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Channels of Sovereign Risk Spillovers and Investment in the Manufacturing Sector*

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Abstract

This paper identifies endogenous and exogenous indicators of firms' investment activity, and examine, in particular, the effect that these variables have in co-determining firms' investment decisions.

Two channels of spillovers from sovereign risk to firms' capital expenditures are defined. The first channel, the "direct channel", describes responses in capital expenditures from an innovation in sovereign risk. The second channel, the "indirect channel", is a transmission mechanism in which spillovers from changes in sovereign risk indirectly affect a firm's capital expenditures via its capital market risk and profitability. While we observe that the direct risk channel is of major importance in Emerging and Developing Economies, it is comparatively small in Advanced Economies. In the case of the latter, contagion from changes in sovereign risk on firms' capital market risk plays a much more important role.

Keywords: Capital expenditures, Risk spillovers, Panel VARX, Differential Evolution

***JEL* classification:** C63, D81, E22, G31

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1 Introduction

For both industrialised and developing economies, the investment activity of firms plays an important role in maintaining economic prosperity or catching up, respectively. Besides firm-specific characteristics, such as size, sector and liquidity, the macroeconomic environment as well as concrete policy measures are crucial in the decision-making process for long-term investments. While the former is often modelled using a measure for the level of general economic activity, applying, for example, the GDP or an industrial production index, the latter depends on the specific question of interest. In this paper, we aim to estimate the interrelationships between firms' capital market risk, profitability and capital expenditures, as well as the impact that an increase in sovereign risk has on capital expenditures, in particular. Our research is motivated by the topical discussion of political and economic uncertainty on investments. Firm executives may prefer to "wait and see" in times of high economic uncertainty, implying a subsequent decline in capital expenditures.

Having defined aggregate spillover as the total multiplier effect from sovereign risk on capital expenditures, decomposition allows identifying two causal subchannels. The first subchannel, the "direct channel", captures all non-second-order effects a shock in sovereign risk has on a firm's investment activity. The second subchannel, called "indirect channel", captures all effects that sovereign risk has on a firm's investments via third-party effects on other endogenous system variables, i.e., a firm's capital market risk and its profitability.

The methodological procedure is based on a vector autoregressive (VAR) model that is modified for panel data and extended by exogenous variables (PVARX). The idea is to model each of the endogenous variables as a process on its own and the other system variables' (both endogenous and exogenous) recent past. We use the Differential Evolution algorithm developed by Storn and Price (1997) and adapted to VAR and vector error correction (VEC) models in Maringer and Deininger (2016) for the selection of parameters during the optimization process. Economic inference is drawn from estimated parameter values, as well as from impulse response analysis and multiplier analysis.

For the empirical analysis, we collect quarterly data on firms' capital expenditures, stock return volatility and the return on capital for a set of more than 5,800 manufacturing firms. Sovereign risk is included as credit default swap (CDS) spreads for a firm's country of incorporation for the period from Q1:2001 until Q4:2015. In total, we include almost 155,000 observations which cover both Advanced Economies and Emerging and Developing Economies permitting for a detailed and comprehensive analysis of additional country subgroups.

We find the total spillover effect to range between zero and minus one for the majority of country subgroups, indicating an increase of sovereign risk of one percent causes a reduction of capital expenditures between zero and one percent. We further find significant differences in the share of direct and indirect spillover channels. The channel decomposition reveals that more than 80 percent of the reduction in capital expenditures can be attributed to second-order spillovers from sovereign risk to firms' capital market risk and profitability in Advanced Economies. On the contrary, we find that almost 50 percent of these decreases are attributable to the direct effects of increases in sovereign risk in Emerging and Developing Economies. The other 50 percent are almost equally distributed among firms' capital market risk and profitability.

The results bear strong economic and policy implications. For firms in Emerging and Developing Economies, sovereign risk has an immediate negative spillover on their investments. A possible explanation for this finding is that for this country aggregate, firms' general business activities are closely tied to government activities and thus sovereign risk is perceived as being corporate risk. Advanced Economy firms, on the other hand, adapt rising sovereign risk mainly through their capital market risk, which is most likely the case because of more developed and efficient stock markets in these countries and greater independence of their operational activity from the respective government. Here, cuts in investments are likely to occur not immediately, but with a lag. Particularly, in the light of rising sovereign risk levels, policy makers need to take into account these differences in sovereign to corporate spillover.

The remainder of the paper is organised as follows: Section 2 provides the economic foundation for studying sovereign to corporate risk spillovers and extends the analysis by its implications to the real economy. Section 3 introduces the basic econometric model, as well as the identified spillover channels and the estimation approach used. After providing empirical evidence and economic implications in Sections 4 and 5, respectively, we conclude in Section 6.

2 Economic Foundation

In the context of corporate finance, risk is usually considered as being investment-specific and is modelled accordingly. In this paper, our approach is quite different, as we aim to explain the general transmission mechanisms from sovereign to corporate risk and profitability and how they affect firms' investment activities.

