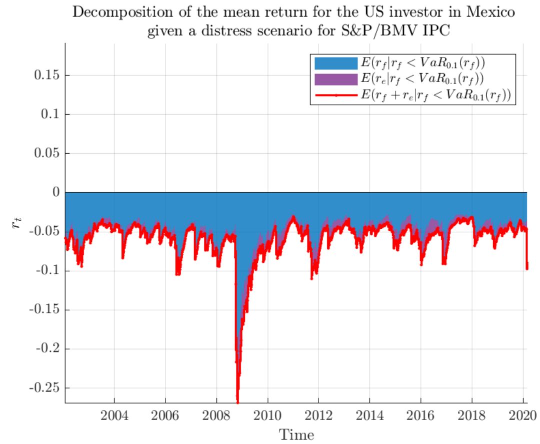
(f) European investment in Mexican equity ($r_f + r_e$) under a EUR depreciation shocks (r_e)

Figure 15 (Cont.): Decomposition of international returns: Mexico and developed markets.

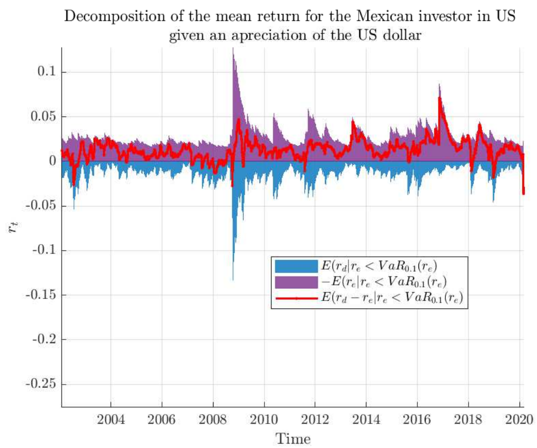
Panel B. Mexico and USA.



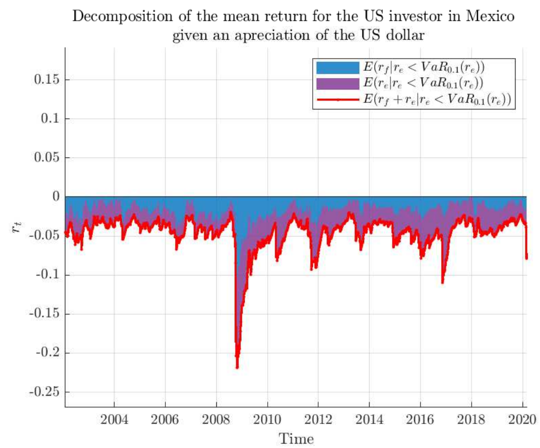
(a) Mexican investment in US equity $(r_d - r_e)$ under a distress scenario for the US stock market (r_d)



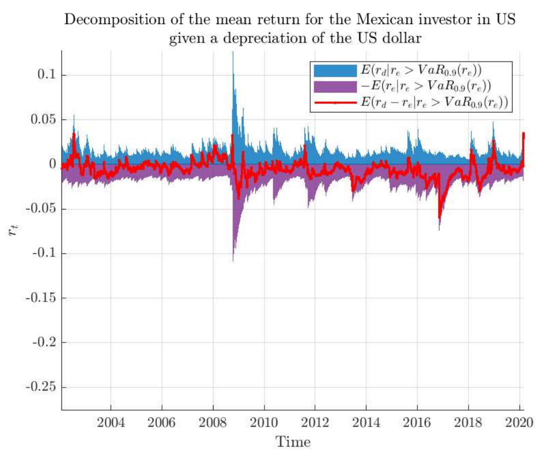
(b) US investment in Mexican equity $(r_f + r_e)$ under a distress scenario for the Mexican stock market (r_f)



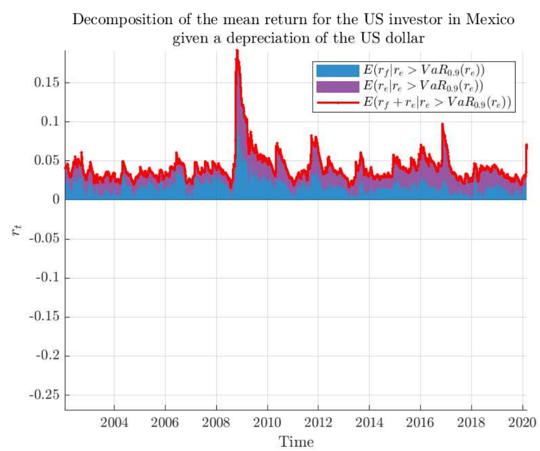
(c) Mexican investment in US equity $(r_d - r_e)$ under a USD appreciation shocks (r_e)



(d) US investment in Mexican equity $(r_f + r_e)$ under a USD appreciation shocks (r_e)



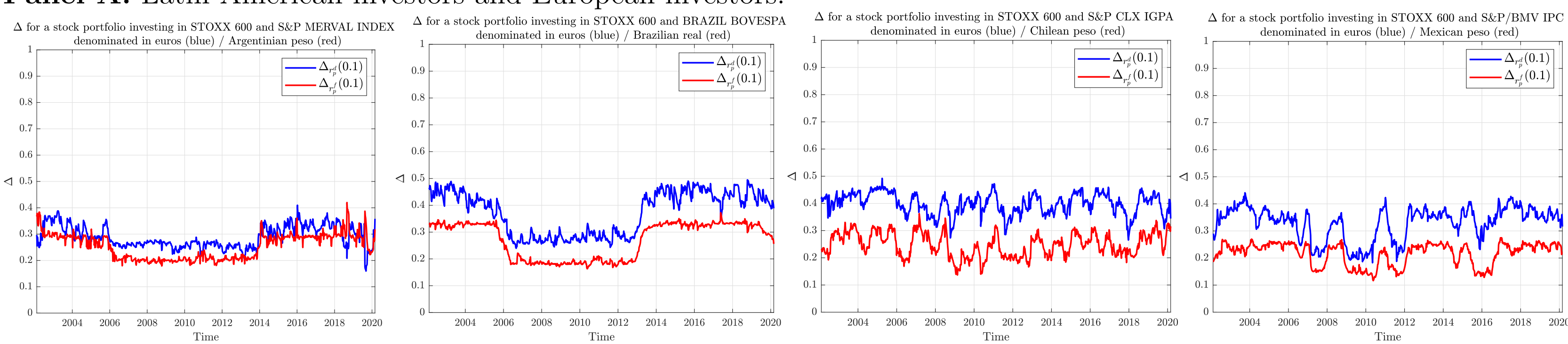
(e) Mexican investment in US equity $(r_d - r_e)$ under a USD depreciation shocks (r_e)



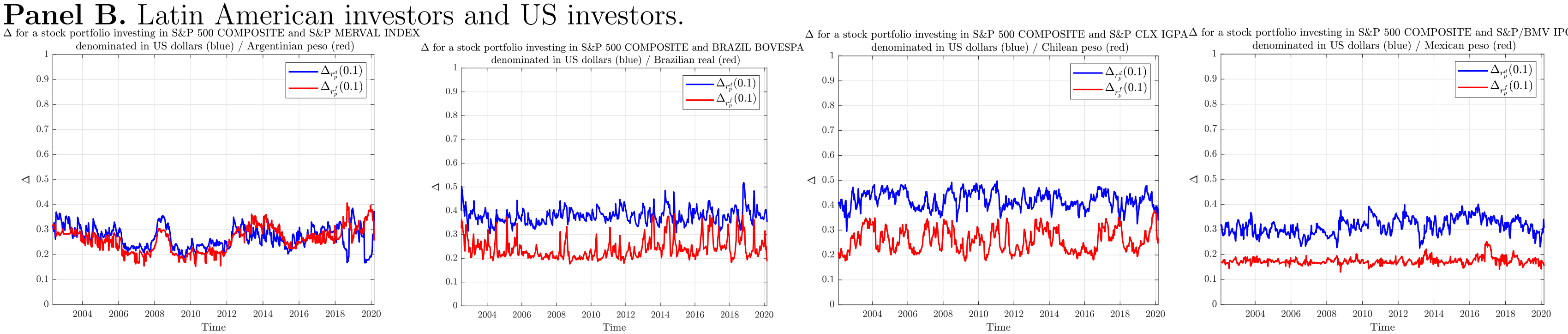
(f) US investment in Mexican equity $(r_f + r_e)$ under a USD depreciation shocks (r_e)

Figure 16: Measure of diversification.

Panel A. Latin American investors and European investors.



Panel B. Latin American investors and US investors.



This figure shows diversification benefits according to Eq. (17), with the blue (red) line indicating the portfolio denominated in the domestic (foreign) currency.

B Tables

Table 1: Tail dependence and Kendall's rank correlation coefficient for each copula.

Family	Copula model	τ_L	τ_U	Kendall's τ
Gaussian	$\Phi(\Phi^{-1}(u_1), \Phi^{-1}(u_2); \rho)$	$-$ (if $\rho = 1$ then 1)	$-$ (if $\rho = 1$ then 1)	$2 \arcsin(\rho)\pi^{-1}$
Student t	$T(T^{-1}(u_1; \eta), T^{-1}(u_2; \eta); \rho, \eta)$	$2t_{\eta+1}\left(-\sqrt{\frac{(\eta+1)(1-\rho)}{1+\rho}}\right)$	$2t_{\eta+1}\left(-\sqrt{\frac{(\eta+1)(1-\rho)}{1+\rho}}\right)$	$2 \arcsin(\rho)\pi^{-1}$
Clayton	$\left(u_1^{-\theta} + u_2^{-\theta} - 1\right)^{-1/\theta}$	$2^{-1/\theta}$	$-$	$\frac{\theta}{\theta+2}$
Gumbel	$\exp\left(-\left\{(-\log u_1)^{\theta} + (-\log u_2)^{\theta}\right\}^{1/\theta}\right)$	$-$	$2 - 2^{1/\theta}$	$\frac{\theta-1}{\theta}$
BB1 (Clayton-Gumbel)	$\left(1 + \left[(u_1^{-\theta} - 1)^{\delta} + (u_2^{-\theta} - 1)^{\delta}\right]^{1/\delta}\right)^{-1/\theta}$	$2^{-\frac{1}{\theta\delta}}$	$2 - 2^{1/\delta}$	$1 - \frac{2}{\delta(\theta+2)}$

Notes. This table summarizes the main features of bivariate copulas to be used in the empirical analysis. τ_L denotes lower tail dependence, defined as $\tau_L = lim_{q \to 0} P(u_2 < q | u_1 < q)$, while τ_U denotes upper tail dependence, defined as $\tau_U = lim_{q \to 1} P(u_2 > q | u_1 > q)$. $-$ represents no tail dependence. $\Phi(...; \rho)$ indicates the normal cumulative distribution function with correlation ρ, whereas $T(...; \eta)$ indicates the student-t cumulative distribution function with η degrees of freedom and correlation ρ. $\Phi^{-1}(\dots)$ and $T^{-1}(\dots)$ indicate, respectively, the inverse cumulative distribution function of the normal and the student-t distribution. Ojea Ferreiro (2019) provides formulas for density copulas and conditional copulas for these models.