We define the various channels of risk spillovers econometrically, and relate our empirical findings to the research that investigates sources of sovereign to corporate risk spillover effects. Augustin et al. (2016) identify six sources[1] of risk spillovers from the sovereign to the corporates. First, the adjustment in taxation of corporate income appears relevant. As Augustin et al. (2016) point out, an increase in an economy's sovereign risk might induce a rise in corporate taxes in both the present and the future. The assumed immediate anticipation of firms can lead to a reduction in investment activity and thus hamper future economic growth at the macro level. Second, an increase in sovereign risk increases the likelihood of private firms being expropriated. This is especially the case for firms in emerging and developing countries. Third, "sovereign ceilings" may create an environment in which corporations are unable to refinance themselves at more favourable conditions than their respective government. Almeida et al. (2017) find sovereign ceiling policies still being applied and that firms reduce their investments due to rises in the cost of debt capital. They argue that "[t]he ceiling rule pushes down ratings and may be responsible for significant effects on firm investment and financial policy in the aftermath of a sovereign downgrade" (Almeida et al., 2017, p. 289). Fourth, increasing sovereign risk can induce a drop in public expenditure and thus a revenue downturn for corporates, on whose economic activities rely to a notable extent on the public sector. This latter causal relationship is also linked to the fifth source that we discuss. Here, an increase in sovereign risk induces a decrease in direct financial aid from the government to the domestic corporates, e.g., in terms of subsidies. The last source is less direct compared to the ones mentioned before. Based on studies by Acharya, Drechsler, and Schnabl (2014), Acharya, Eisert, Eufinger, and Hirsch (2014) and Gennaioli et al. (2012), Augustin et al. (2016) argue that a rise in sovereign risk can affect financial institutions and hence corporates which heavily rely on bank credit. The latter is confirmed by Bedendo and Colla (2013) using firm-level data on corporate CDS spreads in the euro zone.

As argued in The Economist (2016), firms recently need to pay attention to political risk not only in the developing but also in the advanced economies. The executives need to take this new development into account when scheduling long-term investments and forecasting expected returns. Such sources of risk, not mentioned above, can be either domestic, non-domestic or a mix of them. A potential source of domestic risk is political uncertainty on business relevant

[1]Deviating from Augustin et al. (2016), we call them "sources" instead of "channels" in order to distinguish them from the type of channels defined in this paper.

topics in a firm's country of incorporation. A topical example for this source of risk, also mentioned in The Economist (2016), is the United Kingdom European Union membership referendum ("Brexit referendum"), which has taken place in June 2016. In this context, the future arrangements shaping the formal relations between the United Kingdom and the European Union, in particular, the unlimited access for firms to each others' market, state a source of domestic risk. For firms located in the United Kingdom, this political uncertainty might lead to investments being reduced, postponed, or, in the worst case, being called off entirely. For UK-headquartered firms, this risk is purely domestic as the relocation of a firm's headquarters could eliminate the risk. For firms located outside the UK, the political uncertainty works the same way. Non-domestic sources of risk, on the other hand, comprise all sources of risk, that are not solely linked to domestic uncertainty. For example, a highly volatile exchange rate environment might induce non-domestic risk for export-oriented firms, because it is likely to affect their international sales, ceteris paribus.

To our knowledge, there is no paper that models capital expenditures as being specifically dependent on sovereign and firms' capital market risk and profitability using micro panel data. While a higher firms' profitability is assumed to positively affect firms' capital expenditures, a higher capital market risk is expected to decrease their investment activity. In line with the literature mentioned above, sovereign risk is assumed to exert substantial spillover on firms' capital market risk. The latter is assumed to be negatively correlated with firms' profitability and capital expenditures, while more profits are expected to benefit firms' investment activities. Changes in the sovereign risk might thus spill over to firms' capital expenditures directly and indirectly through firms' characteristics.

Our contribution is twofold: First, we provide a general definition of the transmission mechanism from sovereign risk to the real economy, i.e., firms' investments. Second, decomposing the aggregate effect allows us to study the direct and indirect channels of spillover separately.

3 Methodology

3.1 The Econometric Model

In order to study the dynamic behaviour of the variable series, we estimate a trivariate panel vector-autoregressive model, as introduced in Love and Zicchino (2006), extended by exogenous variables (PVARX). It combines the idea of modelling the endogenous variables as an autoregressive process, while at the same time taking into account unobserved individual heterogeneity. Most of the recent applications, making use of the PVAR, but abstain from modelling the exogenous variables explicitly, include, i.a., macro- and microeconomic modelling (Atems and Jones (2015), Lee and Gueye (2015) and Yuan and Chen (2015)), energy economics (Probst and Sauter (2015) and Shahbaz et al. (2015)), industrial economics (Izumi and Kwon (2015) and O'Toole et al. (2015)), and finance (Babalos et al. (2015), Miyajima et al. (2015), Klein (2014) and Dreger and Reimers (2014)). An exception is Djigbenou-Kre and Park (2016), modelling the exogenous variable explicitly in a PVARX framework. The data generating process for such a system containing d endogenous and e exogenous variables is stated by,

$$\mathbf{y}_{i,t} = \mathbf{M}\mathbf{c}_{i,t} + \sum_{\ell=1}^{p} \boldsymbol{\Gamma}_\ell \mathbf{y}_{i,t-\ell} + \sum_{h=0}^{q} \boldsymbol{\Theta}_h \mathbf{x}_{i,t-h} + \boldsymbol{\varepsilon}_{i,t}, \quad i = 1, ..., N \quad t = 1, ..., T, \tag{1}$$

where $\mathbf{y}_{i,t}$ denotes the level of each endogenous variable for firm i at time t and $\mathbf{y}_{i,t-\ell}$ and $\mathbf{x}_{i,t-h}$ contain the ℓ-th and h-th lags of the respective endogenous and exogenous variables up to order p and q, respectively. Moreover, we include model deterministic terms in $\mathbf{c}_{i,t}$ and the respective coefficient matrix M. $\boldsymbol{\Gamma}_\ell$ and $\boldsymbol{\Theta}_h$ span the space of the coefficients for the ℓ-th lagged endogenous and the h-th lagged exogenous variable series, respectively. The disturbances for each of the covariates are captured in $\boldsymbol{\varepsilon}_{i,t}$.

Apart from the coefficient matrices $\boldsymbol{\Gamma}_\ell$ and $\boldsymbol{\Theta}_h$ themselves, economic inference in VARX models is commonly drawn from impulse response functions for the endogenous variables and multiplier analysis for the exogenous variables. Following Lütkepohl (2007), an impulse response function illustrates the impact of a shock ("innovation") on a variable itself and on other variables in the system over time. In both cases, we apply a one-standard deviation shock in order to study the responses consistently. The impulse response function from an endogenous variable k on another endogenous variable j at point r is calculated according to the formula presented in equation (2),

$$\phi_{jk,1} = \gamma_{jk,1} \quad \text{and} \quad \phi_{jk,r} = \gamma_{jk,r} + \sum_{\ell=1}^{r-1} \gamma_{jk,\ell}\eta_{r-\ell} \quad \text{for} \quad r > 1, \tag{2}$$

where $\gamma_{jk,\ell}$ represents the element in the j-th row and k-th column of the ℓ-th lag matrix and η is defined as $[\det(\gamma(L))]^{-1}$. From this, accumulative impulse responses ($\boldsymbol{\Psi}_s$) until point s as well as the total responses ($\boldsymbol{\Psi}_\infty$) can be directly calculated by,

$$\mathbf{\Psi}_s = \sum_{r=0}^{s} \mathbf{\Phi}_r \quad \text{and} \quad \mathbf{\Psi}_\infty = \sum_{r=0}^{\infty} \mathbf{\Phi}_r, \tag{3}$$

where responses to an innovation in the k-th variable are contained in the k-th column of the respective $\mathbf{\Psi}$ matrix.

In order to study the effect an innovation in an exogenous variable has on endogenous variables, we follow Lütkepohl (2007) and use dynamic multiplier analysis. Dynamic multipliers, $\mathbf{D}$, can be recovered from the $\mathbf{\Gamma}$ and $\mathbf{\Theta}$ matrices from equation (1) using,

$$\mathbf{D}(L) = \sum_{r=0}^{\infty} \mathbf{D}_r L^r = \mathbf{\Gamma}(L)^{-1}\mathbf{\Theta}(L), \tag{4}$$

with $\mathbf{\Gamma}(L)$ and $\mathbf{\Theta}(L)$ defined as $\mathbf{\Gamma}(L) = \mathbf{I}_d - \mathbf{\Gamma}_1 L - \cdots - \mathbf{\Gamma}_p L^p$ and $\mathbf{\Theta}(L) = \mathbf{\Theta}_0 + \mathbf{\Theta}_1 L + \cdots + \mathbf{\Theta}_q L^q$ representing the reduced-form operators. We obtain the marginal change (dynamic multiplier, $\delta_{kj,r}$) in an endogenous variable k in period $t+r$ after an innovation in the exogenous variable j in period t, holding the system constant. From this dynamic multiplier, the accumulative effect (interim multiplier, $\mathbf{I}_s$) up to period s and the long-term impact (total multiplier, $\mathbf{T}_\infty$) can be calculated by,

$$\mathbf{I}_s = \sum_{r=0}^{s} \mathbf{D}_r \quad \text{and} \quad \mathbf{T}_\infty = \sum_{r=0}^{\infty} \mathbf{D}_r. \tag{5}$$

3.2 Identification of Spillover Channels

In contrast to vector autoregressive systems without explicitly modelled exogenous variables, PVARX models allow for an in-depth analysis of how innovations in an exogenous variable affect an endogenous variable directly and indirectly through responses in other endogenous variables. We define the total multiplier effect as formulated in equation (5), which contains the aggregate effects from an innovation in the exogenous variable, as the total spillover channel (TSC). Based on this, we identify two subchannels of spillover effects. They are obtained by the decomposition of the total multiplier into a direct spillover channel (DSC) and an aggregate indirect spillover channel ($AISC$), which are contained in the matrices $\mathbf{\Gamma}(L)$ and $\mathbf{\Theta}(L)$, respectively. For this, we state the matrices $\mathbf{\Gamma}(L)$ and

$\boldsymbol{\Theta}(L)$ explicitly by,

$$\boldsymbol{\Gamma}(L) = \begin{bmatrix} \tilde{\gamma}_{mm} & \cdots & \tilde{\gamma}_{md} \\ \vdots & \ddots & \vdots \\ \tilde{\gamma}_{dm} & \cdots & \tilde{\gamma}_{dd} \end{bmatrix} \quad \text{and} \quad \boldsymbol{\Theta}(L) = \begin{bmatrix} \tilde{\theta}_{mmk} & \cdots & \tilde{\theta}_{mme} \\ \vdots & \ddots & \vdots \\ \tilde{\theta}_{dmk} & \cdots & \tilde{\theta}_{dme} \end{bmatrix}. \tag{6}$$

This decomposition allows us to make a detailed examination of how shocks in the exogenous variables are incorporated in the system of endogenous variables. From equation 6, the total spillover channel (TSC) from an innovation in the k-th exogenous variable on the m-th endogenous variable is defined by,

$$TSC_{mk} = \sum_{j=1}^{d} \tilde{\gamma}_{mj} \cdot \tilde{\theta}_{jmk}. \tag{7}$$

The direct and aggregate indirect spillover channels (DSC and $AISC$) are available from the decomposition shown in equation (8). For the convenience of comparability across models, we define them as a share of the TSC.[2]

$$DSC_{mk} = \frac{\tilde{\gamma}_{mm} \cdot \tilde{\theta}_{mmk}}{TSC_{mk}} \quad \text{and} \quad AISC_{mk} = \frac{\sum_{j \neq m} \tilde{\gamma}_{jm} \cdot \tilde{\theta}_{jmk}}{TSC_{mk}}. \tag{8}$$

From $AISC$, further decomposition leads to the individual indirect spillover channel ($IISC$) through the endogenous variable j:

$$IISC_{mjk} = \frac{\tilde{\gamma}_{mj} \cdot \tilde{\theta}_{jmk}}{TSC_{mk}}, \quad j \neq m. \tag{9}$$

The spillover contained in $IISC_{mjk}$ is thus the fraction of a shock in the exogenous variable k transmitted to the endogenous variable m via another endogenous variable j.