Table 2: Correlation between equity markets in different currencies, in the same currency and between equity market and currency value.

Panel A: Correlation between equity returns expressed in their own currencies.

	AR	BR	CL	MX
EU	0.48	0.59	0.55	0.66
US	0.48	0.62	0.52	0.70

Panel B: Correlation between equity returns from developed-market investors' perspective.

	AR	BR	CL	MX
EU	0.46	0.62	0.60	0.73
US	0.45	0.60	0.57	0.72

Panel C: Correlation between equity returns from emerging-market investors' perspective.

	AR	BR	CL	MX
EU	0.39	0.20	0.44	0.53
US	0.36	0.06	0.32	0.43

Notes. This table presents pairwise Pearson linear correlations between equity returns for emerging and developed markets (indicated in columns and rows, respectively). EU, US, AR, BR, CL and MX denote equity returns computed, respectively, for the STOXX EUROPE 600, S&P 500 COMPOSITE, S&P MERVAL, BOVESPA, S&P CLX IGPA and S&P/BMV IPC indices for the EU, USA, Argentina, Brazil, Chile and Mexico. Panel A reports correlations between equity returns denominated in the respective local currencies. Panel B reports correlations between equity returns from the perspective of an investor based in a developed market, i.e., between emerging-market and developed-market equity returns denominated in a developed-market currency (e.g., the first row and column indicate correlation between MERVAL returns in EUR and STOXX returns in EUR). Panel C reports correlations between equity returns from the perspective of an investor based in an emerging market, i.e., between emerging-market and developed-market equity returns denominated in an emerging-market currency (e.g., the first row and column indicate correlation between STOXX and MERVAL returns both in the Argentinian peso).

Table 3: Correlation between equity returns and currency values.

Panel A: Emerging markets.

	AR	BR	CL	MX
XXXEUR	-0.07	0.47	0.19	0.26
XXXUSD	-0.04	0.61	0.32	0.47

Panel B: Developed markets.

	EU	US
XXXARS	-0.05	-0.03
XXXBRL	-0.45	-0.43
XXXCLP	-0.37	-0.38
XXXMXN	-0.47	-0.49

Notes. This table presents pair-wise correlations between equity returns (in columns) and currency values (in rows) in emerging (Panel A) and developed (Panel B) markets. EU, US, AR, BR, CL and MX denote equity returns computed, respectively, for the STOXX EUROPE 600, S&P 500 COMPOSITE, S&P MERVAL, BOVESPA, S&P CLX IGPA and S&P/BMV IPC indices for the EU, USA, Argentina, Brazil, Chile and Mexico. Currency values are denoted by XXXEUR (XXXUSD), indicating the number of EUR (USD) units per monetary unit of the XXX country indicated in the column. Similarly, XXXARS, XXXBRL, XXXCLP and XXXMXN denote units of Argentinian peso, Brazilian real, Chilean peso and Mexican peso, respectively, per unit of EUR or USD.

Table 4: Descriptive statistics.

Panel A: Equity market returns.

	EU	US	AR	BR	CL	MX
mean	0.000	0.001	0.005	0.002	0.001	0.002
std. dev.	0.025	0.023	0.049	0.036	0.020	0.027
skewness	-1.359	-1.002	-1.003	-0.374	-1.056	-0.211
kurtosis	14.092	11.527	9.793	6.297	12.662	9.782
q_1	-0.075	-0.071	-0.127	-0.088	-0.058	-0.073
q_{25}	-0.012	-0.010	-0.020	-0.019	-0.009	-0.012
q_{50}	0.003	0.002	0.007	0.005	0.002	0.003
q_{75}	0.014	0.014	0.032	0.025	0.012	0.017
q_{99}	0.052	0.057	0.118	0.083	0.044	0.064
KS	0.000	0.000	0.000	0.000	0.000	0.000
LBQ	0.000	0.059	0.558	0.035	0.206	0.012
ARCH	0.000	0.000	0.000	0.000	0.000	0.000

Panel B: Exchange rates.

	ARSEUR	BRLEUR	CLPEUR	MXNEUR	ARSUSD	BRLUSD	CLPUSD	MXNUSD
mean	-0.004	-0.001	0.000	-0.001	-0.004	-0.001	0.000	-0.001
std. dev.	0.027	0.022	0.017	0.018	0.024	0.021	0.016	0.016
skewness	-4.558	-0.532	-0.157	-0.584	-3.319	-0.646	-0.798	-1.453
kurtosis	49.598	5.997	4.911	7.136	32.687	6.921	8.538	16.359
q_1	-0.079	-0.068	-0.043	-0.048	-0.081	-0.066	-0.040	-0.045
q_{25}	-0.012	-0.013	-0.011	-0.011	-0.008	-0.011	-0.009	-0.008
q_{50}	-0.003	0.000	-0.001	-0.001	-0.001	0.000	0.001	0.000
q_{75}	0.008	0.011	0.010	0.010	0.004	0.012	0.009	0.007
q_{99}	0.044	0.048	0.041	0.039	0.048	0.051	0.038	0.037
KS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LBQ	0.000	0.001	0.780	0.013	0.000	0.001	0.016	0.005
ARCH	0.000	0.000	0.012	0.000	0.000	0.000	0.000	0.003

Notes. This table presents summary statistics for equity market and currency returns. EU, US, AR, BR, CL and MX denote equity returns computed, respectively, for the STOXX EUROPE 600, S&P 500 COMPOSITE, S&P MERVAL, BOVESPA, S&P CLX IGPA and S&P/BMV IPC indices for the EU, USA, Argentina, Brazil, Chile and Mexico. ARSEUR, BRLEUR, CLPEUR and MXNEUR (ARSUSD, BRLUSD, CLPUSD and MXNUSD) denote the EUR (USD) exchange rate against the Argentinian peso, Brazilian real, Chilean peso and Mexican peso: units of EUR (USD) per monetary unit of the emerging market. q_k indicates the k-th quantile of the return series. KS test refers to the p-value of the Kolgomorov Smirnov test for the null hypothesis of normality. LBQ test indicates the p-value of the Ljung-Box Q-test for autocorrelation performed with 20 lags. ARCH test refers to the p-value of Engle's ARCH test for heteroskedasticity run with 1 lag.

Table 5: Parameter estimates of marginal models for equity and currency returns.

Panel A: Equity market returns.

	EU	US	AR	BR	CL	MX
ϕ_0	0.000	0.001*	0.005***	0.001	0.002***	0.002**
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
ψ_1	-0.282	-0.033	0.027	0.063	0.055	0.002
	[0.69]	[0.04]	[0.04]	[0.03]	[0.03]	[0.03]
ω	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
α	0.000**	0.004***	0.105***	0.000**	0.167***	0.084***
	[0.15]	[0.13]	[0.03]	[0.04]	[0.04]	[0.04]
β	0.783***	0.752***	0.866***	0.906***	0.766***	0.848***
	[0.05]	[0.05]	[0.05]	[0.03]	[0.06]	[0.03]
γ	0.345**	0.390***	0.000***	0.120**	0.000***	0.098***
	[0.24]	[0.19]	[0.02]	[0.05]	[0.02]	[0.05]
λ	-0.341***	-0.302***	-0.182***	-0.244***	-0.117***	-0.210***
	[0.07]	[0.06]	[0.04]	[0.05]	[0.05]	[0.05]
ν	9.663***	9.296***	6.568***	16.446***	7.840***	10.126***
	[31.75]	[35.86]	[10.72]	[29.09]	[34.54]	[33.58]
LBQ test	0.8344	0.8968	0.3732	0.8436	0.1458	0.4992
ARCH test	0.3631	0.3281	0.4369	0.3135	0.5329	0.9599
KS test	0.3574	0.0371	0.6428	0.8619	0.7205	0.7949
AD test	0.6015	0.5136	0.1919	0.1632	0.6313	0.2759
K test q=0.1	0.7107	0.7058	0.8711	0.2955	0.2038	0.2468

Table 5 (Cont.): Parameter estimates of marginal models for equity and currency returns.

Panel B: Exchange rates returns.