3.3 The Estimation Approach

Following Lütkepohl (2010), the estimation of VAR processes is usually done by traditional approaches such as least squares, maximum likelihood or Bayesian methods. While these methods are considered to provide a sound framework for parameter estimation, the optimal estimation for a specific application is often distorted by technical difficulties. The main issue in VAR processes lies in the trade-

[2]Note that the representation as a fraction of the TSC requires the same sign of $\tilde{\gamma}_{mj} \cdot \tilde{\theta}_{mk}$ for each j when m and k held fixed.

off between model fit and over-parametrisation. Here, numerous issues arise when seasonalities, long memory or delayed reactions need to be taken into account. In traditional VAR estimation approaches, where generally all parameters up to a predefined lag length p are estimated, the number of degrees of freedom decreases sharply. This is especially severe in panel models which typically have limited observations across time. Moreover, usually not all the estimated parameters have the same explanatory performance for the process. It is therefore highly appealing to include only those parameters which have high levels of significance and ignoring all the others. This subset selection problem can approached by fitting the model that minimizes the Bayesian Information Criterion (BIC),

$$\text{BIC} = \ln\left(\left|\hat{\Omega}_\varepsilon\right|\right) + \alpha \cdot \frac{\ln(T)}{T}, \tag{10}$$

where $\hat{\Omega}_\varepsilon = T^{-1}\sum_{t=1}^{T}\hat{\varepsilon}_t\hat{\varepsilon}_t{}'$ denotes the residual variance-covariance matrix from the estimated VAR model without correcting for the degrees of freedom. In the second term in the BIC, $\alpha = \#\{\mathbf{M}, \mathbf{\Gamma}, \mathbf{\Theta}\}$ is the number of non-zero parameters included in the model. $\alpha \cdot \ln(T)/T$ facilitates model validation and subset selection: Parameters should only be included if they reduce the in-sample error by more than their potential contribution to over-fitting. Finding the model with the lowest BIC is therefore equivalent with choosing the model with the highest posterior probability (cf., Hastie et al. (2009, section 7.7) and Zivot and Wang (2006)).

4 Empirical Evidence

4.1 Data and Model Specification

In order to capture the response that a shock on one variable has on another as precisely as possible, we collect firm-level quarterly data on capital expenditures (κ_t) in millions of US dollars, the capital market risk calculated as the annualised standard deviation of daily stock returns during a quarter (σ_t), and the return on capital (ρ_t) defined as 0.625 times the EBIT divided by the average of the current and the previous quarter's total capital value in percent[3] for manufacturing firms[4] for the period from Q1:2001 to Q4:2015 are drawn from the S&P Capital IQ database.

[3]We find average corporate tax rates similar in Advanced Economies and Emerging and Developing Economies, on average. The total capital is calculated as the sum of preferred and common equity and the total debt of a firm.

[4]Firms with SIC codes 20–39.

Table 1: Data descriptive statistics

Variable descriptive statistics:	Mean	SD	$Q_{0.25}$	Median	$Q_{0.75}$
Capital expenditures (in 1,000 USD)	63,091	414,677	435.79	2,598	16,866
Annualised stock return volatility	0.49	0.52	0.27	0.38	0.55
Return on capital (in %)	5.59	13.39	1.32	5.48	10.46
Sovereign CDS spread (in basis points)	152.45	437.67	25.66	69.94	140.38

Sample composition:	No. of obs.	Share of obs.	No. of firms	Share of firms
Advanced Economies (AE)	85,206	0.55	3,264	0.56
Major Advanced Economies (MAE)	36,932	0.24	1,139	0.19
Other Advanced Economies (OAE)	48,274	0.31	2,125	0.36
Euro Area (EA)[1]	25,694	0.17	844	0.14
Emerging and Developing Economies (EE)	69,649	0.45	2,608	0.44
Emerging and Developing Europe (EME)	9,563	0.06	414	0.07
Emerging and Developing Asia (EMA)	38,059	0.25	1,244	0.21
Latin America and the Caribbean (LAC)	8,736	0.06	288	0.05
Oth. Emerging and Developing Economies (EMO)	13,291	0.09	662	0.11
Total	154,855	1.00	5,872	1.00

Notes: The table shows descriptive statistics of the variables in levels (upper panel) and information on the sample composition (lower panel). [1] Euro Area countries are contained in Major and Other Advanced Economies.

While the return on capital serves as an indicator for the general success of the firm, i.e., its profitability, the capital market risk is used as a proxy for the ease of refinancing investments. Moreover, we obtain data on sovereign credit default swap (CDS) spreads for the country of incorporation from Markit database. In line with Gyntelberg et al. (2013), we choose 5-year maturity CDS contracts as they state a more liquid market, in terms of quotes, compared to the 10-year maturity CDS contracts market. The credit event considered is a full restructuring of the underlying sovereign. For non-US firms, all CDS spreads are denominated in USD. For US firms, on the other hand, CDS spreads are denominated in euro to remove imprecisions from currency risks. All capital expenditure series are calculated as real values using the US GDP deflator from the IMF World Economic Outlook database.