	ARSEUR	BRLEUR	CLPEUR	MXNEUR	ARSUSD	BRLUSD	CLPUSD	MXNUSD
ϕ_0	-0.002***	-0.001	-0.000*	-0.001**	-0.001***	-0.000	-0.000	-0.001*
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
ϕ_1	-	-	0.017	-	0.142***	0.009	-	-
	-	-	[0.03]	-	[0.03]	[0.04]	-	-
ψ_1	0.037	0.072	-	0.025	-	-	0.022	-0.012
	[0.03]	[0.03]	-	[0.03]	-	-	[0.03]	[0.03]
ω	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
α	0.195***	0.167***	0.055***	0.063***	0.098***	0.138***	0.092***	0.000***
	[0.05]	[0.03]	[0.02]	[0.04]	[0.03]	[0.04]	[0.02]	[0.06]
β	0.657***	0.771***	0.924***	0.825***	0.902***	0.821***	0.883***	0.886***
	[0.14]	[0.06]	[0.04]	[0.05]	[0.02]	[0.05]	[0.04]	[0.03]
γ	0.000***	0.000***	0.000***	0.101***	0.000***	0.000**	0.000*	0.167***
	[0.03]	[0.02]	[0.01]	[0.06]	[0.03]	[0.03]	[0.02]	[0.08]
λ	-0.016	-0.099***	-0.011	-0.112***	-0.087**	-0.167***	-0.109***	-0.189***
	[0.04]	[0.04]	[0.04]	[0.04]	[0.05]	[0.04]	[0.04]	[0.05]
ν	4.176***	10.174***	10.710***	9.291***	3.176***	8.430***	10.064***	6.704***
	[1.71]	[33.75]	[31.98]	[35.90]	[0.67]	[32.72]	[34.85]	[28.30]
LBQ	0.3517	0.3792	0.6936	0.1448	0.1567	0.3355	0.3507	0.1474
ARCH	0.8200	0.4200	0.9075	0.2283	0.2628	0.4450	0.3158	0.4254
KS	0.7949	0.7205	0.9575	0.0782	0.7118	0.3150	0.7584	0.1103
AD	0.6392	0.1798	0.4117	0.6081	0.1835	0.2761	0.6868	0.7466
$K_{q=0.1}$	0.9566	0.9566	0.0884	0.8711	0.2893	0.2320	0.6231	0.9567

Notes. This table presents parameter estimates for the marginal models in Eqs. (11)-(13) for equity and currency returns. EU, US, AR, BR, CL and MX denote equity returns computed, respectively, for the STOXX EUROPE 600, S&P 500 COMPOSITE, S&P MERVAL, BOVESPA, S&P CLX IGPA and S&P/BMV IPC indices for the EU, USA, Argentina, Brazil, Chile and Mexico. ARSEUR, BRLEUR, CLPEUR and MXNEUR (ARSUSD, BRLUSD, CLPUSD and MXNUSD) denote the EUR (USD) exchange rate against the Argentine peso, Brazilian real, Chilean peso and Mexican peso, i.e., units of EUR (USD) per unit of the emerging-market currency. Standard errors of the parameter estimates (computed through simulation) are reported in brackets, with ***, ** and * denoting significance of the estimates at the 1%, 5% and 10% levels. LBQ and ARCH denote, respectively, the p-value of the Ljung-Box Q-test for autocorrelation computed with 20 lags and Engle's ARCH test for heteroskedasticity computed with 1 lag. KS and AD report the p-values for the Kolgomorov Smirnov and Anderson-Darling tests for the null hypothesis that the residual of the marginal model follows a skewed-t distribution with the estimated parameters. $K_{q=0.1}$ refers to the p-values of the Kupiec (1995) test for the goodness-of-fit of the tails of the distribution. Marginal models for EU equity returns and the ARSUSD and BRLUSD currency returns required a larger number of lags to filter out serial correlation (AR(1)-MA(1,3), AR(1,3,4,6,8,9) and AR(1,3,5,6,8,17), respectively).

Table 6: Parameter estimates of copula models

Panel A: Argentina.

	State 1						State 2					
	Copula	Parameter		Kendall's τ	λ_L	λ_U	Copula	Parameter		Kendall's τ	λ_L	λ_U
Argentina-Europe												
AR-ARSEUR	Gaussian	ρ	-0.385*	-0.25	–	–	Student	ρ	-0.023	-0.01	0.05	0.05
			[0.23]						[0.06]			
								η	5.594***			
									[2.79]			
ARSEUR-EU	Gaussian	ρ	-0.192*	-0.12	–	–	Gumbel	θ	1.233***	0.19	–	0.25
			[0.13]						[0.47]			
AR-EU	Student	ρ	0.592*	0.4	0.18	0.18	BB1	θ	0.258***	0.21	0.09	0.15
			[0.21]						[0.10]			
		η	11.056***					δ	1.125***			
			[38.50]						[0.06]			
Transition probabilities		p_{11}	0.997***									
			[0.19]									
		p_{22}	0.998***									
			[0.14]									
		LL	-186.88									
		AICc	-361.67									
Argentina-United States												
AR-ARSUSD	Gaussian	ρ	0.065	0.04	–	–	Student	ρ	-0.033	-0.02	0.04	0.04
			[0.09]						[0.06]			
								η	6.319***			
									[1.22]			
ARSUSD-US	Gaussian	ρ	0.063	0.04	–	–	Clayton	θ	0.009***	0	0	–
			[0.09]						[0.04]			
AR-US	Gaussian	ρ	0.669***	0.47	–	–	BB1	θ	0.324***	0.21	0.14	0.12
			[0.06]						[0.09]			
								δ	1.095***			
									[0.05]			
Transition probabilities		p_{11}	0.978***									
			[0.02]									
		p_{22}	0.991***									
			[0.01]									
		LL	-127.32									
		AICc	-244.57									

Table 6 (Cont.): Parameter estimates of copula models

Panel B: Brazil.

	State 1						State 2					
	Copula	Parameter		Kendall's τ	λ_L	λ_U	Copula	Parameter		Kendall's τ	λ_L	λ_U
Brazil-Europe												
BR-BRLEUR	Gaussian	ρ	0.35	0.23	–	–	Student	ρ	0.405***	0.27	0.1	0.1
			[0.28]						[0.07]			
								η	9.364***			
									[10.76]			
BRLEUR-EU	Gaussian	ρ	0.398*	0.26	–	–	Gumbel	θ	1.279***	0.22	–	0.28
			[0.24]						[0.06]			
BR-EU	Gaussian	ρ	0.656	0.46	–	–	Student	ρ	0.289**	0.19	0.01	0.01
			[0.27]						[0.09]			
								η	18.874***			
									[30.31]			
Transition probabilities		p_{11}	0.996***									
			[0.22]									
		p_{22}	0.998***									
			[0.14]									
		LL	-281.88									
		AICc	-553.69									
Brazil-United States												
BR-BRLUSD	Gaussian	ρ	0.604***	0.41	–	–	Clayton	θ	0.506***	0.2	0.25	–
			[0.03]						[0.25]			
BRLUSD-US	Gaussian	ρ	0.465***	0.31	–	–	Student	ρ	-0.126	-0.08	0.03	0.03
			[0.02]						[0.22]			
								η	6.068***			
									[34.40]			
BR-US	Gaussian	ρ	0.550***	0.37	–	–	Clayton	θ	0.147***	0.07	0.01	–
			[0.03]						[0.14]			
Transition probabilities		p_{11}	0.943***									
			[0.02]									
		p_{22}	0.759***									
			[0.10]									
		LL	-362.95									
		AICc	-717.87									

Table 6 (Cont.): Parameter estimates of copula models

Panel C: Chile.

	State 1						State 2					
	Copula	Parameter		Kendall's τ	λ_L	λ_U	Copula	Parameter		Kendall's τ	λ_L	λ_U
Chile-Europe												
CL-CLPEUR	Gaussian	ρ	0.106*	0.07	–	–	BB1	θ	0.179***	0.1	0.02	0.03
			[0.06]						[0.13]			
								δ	1.019**			
									[0.06]			
CLPEUR-EU	Student	ρ	0.541***	0.36	0	0	Clayton	θ	0.216***	0.1	0.04	–
			[0.07]						[0.30]			
		η	58.949***									
			[37.76]									
CL-EU	Gaussian	ρ	0.319***	0.21	–	–	Student	ρ	0.574***	0.39	0.2	0.2
			[0.06]						[0.08]			
								η	9.513***			
									[32.98]			
Transition probabilities		p_{11}	0.960***									
			[0.05]									
		p_{22}	0.959***									
			[0.12]									
		LL	-193.45									
		AICc	-376.85									
Chile-United States												
CL-CLPUSD	Gaussian	ρ	0.487***	0.32	–	–	Clayton	θ	0.066***	0.03	0	–
			[0.05]						[0.06]			
CLPUSD-US	Gaussian	ρ	0.501***	0.33	–	–	Clayton	θ	0.188***	0.09	0.03	–
			[0.04]						[0.08]			
CL-US	Gaussian	ρ	0.535***	0.36	–	–	Clayton	θ	0.236***	0.11	0.05	–
			[0.04]						[0.09]			
Transition probabilities		p_{11}	0.926***									
			[0.03]									
		p_{22}	0.927***									
			[0.03]									
		LL	-167.92									
		AICc	-327.8									

Table 6 (Cont.): Parameter estimates of copula models

Panel D: Mexico.

	State 1						State 2					
	Copula	Parameter		Kendall's τ	λ_L	λ_U	Copula	Parameter		Kendall's τ	λ_L	λ_U
Mexico-Europe												
MX-MXNEUR	Student	ρ	0.359**	0.23	0.01	0.01	BB1	θ	0.146***	0.09	0.01	0.04
			[0.12]						[0.06]			
		η	18.854***					δ	1.028***			
			[43.20]						[0.03]			
MXNEUR-EU	Gaussian	ρ	0.434**	0.29	–	–	Student	ρ	0.412**	0.27	0.16	0.16
			[0.13]						[0.11]			
								η	7.060***			
									[9.83]			
MX-EU	Gaussian	ρ	0.749**	0.54	–	–	Student	ρ	0.493***	0.33	0	0
			[0.19]						[0.05]			
								η	99.990***			
									[32.47]			
Transition probabilities		p_{11}	0.969***									
			[0.18]									
		p_{22}	0.987***									
			[0.08]									
		LL	-313.3									
		AICc	-616.53									
Mexico-United States												
MX-MXNUSD	Gaussian	ρ	0.543***	0.37	–	–	Clayton	θ	0.056***	0.03	0	–
			[0.04]						[0.08]			
MXNUSD-US	Student	ρ	0.528***	0.35	0.22	0.22	Gumbel	θ	1.124***	0.11	–	0.15
			[0.05]						[0.10]			
		η	7.362***									
			[26.43]									
MX-US	Gaussian	ρ	0.628***	0.43	–	–	Clayton	θ	0.784***	0.28	0.41	–
			[0.03]						[0.16]			
Transition probabilities		p_{11}	0.922***									
			[0.04]									
		p_{22}	0.829***									
			[0.10]									
		LL	-370.77									
		AICc	-733.49									

This table presents parameter estimates for the paired copulas from the vine construction in Eq. (8) that maximize the log-likelihood value in Eq. (14). Dependence for each state is characterized by Eq. (10) and the probability of being in a given state evolves following a Markov switching structure with transition probabilities p_{11} and p_{22} as given by Eq. (9). Panels A-D report results of dependence for equity returns and exchange rates for Argentina, Brazil, Chile and Mexico with the EU and USA. ARSEUR (ARSUSD), BRLEUR (BRLUSD), CLPEUR (CLPUSD), MXNEUR (MXNUSD) denote the units of EUR (USD) per unit of Argentinian peso (panel A), Brazilian real (panel B), Chilean peso (panel C) and Mexican peso (panel D), respectively. Standard errors of the parameter estimates (computed by simulation) are reported in brackets, with ***, ** and * denoting significance at the 1%, 5% and 10% levels. LL and AICc denote, respectively, the maximum log-likelihood and the Akaike information criterion corrected for small-sample bias. Kendall's τ indicates Kendall's rank correlation and λ_L and λ_U refer, respectively, to lower and upper tail dependence for the estimated copulas (see Table 1).

Table 7: Average of the conditional expectation decomposition.

Panel A: Europe and emerging markets.

	Scenario A: $r_d < VaR_\alpha(r_d)$			Scenario B: $r_f < VaR_\alpha(r_f)$		
Currency country	$E(r_d\|A)$	$E(-r_e\|A)$	$E(r_d - r_e\|A)$	$E(r_f\|B)$	$E(r_e\|B)$	$E(r_f + r_e\|B)$
Argentina	-4.91	0.45	-4.46	-8.86	0.33	-8.53
Brazil	-4.91	1.19	-3.72	-6.66	-1.47	-8.13
Chile	-4.91	1.15	-3.76	-3.37	-0.52	-3.88
Mexico	-4.91	1.42	-3.49	-4.82	-0.86	-5.68
• State 1						
Currency country	$E(r_d\|A)$	$E(-r_e\|A)$	$E(r_d - r_e\|A)$	$E(r_f\|B)$	$E(r_e\|B)$	$E(r_f + r_e\|B)$
Argentina	-4.91	-0.45	-5.36	-8.86	1.13	-7.73
Brazil	-4.91	1.5	-3.41	-6.66	-1.33	-7.98
Chile	-4.91	1.6	-3.31	-3.37	-0.35	-3.72
Mexico	-4.91	1.44	-3.47	-4.82	-1.22	-6.04
•State 2						
Currency country	$E(r_d\|A)$	$E(-r_e\|A)$	$E(r_d - r_e\|A)$	$E(r_f\|B)$	$E(r_e\|B)$	$E(r_f + r_e\|B)$
Argentina	-4.91	0.97	-3.94	-8.86	-0.13	-8.99
Brazil	-4.91	0.98	-3.93	-6.66	-1.56	-8.22
Chile	-4.91	0.73	-4.18	-3.37	-0.67	-4.04
Mexico	-4.91	1.41	-3.5	-4.82	-0.7	-5.52
Scenario C: $r_e < VaR_\alpha(r_e)$						
Currency country	$E(r_d\|C)$	$E(-r_e\|C)$	$E(r_d - r_e\|C)$	$E(r_f\|C)$	$E(r_e\|C)$	$E(r_f + r_e\|C)$
Argentina	-0.05	3.83	3.78	1.74	-3.83	-2.09
Brazil	-1.37	3.83	2.47	-2.29	-3.83	-6.13
Chile	-1.68	2.94	1.26	-0.39	-2.94	-3.34
Mexico	-1.88	3.33	1.46	-1	-3.33	-4.33
• State 1						
Currency country	$E(r_d\|C)$	$E(-r_e\|C)$	$E(r_d - r_e\|C)$	$E(r_f\|C)$	$E(r_e\|C)$	$E(r_f + r_e\|C)$
Argentina	0.83	3.83	4.66	3.51	-3.83	-0.32
Brazil	-1.72	3.83	2.12	-2.05	-3.83	-5.88
Chile	-2.41	2.94	0.53	-0.19	-2.94	-3.13
Mexico	-1.89	3.33	1.45	-1.5	-3.33	-4.83
•State 2						
Currency country	$E(r_d\|C)$	$E(-r_e\|C)$	$E(r_d - r_e\|C)$	$E(r_f\|C)$	$E(r_e\|C)$	$E(r_f + r_e\|C)$
Argentina	-0.9	3.83	2.93	0.52	-3.83	-3.31
Brazil	-1.05	3.83	2.78	-2.48	-3.83	-6.31
Chile	-1.04	2.94	1.9	-0.57	-2.94	-3.52
Mexico	-1.87	3.33	1.46	-0.74	-3.33	-4.07
Scenario D: $r_e > VaR_{1-\alpha}(r_e)$						
Currency country	$E(r_d\|D)$	$E(-r_e\|D)$	$E(r_d - r_e\|D)$	$E(r_f\|D)$	$E(r_e\|D)$	$E(r_f + r_e\|D)$
Argentina	0.41	-3.35	-2.94	-1.07	3.35	2.28
Brazil	1.68	-3.41	-1.73	2.35	3.41	5.76
Chile	1.24	-2.82	-1.58	0.51	2.82	3.33
Mexico	1.67	-2.84	-1.17	1.06	2.84	3.9
• State 1						
Currency country	$E(r_d\|D)$	$E(-r_e\|D)$	$E(r_d - r_e\|D)$	$E(r_f\|D)$	$E(r_e\|D)$	$E(r_f + r_e\|D)$
Argentina	-0.77	-3.35	-4.12	-2.81	3.35	0.54
Brazil	1.62	-3.41	-1.79	2.19	3.41	5.6
Chile	2.14	-2.82	-0.68	0.49	2.82	3.31
Mexico	1.75	-2.84	-1.09	1.7	2.84	4.54
• State 2						
Currency country	$E(r_d\|D)$	$E(-r_e\|D)$	$E(r_d - r_e\|D)$	$E(r_f\|D)$	$E(r_e\|D)$	$E(r_f + r_e\|D)$
Argentina	1.54	-3.35	-1.81	0.14	3.35	3.48
Brazil	1.73	-3.41	-1.68	2.47	3.41	5.88
Chile	0.46	-2.82	-2.36	0.53	2.82	3.35
Mexico	1.63	-2.84	-1.21	0.71	2.84	3.55

Table 7 (Cont.): Average of the conditional expectation decomposition.

Panel B: USA and emerging markets.

	Scenario A: $r_d < VaR_\alpha(r_d)$			Scenario B: $r_f < VaR_\alpha(r_f)$		
Currency country	$E(r_d\|A)$	$E(-r_e\|A)$	$E(r_d - r_e\|A)$	$E(r_f\|B)$	$E(r_e\|B)$	$E(r_f + r_e\|B)$
Argentina	-4.32	0.21	-4.1	-8.78	-0.16	-8.94
Brazil	-4.3	1.29	-3.02	-6.64	-2.11	-8.75
Chile	-4.32	0.96	-3.36	-3.37	-0.76	-4.13
Mexico	-4.32	1.21	-3.11	-4.82	-1.17	-5.99
• State 1						
Currency country	$E(r_d\|A)$	$E(-r_e\|A)$	$E(r_d - r_e\|A)$	$E(r_f\|B)$	$E(r_e\|B)$	$E(r_f + r_e\|B)$
Argentina	-4.32	0.36	-3.96	-8.78	-0.36	-9.14
Brazil	-4.3	1.67	-2.64	-6.64	-2.19	-8.83
Chile	-4.32	1.34	-2.97	-3.37	-1.3	-4.67
Mexico	-4.32	1.54	-2.78	-4.82	-1.54	-6.36
• State 2						
Currency country	$E(r_d\|A)$	$E(-r_e\|A)$	$E(r_d - r_e\|A)$	$E(r_f\|B)$	$E(r_e\|B)$	$E(r_f + r_e\|B)$
Argentina	-4.32	0.18	-4.14	-8.78	-0.11	-8.89
Brazil	-4.3	-0.39	-4.69	-6.64	-1.75	-8.39
Chile	-4.32	0.57	-3.75	-3.37	-0.21	-3.58
Mexico	-4.32	0.39	-3.92	-4.82	-0.24	-5.06
Scenario C: $r_e < VaR_\alpha(r_e)$						
Currency country	$E(r_d\|C)$	$E(-r_e\|C)$	$E(r_d - r_e\|C)$	$E(r_f\|C)$	$E(r_e\|C)$	$E(r_f + r_e\|C)$
Argentina	0.06	3.32	3.38	0.4	-3.32	-2.92
Brazil	-1.33	3.76	2.43	-3.58	-3.76	-7.34
Chile	-1.35	2.76	1.41	-0.77	-2.76	-3.53
Mexico	-1.6	2.93	1.33	-1.73	-2.93	-4.65
• State 1						
Currency country	$E(r_d\|C)$	$E(-r_e\|C)$	$E(r_d - r_e\|C)$	$E(r_f\|C)$	$E(r_e\|C)$	$E(r_f + r_e\|C)$
Argentina	-0.09	3.32	3.23	-0.07	-3.32	-3.39
Brazil	-1.73	3.76	2.04	-3.72	-3.76	-7.49
Chile	-1.89	2.76	0.87	-1.45	-2.76	-4.21
Mexico	-2.07	2.93	0.85	-2.36	-2.93	-5.29
• State 2						
Currency country	$E(r_d\|C)$	$E(-r_e\|C)$	$E(r_d - r_e\|C)$	$E(r_f\|C)$	$E(r_e\|C)$	$E(r_f + r_e\|C)$
Argentina	0.15	3.32	3.47	0.62	-3.32	-2.7
Brazil	0.55	3.76	4.31	-2.93	-3.76	-6.7
Chile	-0.72	2.76	2.04	-0.1	-2.76	-2.86
Mexico	-0.34	2.93	2.59	-0.14	-2.93	-3.07
Scenario D: $r_e > VaR_{1-\alpha}(r_e)$						
Currency country	$E(r_d\|D)$	$E(-r_e\|D)$	$E(r_d - r_e\|D)$	$E(r_f\|D)$	$E(r_e\|D)$	$E(r_f + r_e\|D)$
Argentina	0.24	-2.62	-2.38	0.36	2.62	2.99
Brazil	1.42	-3.22	-1.8	3.16	3.22	6.38
Chile	1.27	-2.49	-1.22	0.96	2.49	3.45
Mexico	1.73	-2.32	-0.59	1.84	2.32	4.17
• State 1						
Currency country	$E(r_d\|D)$	$E(-r_e\|D)$	$E(r_d - r_e\|D)$	$E(r_f\|D)$	$E(r_e\|D)$	$E(r_f + r_e\|D)$
Argentina	0.39	-2.62	-2.24	0.99	2.62	3.61
Brazil	1.81	-3.22	-1.41	3.58	3.22	6.8
Chile	1.94	-2.49	-0.55	1.67	2.49	4.16
Mexico	2.01	-2.32	-0.31	2.46	2.32	4.78
• State 2						
Currency country	$E(r_d\|D)$	$E(-r_e\|D)$	$E(r_d - r_e\|D)$	$E(r_f\|D)$	$E(r_e\|D)$	$E(r_f + r_e\|D)$
Argentina	0.15	-2.62	-2.47	0.07	2.62	2.69
Brazil	-0.42	-3.22	-3.65	1.3	3.22	4.52
Chile	0.48	-2.49	-2.01	0.26	2.49	2.75
Mexico	0.99	-2.32	-1.33	0.29	2.32	2.62