Table 1 illustrates some data descriptive statistics. The median of quarterly capital expenditures is approximately 2.6 million US dollar, with a relatively broad range as indicated by the 0.25 and 0.75 percentiles. Considering the latter, the annualised stock return volatility – used as a measure for firms' capital market risk ranges between 0.27 and 0.55 with a mean of 0.49. For the return on capital, we find the mean (median) at 5.6 (5.5) percent. Sovereign risk, as measured by the respective CDS spread in basis points, has a mean of 152.5 with the lowest (highest) quantile below (above) 25.7 (140.4). When it comes to estimation, all series are log-transformed.[5]

The dataset spans across more than 5,800 firms with approximately 155,000 observations located in Advanced Economies or Emerging and Developing Economies. For reasons of comparability, we rely on the country aggregation proposed by the International Monetary Fund (cf., International Monetary Fund (2015)) and define Advanced Economies (AE) and Emerging and Developing Economies (EE) as well as their subcategories of Major Advanced Economies (MAE), Other Advanced Economies (OAE), the Euro Area (EA), Emerging and Developing Europe (EME), Emerging and Developing Asia (EMA), Latin America and the Caribbean (LAC), and Other Emerging and Developing Economies (EMO).[6]

In order to prevent biased results and inference drawn from the estimated coefficients, all series contained in the vector autoregression must be stationary. We apply the augmented version of the Im-Pesaran-Shin (IPS) panel unit root test introduced in Pesaran (2007), which belongs to the second generation unit-root tests as it exhibits robustness towards cross-sectional dependence. The null hypothesis of a unit root in the series can be tested against various alternatives. For the exogenous variable, the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test introduced in Kwiatkowski et al. (1992), is used. The null hypothesis of the test states level-stationarity of a series.[7] The results of the two tests, displayed in the Tables 9 and 8 in Appendix C, respectively, indicate that all panel variables are tested stationary, and hence taken in their level values. Most sovereign CDS spread series, on the other hand, are non-stationary, and hence – for consistency – all CDS spread series are taken in their stationary first differences. For the latter, especially for small countries with only a few large firms, endogeneity arising from reverse causality between firms' capital market risk and sovereign risk might be an issue. Hence, we apply the Durbin-Wu-Hausman test considering any country aggregate used in the empirical analysis. Here, under the null hypothesis the suspected endogenous variable can be considered exogenous. As Table 7 in Appendix C shows, endogeneity is not present in any subsample.

Furthermore, when it comes to empirical application, we follow Arellano and Bover (1995) and Love and Zicchino (2006) and transform the data using the "Helmert procedure" to control for individual fixed effects.[8] In order to make the

[5] Descriptive statistics for the log-transformed variables and by region can be found in Tables 5 and 6 in Appendix A, respectively.

[6] Other Emerging and Developing Economies (EMO) are defined as the residual of EE not elsewhere classified.

[7] For more details, please refer to Pesaran (2007) and Kwiatkowski et al. (1992).

[8] "This procedure removes only the forward mean, i.e. the mean of all the future observations

dataset as representative as possible, we use an individual weighting approach within each of the country aggregates. Each observation is weighted by the share of the country's GDP in the respective aggregate adjusted by the share of observations per country in the sample. For this, we collect annual data on the real GDP from the IMF World Economic Outlook for each country included.[9]

4.2 Model Fitting Procedure

Minimizing the BIC in equation (10) requires choosing the subset of included parameters and finding their optimal values. The resulting minimization problem is neither convex nor continuous, traditional deterministic methods therefore fail. Exhaustive search for the subset selection is also not possible due to the large number of alternatives[10], nor is manual selection in the absence of an efficient and reliable rule. In this paper, we follow the approach suggested by Maringer and Deininger (2016) who adapt Differential Evolution[11] (DE) for the selection and estimation of VAR models. There, the selection process is combined with estimating the included parameters' values. Specifically, the method primarily finds the parameter values, but values that are sufficiently close to zero (here: an absolute value of less than 0.001) are excluded from the model. DE is an Markov Chain Monte Carlo (MCMC)-type search process incorporating evolutionary principles and exhibits favourable convergence properties for challenging optimization problems like the one in this paper. The reported results are based on 100 restarts for each model, all implementations where done with R, version 3.2.3.

4.3 Estimation Results

In this section, we discuss the estimation results from the trivariate PVARX model. Economic inference is drawn from estimated parameters as well as impulse response functions, interim multipliers and total multipliers. For reasons of clarity and comprehensibility, we focus on the results for the aggregates of Advanced Economies (AE) and Emerging and Developing Economies (EE).[12]

The parameter estimates for the models of country aggregates, allowing for a maximum of four lags in both endogenous and exogenous variables, are depicted in Table 2. Here, blank fields indicate that these parameters add no substantial

available for each firm-year." (Love and Zicchino, 2006, p. 195)

[9] A detailed description of the weighting approach is provided in Appendix B.

[10] With 63 parameters to choose from, there are $2^{63} = 9.2 \times 10^{18}$ combinations.

[11] cf., Storn and Price (1997) and Price et al. (2005).

[12] The model estimates for the subgroups can be found in the Tables 10 to 12 in Appendix D.