Notes. This table presents the decomposition of the conditional expected stock returns for an investor investing abroad under a certain scenario. The results are averaged over the sample period. In panel A (B), r_d refers to EU (US) equity returns, while r_f refers to equity returns in Argentina, Brazil, Chile and Mexico. r_e indicates the currency returns computed as the units of EUR (USD) obtained for a unit of the emerging-market currency (Argentinian peso, Brazilian real, Chilean peso and Mexican peso). Note that for emerging-market investors with an equity portfolio in euros, we use $-r_e$ to reflect the currency returns as the units of the emerging-market currency that can be exchanged for one EUR (USD).

C Proofs of key equations

Proof of Eq. (3). The expression from Eq. (3) in terms of copulas depends on the vine structure that has been employed to define the multivariate relationship, which is expressed by Figure 1 and Eq. (8).

$$\begin{aligned} E(r_d|r_f \leq VaR_\alpha(r_f)) &= \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} r_d f(r_d, r_e|r_f \leq VaR_\alpha(r_f)) dr_e dr_d \\ &= \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} r_d \frac{\int_{-\infty}^{VaR_\alpha(r_f)} f(r_f, r_d, r_e) dr_f}{P(r_f < VaR_\alpha(r_f))} dr_e dr_d \\ &= \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} r_d \frac{f(r_f \leq VaR_\alpha(r_f), r_d, r_e)}{P(r_f < VaR_\alpha(r_f))} dr_e dr_d \end{aligned} \tag{18}$$

Moreover, note that $P\left(r_f \leq VaR_\alpha(r_f)\right) = \alpha$ and that

$$f(r_f \leq VaR_\alpha, r_d, r_e) = P\left(r_f \leq VaR_\alpha(r_f)|r_d, r_e\right) f_d(r_d) f_e(r_e) \tag{19}$$

Then, inserting this expression in Eq. (18) we have that:

$$E(r_d|r_f \leq VaR_\alpha(r_f)) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} r_d \frac{P(r_f \leq VaR_\alpha(r_f)|r_d, r_e)}{\alpha} f_d(r_d) f_e(r_e) dr_e dr_d \tag{20}$$

Taking into account that the conditional probability can be written in terms of the conditional copula function:

$$P(r_f \leq VaR_\alpha(r_f)|r_d, r_e) = C_{f|d}\left(C_{f|e}\left(\alpha|F_e(r_e)\right)|C_{d|e}\left(F_d(r_d)|F_e(r_e)\right)\right), \tag{21}$$

and that $r_d = F_d^{-1}(u_d)$, $du_e = f_e(r_e)dr_e$, $du_d = f_d(r_d)dr_d$. Consequently, the conditional expectation in Eq. (18) can be rewritten in terms of conditional copula as:

$$E\left(r_d|r_f \leq VaR_\alpha(r_f); r_e\right) = \int_0^1\int_0^1 F_d^{-1}(u_d)\frac{C_{f|d}(C_{f|e}(\alpha|u_e)|C_{d|e}(u_d|u_e))}{\alpha} du_e du_d.$$

Proof of Eq. (5). The expression from Eq. (5) in terms of copulas depends on the vine structure that has been employed to define the multivariate relationship, which is expressed by Figure 1 and

Eq. (8).

$$
\begin{aligned}
E(r_d|r_f \geq VaR_{1-\alpha}(r_f)) &= \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} r_d f(r_d, r_e|r_f \geq VaR_{1-\alpha}(r_f))dr_e dr_d \\
&= \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} r_d \frac{\int_{VaR_{1-\alpha}(r_f)}^{\infty} f(r_f, r_d, r_e)dr_f}{P(r_f \geq VaR_{1-\alpha}(r_f))} dr_e dr_d \\
&= \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} r_d \frac{f(r_f \geq VaR_{1-\alpha}(r_f), r_d, r_e)}{P(r_f \geq VaR_{1-\alpha}(r_f))} dr_e dr_d
\end{aligned} \tag{22}
$$

Moreover, note that $P\left(r_f \geq VaR_{1-\alpha}(r_f)\right) = \alpha$ and that

$$
f(r_f \geq VaR_{1-\alpha}, r_d, r_e) = P\left(r_f \geq VaR_{1-\alpha}(r_f|r_d, r_e)\right) f_d(r_d) f_e(r_e) \tag{23}
$$

Then, inserting this expression in Eq. 22 we have that:

$$
E(r_d|r_f \geq VaR_{1-\alpha}(r_f)) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} r_d \frac{P(r_f \geq VaR_{1-\alpha}(r_f)|r_d, r_e)}{\alpha} f_d(r_d) f_e(r_e) dr_e dr_d \tag{24}
$$

Taking into account that the conditional probability can be written in terms of the conditional copula function:

$$
P(r_f \geq VaR_{1-\alpha}(r_f)|r_d, r_e) \;=\; 1 - C_{f|d}\left(C_{f|e}\left(1-\alpha|F_e(r_e)\right)|C_{d|e}\left(F_d(r_d)|F_e(r_e)\right)\right), \tag{25}
$$

and that $r_d = F_d^{-1}(u_d)$, $du_e = f_e(r_e)dr_e$, $du_d = f_d(r_d)dr_d$. Consequently, the conditional expectation in Eq. (22) can be rewritten in terms of conditional copula as:

$$
E\left(r_d|r_f \geq VaR_{1-\alpha}(r_f); r_e\right) = \int_0^1\int_0^1 F_d^{-1}(u_d)\frac{1 - C_{f|d}(C_{f|e}(1-\alpha|u_e)|C_{d|e}(u_d|u_e))}{\alpha} du_e du_d.
$$

D Online appendix

D.1 Algorithms concerning the joint distribution

Algorithm 1 Pseudo-likelihood evaluation in the second stage of the IFM approach under a C-vine dependence structure with two layers (Aas et al. (2009)).

procedure LOG-EVAL$(r, \mu, \sigma, \nu, \lambda, \xi_{t+1|t}, \Theta_{s_t=1}, \Theta_{s_t=2})$
  $LogLik = 0$
  for $t \leftarrow T$ **do**
    for $i \leftarrow N$ **do**
      $u_{i,t} = F(r_{i,t}; \mu_{i,t}, \sigma_{i,t}, \nu_i, \lambda_i)$
    end for i
    for $i \leftarrow 1, \dots, 2$ **do**
      for $j \leftarrow i+1, \dots, N$ **do**
        $LogLik = LogLik + log(c(u_{i,t}, u_{j,t}; \Theta_{s_t=1,ij})\xi_{t+1|t,s_t=1} + c(u_{i,t}, u_{j,t}; \Theta_{s_t=2,ij})\xi_{t+1|t,s_t=2})$
        $u_{j,t} = C_{j|i,t}(u_{j,t}|u_{i,t}; \Theta_{s_t=1,ij})\xi_{t+1|t,s_t=1} + C_{j|i,t}(u_{j,t}|u_{i,t}; \Theta_{s_t=2,ij})\xi_{t+1|t,s_t=2}$
      end for j
    end for i
  end for t
  Return $LogLik$
end procedure

r is a matrix TxN of returns where T expresses the data length and N the number of series.
μ and σ are matrices TxN obtained from Eqs. (11) and (12), respectively.
ν and λ are vectors of length N with the values of asymmetry and number of degrees of freedom from Eq. (12).
$\xi_{t+1|t}$ is the forecast probability of being in each of the two states, hence it corresponds to a $Tx2$ matrix where the sum of the rows are equal to one.
$\Theta_{s_t=1}$ and $\Theta_{s_t=2}$ are the set of parameters for the copula structure under state 1 and state 2.

Algorithm 2 Simulation of the dependence under a vine in dimension N=3 over a time period T and a dynamic in the copula following two-state Markov switching.

```
procedure SIM-DEPENDENCE(Θ_{s_t=1}, Θ_{s_t=2}, π_1, p_11, p_22)
    for ω ← 1, . . . , W do
        for t ← T do
            u_{t,ω,1} = rand
            if rand < π_1 then
                state = 1
            else
                state = 2
            end if
            u_{t,ω,2} = C^{-1}_{2|1} (rand|u_{t,ω,1}; Θ_{s_t=state,12})
            for n ← 3, . . . N do
                u_{t,ω,n} = rand
                for k ← 1, 2 do
                    u_{t,ω,n} = C^{-1}_{n|k} (u_{t,ω,n}|u_{t,ω,k}; Θ_{s_t=state,nk})
                end for k
            end for n
            if state = 1 then

                if rand < p_11 then
                    π_1 = 1
                else
                    π_1 = 0
                end if
                else if state = 2 then

                    if rand < p_22 then
                        π_1 = 0
                    else
                        π_1 = 1
                    end if
                    end if
                end for t
            end for ω
            Return u
        end procedure
```

$\Theta_{s_t=1}$ and $\Theta_{s_t=2}$ are the set of parameters for the copula structure under state 1 and 2. π_1 is the unconditional probability of being in state 1, i.e. $\pi_1 = \frac{1-p_{22}}{2-p_{11}-p_{22}}$.
p_{11} and p_{22} are the diagonal values from the transition matrix in Eq. (9).
rand refers to an uniform-distributed random simulation.
The *OUTPUT* u is a uniform-distributed matrix that presents the joint dependence given by the model.

D.2 Cumulative distribution function of the portfolio returns within the copula framework

The cumulative distribution function of the portfolio returns of an investor in a developed market is defined using the copula structure in Eq. 8, the formula of the portfolio returns in Eq. 16 and the convolution of the different asset within the portfolio (see Cherubini et al. (2016),Ojea Ferreiro (2020)).

$$F(r_p^d) = \begin{cases} \int_0^1 \int_0^1 C_{f|d}\left(C_{f|e}\left(F_f\left(\frac{r_p^d - (1-\omega)F_d^{-1}(u_d}{\omega}) - F_e^{-1}(u_e)\right)|u_e\right)|C_{d|e}(u_d|u_e)\right) du_e du_d, & \text{if } \omega > 0 \\ F_d(r_d) & \text{otherwise} \end{cases}. \quad (26)$$

Similarly, we obtain the cumulative distribution function of the international portfolio returns of an investor in an emerging economy as:

$$F(r_p^f) = \begin{cases} \int_0^1 \int_0^1 C_{d|f}\left(C_{d|e}\left(F_d\left(\frac{r_p^f - \omega F_f^{-1}(u_f)}{1-\omega} + F_e^{-1}(u_e)\right)|u_e\right)|C_{f|e}(u_f|u_e)\right) du_e du_f, & \text{if } \omega < 1 \\ F_f(r_f) & \text{otherwise} \end{cases}. \quad (27)$$

D.3 Extra tables

Table 8 (Cont.): Descriptive statistics of the impact of emerging markets on developed markets.

Panel A: Argentina.

	$ES_{d\|f}$	$ES_{d\|e^L}$	$ES_{d\|e^U}$	γ_f	γ_c^L	γ_c^U	θ_f^L	θ_f^U
	EU							
mean	-2.12	-0.05	0.41	-2.17	-0.1	0.36	71.22	64.85
st. dev.	1.45	0.96	1.25	1.42	0.96	1.24	6.35	10.99
skewness	-4.05	0.61	-0.45	-4.05	0.72	-0.34	0.83	0.39
kurtosis	27.11	3.81	3.5	26.9	4.08	3.13	3.53	1.6
min	-15.61	-2.91	-5.28	-15.45	-3.11	-4.98	65.4	54.67
max	-0.82	4.56	5.07	-0.98	4.72	4.88	99.77	97.9
q_1	-8.44	-1.83	-2.72	-9.04	-1.83	-2.91	65.44	54.71
q_{25}	-2.39	-0.74	-0.61	-2.42	-0.79	-0.69	65.59	54.87
q_{50}	-1.76	-0.47	0.93	-1.79	-0.54	0.86	66.72	55.98
q_{75}	-1.31	0.69	1.3	-1.39	0.65	1.25	76.68	75.68
q_{99}	-0.92	2.64	2.91	-1	2.75	2.87	90.67	90.42
	US							
mean	-1.97	0.06	0.24	-2.12	-0.09	0.09	97.02	97.06
st. dev.	1.43	0.14	0.16	1.45	0.13	0.13	3.06	3.01
skewness	-3.08	-1.9	2.32	-3.09	-2.1	2.1	-0.52	-0.52
kurtosis	15.91	9.56	10.62	16.1	7.88	7.88	1.52	1.52
min	-12.04	-0.95	-0.08	-12.86	-0.8	0	92.06	92.18
max	-0.78	0.42	1.24	-0.93	0	0.78	100	100
q_1	-8.64	-0.45	0.03	-8.91	-0.6	0	92.07	92.19
q_{25}	-2.25	0	0.14	-2.41	-0.14	0	93.57	93.67
q_{50}	-1.49	0.1	0.19	-1.63	-0.02	0.02	98.7	98.72
q_{75}	-1.12	0.15	0.29	-1.26	0	0.13	99.73	99.73
q_{99}	-0.8	0.29	0.88	-0.95	0	0.59	99.99	99.99

This table presents summary statistics for the risk measures of the developed stock market returns computed, respectively, from the STOXX EUROPE 600 and S&P 500 COMPOSITE indices for the EU and USA.
$ES_{d|f} = E(r_d|r_f < VaR_{0.1}(r_f))$, where r_f is the Argentinian stock market returns computed from the S&P MERVAL INDEX.
$E(r_d|r_f < VaR_{0.1}(r_f))$ is defined by Eq. (6). $ES_{d|e^L} = E(r_d|r_e < VaR_{0.1}(r_e))$, i.e. the mean returns of the EU (US) stock market under a scenario where the EUR (USD) experiences a sharp appreciation against the Argentinian peso.
$ES_{d|e^U} = E(r_d|r_e > r_f < VaR_{0.9}(r_e))$, i.e. the mean returns of the EU (US) stock market under a scenario where the EUR (USD) experiences a sharp depreciation against the Argentinian peso. γ_f, γ_c^L and γ_c^U express the difference between the conditional and the unconditional expected returns according to Eq. (6). θ_f^L and θ_f^U indicates the contribution of the emerging markets to the developed markets following Eq.(9).
q_k indicates the k-th quantile of the risk measure series. Results are shown in percentages.

Table 8 (Cont.): Descriptive statistics of the impact of emerging markets on developed markets.

Panel B: Brazil.

	$ES_{d\|f}$	$ES_{d\|e^L}$	$ES_{d\|e^U}$	γ_f	γ_c^L	γ_c^U	θ_f^L	θ_f^U
	EU							
mean	-2.04	-1.37	1.68	-2.09	-1.42	1.63	57.34	52.45
st. dev.	1.9	1.04	0.84	1.87	1.01	0.87	5.06	11.14
skewness	-3.7	-4.02	3.7	-3.67	-4.02	3.7	0.28	0.31
kurtosis	23.12	26.73	23.63	22.69	26.29	23.77	1.17	1.18
min	-18.76	-10.88	0.93	-18.6	-10.72	0.88	52.37	41.97
max	-0.52	-0.44	9.38	-0.68	-0.61	9.54	63.58	66.23
q_1	-10.26	-5.87	0.96	-10.86	-6.24	0.91	52.42	42.02
q_{25}	-2.47	-1.57	1.19	-2.56	-1.61	1.13	52.64	42.25
q_{50}	-1.43	-1.1	1.44	-1.48	-1.13	1.38	54.26	45.08
q_{75}	-0.92	-0.78	1.86	-1	-0.86	1.8	63.41	66.05
q_{99}	-0.6	-0.52	5.77	-0.69	-0.62	5.56	63.52	66.18
	US							
mean	-1.54	-1.33	1.42	-1.69	-1.48	1.27	55.45	58.89
st. dev.	1.08	1.13	1.06	1.1	1.15	1.03	8.72	8.59
skewness	-3.78	-3.23	3.16	-3.81	-3.29	3.08	2.95	2.74
kurtosis	25.42	21.69	21.89	25.96	22.34	21.04	11.69	10.25
min	-11.44	-11.12	-0.56	-12.26	-11.94	-0.95	50.09	52.05
max	-0.26	0.92	11.37	-0.43	0.53	10.55	99.53	99.27
q_1	-6.29	-6.1	-0.3	-6.51	-6.32	-0.48	50.35	53.37
q_{25}	-1.78	-1.61	0.93	-1.96	-1.78	0.79	51.28	54.48
q_{50}	-1.26	-1.1	1.2	-1.38	-1.23	1.07	52.17	55.6
q_{75}	-0.96	-0.79	1.72	-1.1	-0.93	1.55	54.5	58.46
q_{99}	-0.37	0.37	5.8	-0.5	0.25	5.57	93.33	93.83

This table presents summary statistics for the risk measures of the developed stock market returns computed, respectively, from the STOXX EUROPE 600 and S&P 500 COMPOSITE indices for the the EU and USA.
$ES_{d|f} = E(r_d|r_f < VaR_{0.1}(r_f))$, where r_f is the Brazilian stock market returns computed from the BOVESPA.
$E(r_d|r_f < VaR_{0.1}(r_f))$ is defined by Eq. (6). $ES_{d|e^L} = E(r_d|r_e < VaR_{0.1}(r_e))$, i.e. the mean returns of the EU (US) stock market under a scenario where the EUR (USD) experiences a sharp appreciation against the Brazilian real. $ES_{d|e^U} = E(r_d|r_e > VaR_{0.9}(r_e))$, i.e. the mean returns of the EU (US) stock market under a scenario where the EUR (USD) experiences a sharp depreciation against the Brazilian real. γ_f, γ_c^L and γ_c^U express the difference between the conditional and the unconditional expected returns according to Eq. (6). θ_f^L and θ_f^U indicates the contribution of the emerging markets to the developed markets following Eq. (9).
q_k indicates the k-th quantile of the risk measure series. Results are shown in percentages.

Table 8 (Cont.): Descriptive statistics of the impact of emerging markets on developed markets.

Panel C: Chile.