Table 2: Parameter estimates by main country aggregate

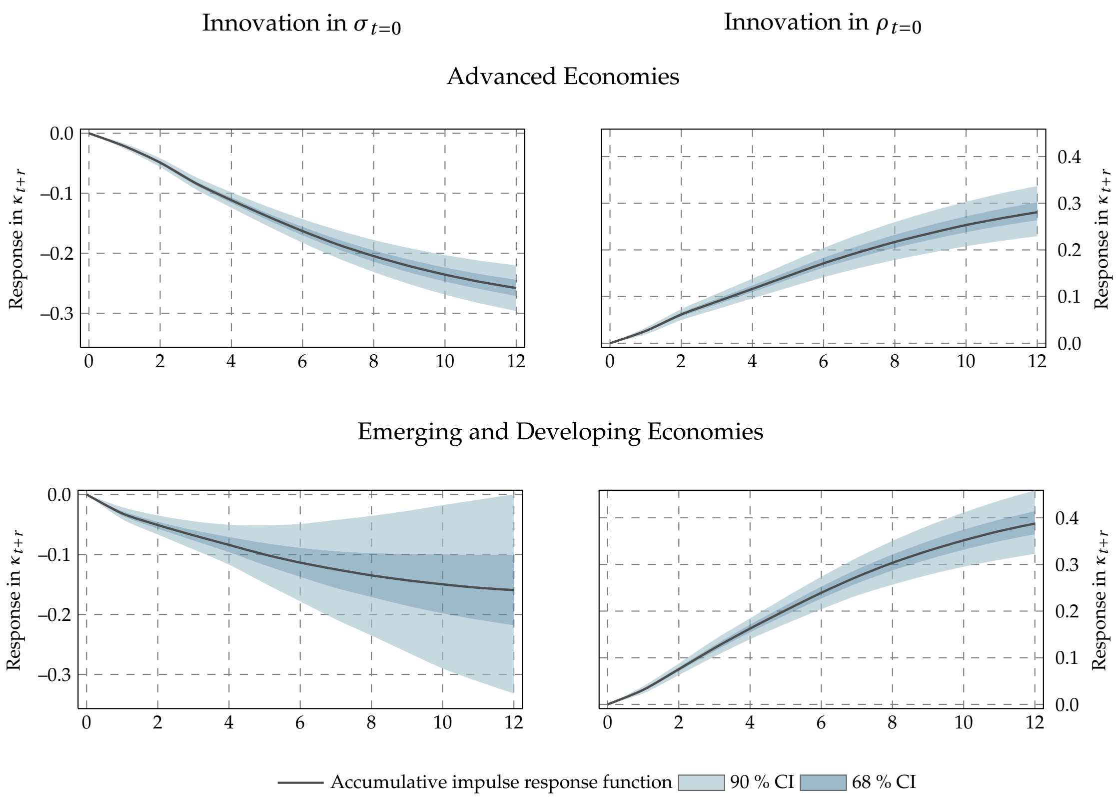
	Advanced Economies			Emerging and Developing Economies		
	κ_t	σ_t	ρ_t	κ_t	σ_t	ρ_t
Q_1	-0.130^{***} (0.002)	-0.024^{***} (0.002)		-0.210^{***} (0.001)		0.004^{***} (0.001)
Q_2			0.006^{***} (0.002)		0.039^{***} (0.001)	0.007^{**} (0.003)
Q_3	0.027^{***} (0.001)		0.007^{***} (0.002)			0.007^{***} (0.002)
Q_4	0.149^{***} (0.002)			0.220^{***} (0.001)	0.019^{***} (0.002)	-0.009^{***} (0.001)
κ_{t-1}	0.399^{***} (0.011)	-0.013 (0.010)		0.312^{***} (0.010)	-0.014 (0.023)	
κ_{t-2}	0.113^{***} (0.010)			0.133^{***} (0.010)		
κ_{t-3}	0.038^{***} (0.010)			0.081^{***} (0.009)	-0.009 (0.007)	-0.001 (0.003)
κ_{t-4}	0.128^{***} (0.009)		-0.005 (0.005)	0.108^{***} (0.008)		-0.002 (0.017)
σ_{t-1}	-0.066^{***} (0.011)	0.318^{***} (0.010)		-0.076^{***} (0.019)	0.282^{***} (0.024)	-0.003 (0.024)
σ_{t-2}	-0.036^{***} (0.013)	0.102^{***} (0.010)			0.106^{***} (0.021)	
σ_{t-3}	-0.041^{***} (0.011)	0.094^{***} (0.005)			0.071^{***} (0.007)	
σ_{t-4}		0.018^{**} (0.007)			0.017 (0.021)	
ρ_{t-1}	0.253^{***} (0.053)	-0.082^{***} (0.010)	0.322^{***} (0.020)	0.396^{***} (0.077)	-0.084^{***} (0.025)	0.180^{***} (0.037)
ρ_{t-2}	0.151^{***} (0.052)		0.086^{***} (0.017)	0.355^{***} (0.079)		0.070^{**} (0.035)
ρ_{t-3}				0.236^{**} (0.094)		0.074^{**} (0.032)
ρ_{t-4}	0.052 (0.042)	-0.049^{***} (0.019)	0.141^{***} (0.006)	0.120 (0.083)		0.168^{***} (0.015)
ζ_{t-0}		0.318^{***} (0.006)			0.335^{***} (0.016)	-0.010^{***} (0.004)
ζ_{t-1}		0.107^{***} (0.003)	-0.007^{***} (0.003)		0.039^{***} (0.004)	-0.006^{**} (0.004)
ζ_{t-2}		0.103^{***} (0.002)	-0.008 (0.045)	-0.057^{***} (0.001)	0.079^{***} (0.001)	-0.006 (0.029)
ζ_{t-3}		0.065^{***} (0.002)			0.088^{***} (0.001)	-0.010 (0.025)
ζ_{t-4}	-0.047^{***} (0.002)	0.031^{***} (0.002)	-0.009 (0.027)	-0.088^{***} (0.001)		

Notes: κ_t = capital expenditures, σ_t = stock return volatility, ρ_t = return on capital and ζ_t = sovereign CDS. ***, ** and * denote significance at the 1, 5 and 10 percent levels, respectively. Standard errors in parentheses. Blank fields indicate that these parameters can be excluded from the model without loss of information in the sense of the BIC.

information and should therefore be excluded: in the sense of the BIC, any additional parameter must (marginally) improve the model fit by more than its cost due to potential over-fitting, which is only the case for reported parameters. In all models, we detect significant seasonal effects with capital expenditures being lowest in the first and highest in the fourth calendar quarter. Although seasonal effects are of minor importance for firms' capital market risk, we detect significant differences between quarters for the return on capital, especially in the case of EE.

We observe a long memory for capital expenditures, firms' capital market risk and profitability in both country aggregates. An inspection of the cross-variable impact reveals significant negative effects from a firm's capital market risk on its capital expenditures. While this effect is persistent for three quarters in the case of AE, we observe no negative spillover effects for EE after the first quarter. For the latter, profitability seems to be of comparatively greater significance for capital expenditures in both persistence and magnitude. No significant influences from capital expenditures on either firms' capital market risk or their profitability is found. An increase in profitability leads to a decline in the firms' capital market risk. However, a transmission effect in the opposite direction of changing capital market risk leading to an adjustment in firms' profitability cannot be confirmed.