	$ES_{d\|f}$	$ES_{d\|e^L}$	$ES_{d\|e^U}$	γ_f	γ_c^L	γ_c^U	θ_f^L	θ_f^U
	EU							
mean	-2.17	-1.68	1.24	-2.22	-1.73	1.19	55.29	64.37
st. dev.	1.53	0.88	0.71	1.49	0.85	0.72	10.9	15
skewness	-4.2	-1.9	1.34	-4.21	-1.86	1.36	0.12	0.16
kurtosis	28.42	8.16	5.48	28.23	7.87	5.39	1.45	1.46
min	-16.56	-6.84	0.26	-16.4	-6.68	0.23	40.33	44.34
max	-0.76	-0.49	5.27	-0.92	-0.62	5.07	71.17	86.75
q_1	-8.85	-4.86	0.33	-9.45	-4.63	0.29	40.61	44.68
q_{25}	-2.38	-1.99	0.7	-2.42	-2.03	0.66	44.38	49.42
q_{50}	-1.8	-1.45	1.13	-1.85	-1.51	1.08	53.57	61.48
q_{75}	-1.39	-1.13	1.56	-1.46	-1.19	1.52	67.52	81.27
q_{99}	-0.88	-0.6	3.62	-0.95	-0.67	3.65	71.09	86.64
	US							
mean	-1.53	-1.35	1.27	-1.68	-1.5	1.12	53.32	63.06
st. dev.	1.17	1.12	1.05	1.19	1.14	1.02	1.62	7.37
skewness	-3.9	-3.86	3.66	-3.93	-3.89	3.61	0.37	0.52
kurtosis	27.18	26.83	26.19	27.77	27.49	25.18	1.65	1.81
min	-12.64	-11.9	0.24	-13.46	-12.72	0.18	51.04	54.4
max	-0.46	-0.33	11.83	-0.61	-0.48	11.01	56.21	77.24
q_1	-6.48	-6.02	0.3	-6.71	-6.21	0.2	51.27	54.72
q_{25}	-1.76	-1.61	0.58	-1.93	-1.75	0.45	51.78	56.25
q_{50}	-1.22	-1.07	1.05	-1.36	-1.22	0.91	52.86	60.31
q_{75}	-0.85	-0.69	1.54	-0.98	-0.82	1.39	54.77	69.21
q_{99}	-0.5	-0.37	5.45	-0.63	-0.5	5.04	56.18	77

This table presents summary statistics for the risk measures of the developed stock market returns computed, respectively, from the STOXX EUROPE 600 and S&P 500 COMPOSITE indices for the EU and USA.
$ES_{d|f} = E(r_d|r_f < VaR_{0.1}(r_f))$, where r_f is the Chilean stock market returns computed from the S&P CLX IGPA.
$E(r_d|r_f < VaR_{0.1}(r_f))$ is defined by Eq. (6). $ES_{d|e^L} = E(r_d|r_e < VaR_{0.1}(r_e))$, i.e. the mean returns of the EU (US) stock market under a scenario where the EUR (USD) experiences a sharp appreciation against the Chilean peso. $ES_{d|e^U} = E(r_d|r_e > VaR_{0.1}(r_e))$, i.e. the mean returns of the EU (US) stock market under a scenario where the EUR (USD) experiences a sharp depreciation against the Chilean peso. γ_f, γ_c^L and γ_c^U express the difference between the conditional and the unconditional expected returns according to Eq. (6). θ_f^L and θ_f^U indicates the contribution of the emerging markets to the developed markets following Eq. (9).
q_k indicates the k-th quantile of the risk measure series. Results are shown in percentages.

Table 8 (Cont.): Descriptive statistics of the impact of emerging markets on developed markets.

Panel D: Mexico.

	$ES_{d\|f}$	$ES_{d\|e^L}$	$ES_{d\|e^U}$	γ_f	γ_c^L	γ_c^U	θ_f^L	θ_f^U
	EU							
mean	-2.78	-1.88	1.67	-2.83	-1.93	1.62	58.48	62.64
st. dev.	1.85	1.1	0.89	1.82	1.06	0.91	3.73	3.04
skewness	-2.91	-3.8	3.64	-2.9	-3.82	3.65	0.83	0.82
kurtosis	14.06	24.9	22.33	13.9	24.77	22.48	2	1.98
min	-14.59	-11.82	0.9	-14.43	-11.66	0.86	55.23	59.98
max	-1.14	-0.88	9.45	-1.3	-1.05	9.61	65.42	68.25
q_1	-10.99	-6.39	0.93	-11.58	-6.83	0.88	55.25	59.99
q_{25}	-3.24	-2.07	1.17	-3.29	-2.13	1.1	55.47	60.18
q_{50}	-2.27	-1.58	1.43	-2.3	-1.63	1.39	56.31	60.89
q_{75}	-1.62	-1.25	1.88	-1.7	-1.33	1.81	61.76	65.35
q_{99}	-1.24	-0.97	6.14	-1.33	-1.06	5.9	65.41	68.25
	US							
mean	-2.33	-1.6	1.73	-2.48	-1.75	1.58	60.52	62.08
st. dev.	1.36	1.29	1.1	1.38	1.31	1.08	8.09	5.06
skewness	-3.62	-3.66	3.82	-3.63	-3.68	3.8	1.19	1.06
kurtosis	23.1	24.76	26.39	23.43	25.17	25.9	3.39	3.02
min	-14.57	-13.35	0.54	-15.39	-14.17	0.47	51.71	56.11
max	-1.21	-0.12	12.7	-1.32	-0.28	11.88	84.45	76.08
q_1	-8.01	-7.17	0.64	-8.25	-7.4	0.51	52.23	56.55
q_{25}	-2.66	-1.93	1.13	-2.78	-2.07	0.99	54.43	58.16
q_{50}	-1.91	-1.31	1.43	-2.04	-1.46	1.29	57.18	60.09
q_{75}	-1.53	-0.89	1.96	-1.66	-1.02	1.83	64.77	65.04
q_{99}	-1.26	-0.21	6.49	-1.39	-0.34	6.25	83.27	75.49

This table presents summary statistics for the risk measures of the developed stock market returns computed, respectively, from the STOXX EUROPE 600 and S&P 500 COMPOSITE indices for the EU and USA.
$ES_{d|f} = E(r_d|r_f < VaR_{0.1}(r_f))$, where r_f is the Mexican stock market returns computed from the S&P/BMV IPC.
$E(r_d|r_f < VaR_{0.1}(r_f))$ is defined by Eq. (6). $ES_{d|e^L} = E(r_d|r_e < VaR_{0.1}(r_e))$, i.e. the mean returns of the EU (US) stock market under a scenario where the EUR (USD) experiences a sharp appreciation against the Mexican peso. $ES_{d|e^U} = E(r_d|r_e > VaR_{0.9}(r_e))$, i.e. the mean returns of the EU (US) stock market under a scenario where the EUR (USD) experiences a sharp depreciation against the Mexican peso. γ_f, γ_c^L and γ_c^U express the difference between the conditional and the unconditional expected returns according to Eq. (6). θ_f^L and θ_f^U indicates the contribution of the emerging markets to the developed markets following Eq. (9).
q_k indicates the k-th quantile of the risk measure series. Results are shown in percentages.

Table 9: Descriptive statistics of the impact of developed markets on emerging markets.

Panel A: Argentina.

	$ES_{f\|d}$	$ES_{f\|e^L}$	$ES_{f\|e^U}$	γ_d	γ_c^L	γ_c^U	θ_d^L	θ_d^U
	EU							
mean	-3.87	1.74	-1.07	-4.33	1.28	-1.53	83.35	78.76
st. dev.	1.77	1.52	1.53	1.75	1.52	1.51	16.04	13.41
skewness	-2.89	1.28	-1.46	-2.9	1.29	-1.47	-0.22	-0.22
kurtosis	15.82	5.31	6.36	15.87	5.29	6.27	1.07	1.07
min	-15.73	-0.42	-9.16	-16.04	0.04	-9.21	65.05	63.44
max	-1.55	9.54	0.39	-2.04	8.59	-0.2	98.31	91.27
q_1	-12.32	0.24	-6.91	-12.67	0.05	-7.26	65.06	63.46
q_{25}	-4.4	0.54	-2.11	-4.89	0.06	-2.55	65.14	63.54
q_{50}	-3.54	0.72	-0.16	-3.99	0.13	-0.49	96.41	89.73
q_{75}	-2.84	2.85	0.17	-3.31	2.37	-0.33	98.27	91.22
q_{99}	-1.72	7.18	0.34	-2.19	6.77	-0.22	98.3	91.25
	US							
mean	-3.93	0.4	0.36	-4.4	-0.07	-0.1	95.71	92.9
st. dev.	1.7	0.3	0.38	1.68	0.27	0.36	2.11	2.39
skewness	-2.6	-0.87	0.41	-2.61	-1.11	0.66	-0.45	1.27
kurtosis	12.63	4.05	4.16	12.73	3.72	2.8	2.3	3.9
min	-14.62	-1.12	-1.69	-15.29	-1.11	-1.11	91.69	90.51
max	-1.88	1.17	1.91	-2.33	0.44	0.96	100	99.99
q_1	-11.84	-0.51	-0.44	-12.21	-0.9	-0.73	91.7	90.52
q_{25}	-4.52	0.19	0.12	-4.96	-0.27	-0.35	94.1	91
q_{50}	-3.45	0.48	0.25	-3.92	0.07	-0.25	96.25	92.22
q_{75}	-2.94	0.6	0.67	-3.42	0.13	0.22	96.95	93.94
q_{99}	-2.02	0.93	1.41	-2.48	0.29	0.83	99.71	99.82

This table presents summary statistic for the risk measures of the emerging stock market returns computed from the S&P MERVAL INDEX, for Argentina.
$ES_{f|d} = E(r_f|r_d < VaR_{0.1}(r_d))$, where r_d, where r_d is the returns from the STOXX EUROPE 600 and S&P 500 COMPOSITE indices for the EU and USA.
$E(r_f|r_d < VaR_{0.1}(r_d))$ is defined by Eq. (6). $ES_{f|e^L} = E(r_f|r_e < VaR_{0.1}(r_e))$, i.e. the mean returns of the Argentinian stock market under a scenario where the EUR (USD) experiences a sharp appreciation against the Argentinian peso.
$ES_{f|e^U} = E(r_f|r_e > VaR_{0.9}(r_e))$, i.e. the mean returns of the Argentinian stock market under a scenario where the EUR (USD) experiences a sharp depreciation against the Argentinian peso. γ_d, γ_c^L and γ_c^U express the difference between the conditional and the unconditional expected returns of the Argentinian stock returns according to Eq. (6). θ_d^L and θ_d^U indicates the contribution of the developed markets to the emerging markets following Eq.(9).
q_k indicates the k-th quantile of the risk measure series. Results are shown in percentages.

Table 9 (Cont.): Descriptive statistics of the impact of developed markets on emerging markets.

Panel B: Brazil.

	$ES_{f\|d}$	$ES_{f\|e^L}$	$ES_{f\|e^U}$	γ_d	γ_c^L	γ_c^U	θ_d^L	θ_d^U
	EU							
mean	-2.71	-2.29	2.35	-2.85	-2.43	2.21	51.94	54.24
st. dev.	1.54	0.75	0.62	1.51	0.68	0.62	10.52	9.9
skewness	-2.33	-2.41	2.67	-2.35	-2.46	2.68	0.33	0.32
kurtosis	11.69	11.7	13.34	11.47	11.06	12.55	1.18	1.18
min	-12.51	-7.42	1.57	-11.59	-6.31	1.48	42.2	45.04
max	-0.81	-1.24	6.81	-1.37	-1.61	5.9	65.13	66.64
q_1	-9.64	-5.38	1.66	-9.92	-5.34	1.55	42.25	45.08
q_{25}	-3.44	-2.54	1.97	-3.54	-2.65	1.82	42.4	45.23
q_{50}	-2.23	-2.12	2.21	-2.24	-2.27	2.06	44.67	47.46
q_{75}	-1.62	-1.82	2.51	-1.81	-2.01	2.39	64.81	66.33
q_{99}	-1.12	-1.4	5.06	-1.42	-1.68	4.99	65.1	66.61
	US							
mean	-3.23	-3.58	3.16	-3.38	-3.72	3.02	47.13	52.83
st. dev.	1.24	1.17	1.07	1.2	1.12	1.08	3.88	0.11
skewness	-2.49	-3.08	2.5	-2.51	-3.18	2.52	-2.37	0.27
kurtosis	14.65	17.02	14.69	14.54	17.14	14.56	8.25	5.53
min	-11.89	-12.12	0.96	-10.91	-11.13	0.99	30.02	52.49
max	-0.78	-2.09	10.61	-1.11	-2.41	9.83	50.25	53.48
q_1	-8.94	-9.12	1.3	-9.22	-9.44	1.13	31.96	52.58
q_{25}	-3.61	-3.89	2.61	-3.81	-4.03	2.49	47.02	52.77
q_{50}	-3.08	-3.3	3.02	-3.22	-3.46	2.87	48.68	52.84
q_{75}	-2.61	-2.88	3.52	-2.78	-3.06	3.4	49.33	52.9
q_{99}	-1.06	-2.22	8.41	-1.27	-2.49	8.23	49.98	53.09

This table presents summary statistics for the risk measures of the emerging stock market returns computed from BOVESPA for Brazil.
$ES_{f|d} = E(r_f|r_d < VaR_{0.1}(r_d))$, where r_d, where r_d is the returns from the STOXX EUROPE 600 and S&P 500 COMPOSITE indices for the EU and the USA.
$E(r_f|r_d < VaR_{0.1}(r_d))$ is defined by Eq. (6). $ES_{f|e^L} = E(r_f|r_e < VaR_{0.1}(r_e))$, i.e. the mean returns of the Brazilian stock market under a scenario where the EUR (USD) experiences a sharp appreciation against the Brazilian peso.
$ES_{f|e^U} = E(r_f|r_e > VaR_{0.1}(r_e))$, i.e. the mean returns of the Brazilian stock market under a scenario where the EUR (USD) experiences a sharp depreciation against the Brazilian peso. γ_d, γ_c^L and γ_c^U express the difference between the conditional and the unconditional expected returns of the Brazilian stock returns according to Eq. (6). θ_d^L and θ_d^U indicates the contribution of the developed markets to the emerging markets following Eq. (9).
q_k indicates the k-th quantile of the risk measure series. Results are shown in percentages.

Table 9 (Cont.): Descriptive statistics of the impact of developed markets on emerging markets.

Panel C: Chile.

	$ES_{f\|d}$	$ES_{f\|e^L}$	$ES_{f\|e^U}$	γ_d	γ_c^L	γ_c^U	θ_d^L	θ_d^U
	EU							
mean	-1.29	-0.39	0.51	-1.44	-0.55	0.36	72.38	78.87
st. dev.	0.84	0.33	0.17	0.83	0.31	0.14	0.25	3.96
skewness	-3.32	-3.44	3.43	-3.27	-3.31	3.88	-0.37	-0.24
kurtosis	22.18	24.93	27.38	21.58	21.95	27.8	1.76	1.55
min	-9.09	-3.95	0.31	-8.73	-3.28	0.22	71.72	72.03
max	-0.39	-0.01	2.49	-0.58	-0.22	1.7	72.69	83.76
q_1	-4.49	-1.71	0.33	-4.3	-1.62	0.23	71.89	72.35
q_{25}	-1.51	-0.49	0.4	-1.67	-0.63	0.28	72.15	74.97
q_{50}	-1.11	-0.32	0.47	-1.26	-0.48	0.32	72.42	79.25
q_{75}	-0.74	-0.19	0.57	-0.91	-0.35	0.38	72.63	83.06
q_{99}	-0.46	-0.05	1.16	-0.63	-0.24	0.84	72.68	83.73
	US							
mean	-1.11	-0.77	0.96	-1.26	-0.92	0.8	60.43	65.23
st. dev.	0.62	0.66	0.65	0.6	0.65	0.65	8.07	11.55
skewness	-4.35	-3.33	2.81	-4.34	-3.27	2.9	0.57	0.64
kurtosis	36.03	25.89	20.82	35.43	24.54	21.06	1.89	2
min	-7.74	-7.44	-0.11	-7.46	-6.87	0.08	50.93	52.28
max	-0.38	0.06	7.25	-0.59	-0.19	6.47	76.47	89.05
q_1	-3.5	-3.1	0.15	-3.49	-3	0.1	51.39	52.78
q_{25}	-1.33	-1.07	0.48	-1.45	-1.22	0.33	53.1	54.91
q_{50}	-1	-0.69	0.89	-1.16	-0.85	0.72	57.18	60.32
q_{75}	-0.72	-0.31	1.27	-0.89	-0.45	1.12	66.93	74.11
q_{99}	-0.45	0.01	3.1	-0.62	-0.22	2.76	76.13	88.51

This table presents summary statistics for the risk measures of the emerging stock market returns computed from the S&P CLX IGPA for Chile.
$ES_{f|d} = E(r_f|r_d < VaR_{0.1}(r_d))$, where r_d, where r_d is the returns from the STOXX EUROPE 600 and S&P 500 COMPOSITE indices for the EU and USA.
$E(r_f|r_d < VaR(0.1))$ is defined by Eq. (6). $ES_{f|e^L} = E(r_f|r_e < VaR_{0.1}(r_e))$, i.e. the mean returns of the Brazilian stock market under a scenario where the EUR (USD) experiences a sharp appreciation against the Chilean peso. $ES_{f|e^U} = E(r_f|r_e > VaR_{0.1}(r_e))$, i.e. the mean returns of the Chilean stock market under a scenario where the EUR (USD) experiences a sharp depreciation against the Chilean peso. γ_d, γ_c^L and γ_c^U express the difference between the conditional and the unconditional expected returns of the Chilean stock returns according to Eq. (6). θ_d^L and θ_d^U indicates the contribution of the developed markets to the emerging markets following Eq. (9).
q_k indicates the k-th quantile of the risk measure series. Results are shown in percentages.

Table 9 (Cont.): Descriptive statistics of the impact of developed markets on emerging markets.

Panel D: Mexico.

	$ES_{f\|d}$	$ES_{f\|e^L}$	$ES_{f\|e^U}$	γ_d	γ_c^L	γ_c^U	θ_d^L	θ_d^U
	EU							
mean	-2.36	-1	1.06	-2.53	-1.17	0.89	68.76	75.72
st. dev.	1.36	0.7	0.67	1.36	0.7	0.67	1.23	4.13
skewness	-2.69	-2.51	2.19	-2.69	-2.52	2.19	-0.75	-0.72
kurtosis	12.35	10.88	8.44	12.36	10.9	8.42	1.88	1.82
min	-10.24	-4.83	0.48	-10.44	-5.02	0.31	66.54	68.46
max	-1.03	-0.35	4.43	-1.2	-0.52	4.24	69.91	79.55
q_1	-8.24	-3.96	0.5	-8.4	-4.12	0.33	66.56	68.5
q_{25}	-2.7	-1.21	0.64	-2.87	-1.38	0.47	67.61	71.64
q_{50}	-1.9	-0.74	0.76	-2.07	-0.91	0.59	69.45	77.99
q_{75}	-1.55	-0.58	1.31	-1.72	-0.75	1.15	69.78	79.2
q_{99}	-1.08	-0.37	3.85	-1.25	-0.54	3.69	69.88	79.53
	US							
mean	-2.85	-1.73	1.84	-3.02	-1.9	1.67	63.34	66.44
st. dev.	1.27	1.19	1.1	1.27	1.19	1.1	8.67	9.35
skewness	-3.46	-2.65	2.54	-3.46	-2.65	2.54	1.31	1.32
kurtosis	20.15	15.45	14.81	20.17	15.46	14.8	3.74	3.78
min	-12.68	-10.32	0.27	-12.88	-10.52	0.1	54.66	57.12
max	-1.52	-0.04	9.71	-1.69	-0.21	9.51	90.45	95.79
q_1	-8.68	-6.91	0.34	-8.85	-7.08	0.16	54.94	57.42
q_{25}	-3.13	-2.14	1.18	-3.29	-2.31	1.01	56.95	59.55
q_{50}	-2.54	-1.52	1.68	-2.72	-1.69	1.5	59.67	62.47
q_{75}	-2.14	-1.02	2.24	-2.31	-1.19	2.06	67.46	70.83
q_{99}	-1.59	-0.13	6.58	-1.76	-0.3	6.4	88.95	94.15

This table presents summary statistics for the risk measures of the emerging stock market returns computed from the S&P/BMV IPC for Mexico.
$ES_{f|d} = E(r_f|r_d < VaR_{0.1}(r_d))$, where r_d, where r_d is the returns from the STOXX EUROPE 600 and S&P 500 COMPOSITE indices for the EEU and USA.
$E(r_f|r_d < VaR_{0.1}(r_d))$ is defined by Eq. (6). $ES_{f|e^L} = E(r_f|r_e < VaR_{0.1}(r_e))$, i.e. the mean returns of the Mexican stock market under a scenario where the EUR (USD) experiences a sharp appreciation against the Mexican peso.
$ES_{f|e^U} = E(r_f|r_e > VaR_{0.9}(r_e))$, i.e. the mean returns of the Mexican stock market under a scenario where the EUR (USD) experiences a sharp depreciation against the Mexican peso. γ_d, γ_c^L and γ_c^U express the difference between the conditional and the unconditional expected returns of the Mexican stock returns according to Eq. (6). θ_d^L and θ_d^U indicates the contribution of the developed markets to the emerging markets following Eq. (9).
q_k indicates the k-th quantile of the risk measure series. Results are shown in percentages.

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