Figure 1: Accumulative impulse response functions from system variable shocks on capital expenditures



Notes: κ_t = capital expenditures, σ_t = stock return volatility and ρ_t = return on capital. The figures show accumulative orthogonalised impulse response functions, i.e., the cumulative response of one variable at time $t + r$ after a one-standard deviation shock on itself or another variable at time t.

These findings are validated by accumulative impulse responses illustrated in Figure 1.[13] It can be seen that at a 10 percent level of significance, represented

[13]The magnitude is scaled by the respective sample standard deviation such that, in the case of log series, an innovation represents a one percent change causing a percent response.

by the pale-shaded confidence interval[14], for the aggregate of AE, an innovation in a firm's capital market risk has a significant negative impact on its capital expenditures for more than twelve quarters. The magnitude of the effect of -0.26 indicates that an increase in the firm's capital market risk of one percent is associated with a decrease of 0.26 percent in its capital expenditures.

For the group of EE, the negative influence of approximately 0.15 percent is offset twelve quarters after the innovation at least at the 10 percent level of significance. When considering instead an innovation in the firms' profitability, we find significant positive responses for both country groups. An innovation in the profitability results in a rise of 0.28 and 0.39 percent in Advanced Economies and Emerging and Developing Economies, respectively.

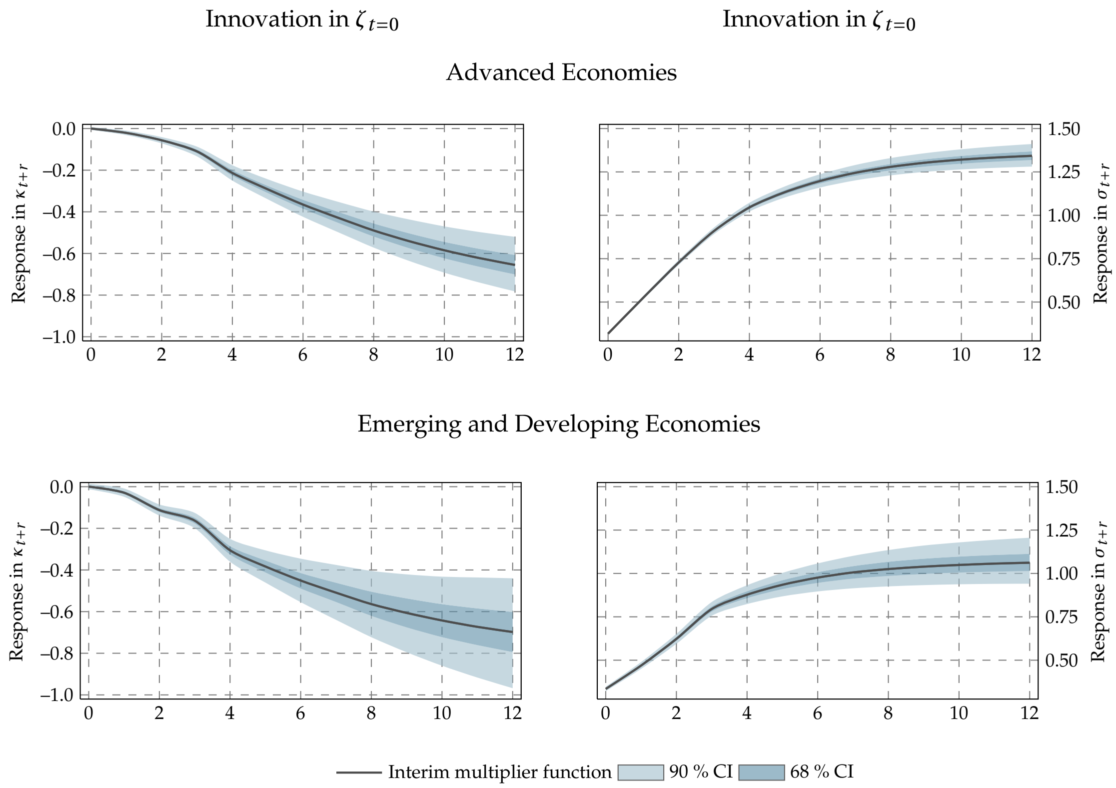
For the case of sovereign risk as an exogenous variable, when restricting our analysis on parameter estimates, we observe no immediate effect on capital expenditures for either AE or EE. For the latter, a negative impact from rising sovereign risk can be detected after two quarters, and after additional two quarters in AE. While we find some influence from sovereign risk on the profitability, the main spillover is detected in the firms' capital market risk. For both Advanced Economies and Emerging and Developing Economies, we find significant persistent and high magnitude risk spillover effects.

Having studied the parameter estimates in an isolated manner, the examination of interrelationships between exogenous and endogenous variables can be conducted by using multiplier analysis as introduced in Section 3. This allows us to examine the channels of an innovation in sovereign risk through the interrelationships among the endogenous variables. Figure 2 illustrates the interim multipliers from an innovation in sovereign risk on the firms' capital expenditures (left panel) and on their capital market risk (right panel) for Advanced Economies (upper) and Emerging and Developing Economies (lower).[15] In opposition to the inferences drawn from the estimated parameter values, we find significant negative effects for both country aggregates one period after the shock. This is due to the fact that not only direct effects but also indirect second-order effects through other endogenous variables – in particular via the firms' capital market risk – are incorporated in these estimations. For both country groups, we find that a one percent innovation in sovereign risk causes an accumulated decrease in capital expenditures between 0.6 and 0.7 percent after 12 quarters. The effects on the firms' capital market risk reveal a clear overshooting for the group of AEs and a nearly

[14]The confidence intervals are calculated from 5,000 Monte Carlo simulations.

[15]Being of minor significance for the two main aggregates, a graphical illustration for the firms' profitability can be found in Figure 3 in Appendix D.

Figure 2: Interim multipliers from an innovation in sovereign risk on firms' capital expenditures (left) and capital market risk (right)



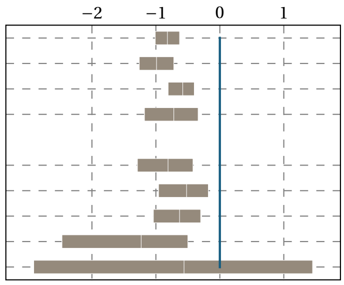
Notes: κ_t = capital expenditures, σ_t = stock return volatility and ζ_t = sovereign CDS spread. The figures show interim multiplier functions, i.e., the cumulative response of one endogenous variable at time $t + r$ after a one-standard deviation shock on an exogenous variable at time t.

one-to-one relationship for EEs. For the former, this implies that a one percent change in sovereign risk leads to a disproportional cumulative spillover effect on the firms' capital market risk of approximately 1.3 percent after 12 quarters. Considering both the direct and indirect effect together leads to the total spillover channel (TSC).

The TSC is illustrated in the left panel of Table 3, which also contains the subgroups of AE and EE and 90 percent Monte Carlo-simulated confidence bands. We observe significant values between zero and minus one for MAE, OAE, EA, EME and EMA as well as their respective main groups AE and EE. An increase in sovereign risk of one percent, leads thus to a long-term reduction of capital expenditures between zero and one percent. While we find a significant TSC value below minus one for the group of LAC, no significance is attained for the residual group of EMO. Hence, at least for the two main aggregates, no significant differences on long-term spillovers from sovereign risk on capital

Table 3: The total spillover channel (TSC) from an innovation in sovereign risk on firms' capital expenditures by country aggregate

	TSC	LCL	UCL
Advanced Economies (AE)	0.82	1.01	0.63
Major advanced (MAE)	0.99	1.26	0.72
Other advanced (OAE)	0.58	0.81	0.40
Euro area (EA)	0.72	1.18	0.34
Emerging Economies (EE)	0.81	1.29	0.42
Emerging Europe (EME)	0.52	0.96	0.18
Emerging Asia (EMA)	0.63	1.04	0.30
Latin America (LAC)	1.23	2.47	0.50
Other emerging (EMO)	0.56	2.91	1.45



Notes: LCL and UCL denote the lower and upper 10 percent confidence limit of the TSC estimate, respectively. The figure shows 90 percent confidence intervals from 5,000 Monte Carlo simulations for the respective parameter estimate.

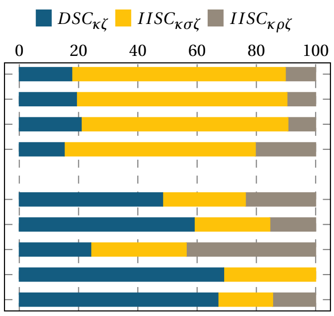
expenditures can be detected.[16]

Having inspected the total effect, another interesting question concerns the size of each subchannel's percentage share in the total spillover channel (TSC). For this, we decompose the latter into its components of DSC and $AISC$ with its individual subcomponents $IICS$.

Referring to Table 4, we find significant differences in the composition of the TSC. For the main group of Advanced Economies, more than 70 percent of the reduction in capital expenditures after an innovation in sovereign risk is attributable to the indirect channel via the firms' capital market risk ($IISC_{\kappa\sigma\zeta}$). The remainder of the indirect channel (approximately 10 percent) is caused by the

Table 4: Decomposition of the TSC into subchannels (in percent) by country aggregate

	$DSC_{\kappa\zeta}$	Indirect channels		
		$AISC_{\kappa\zeta}$	$IISC_{\kappa\sigma\zeta}$	$IISC_{\kappa\rho\zeta}$
Advanced Economies (AE)	17.69	82.31	72.06	10.24
Major advanced (MAE)	19.28	80.72	71.03	9.70
Other advanced (OAE)	20.87	79.13	69.76	9.36
Euro area (EA)	15.15	84.85	64.49	20.37
Emerging Economies (EE)	48.36	51.64	27.92	23.72
Emerging Europe (EME)	59.01	40.99	25.51	15.47
Emerging Asia (EMA)	24.11	75.89	32.22	43.68
Latin America (LAC)	68.96	31.04	31.04	0.00
Other emerging (EMO)	67.03	32.97	18.45	14.52



Notes: The direct channel (DSC) contains all non-second order effects from an increase in sovereign risk on firms' capital expenditures. The indirect spillover channels contain all second-order effects from an increase in sovereign risk on firms' capital expenditures through firms' capital market risk ($IISC_{\kappa\sigma\zeta}$) and profitability ($IISC_{\kappa\rho\zeta}$). Together, the latter two form the aggregate indirect spillover channel ($AISC_{\kappa\zeta}$).

firms' profitability ($IISC_{\kappa\rho\zeta}$). For this country aggregate, the direct channel is of

[16] There exist, however, significant differences within each main aggregate. For example, within AE, we find the TSC to be highest in MAE with -0.99 and lowest for OAE with -0.58.

minor importance and accounts for only 18 percent. For Emerging and Developing Economies, on the contrary, the direct channel accounts for almost 50 percent of the reduction in capital expenditures. As can be inferred from their respective shares of 28 and 24 percent, firms' capital market risk is of less significance while the portion of profitability is comparable to that of AEs. However, it is worth emphasizing that the estimated shares for the subgroups of MAE, OEA and EA are of similar size, while the composition within the various subgroups of EE is more heterogeneous. In particular, this becomes visible when comparing LAC and EMO with EMA. While for the first two groups the direct channel accounts for almost 70 percent of the total spillover from sovereign risk to capital expenditures, only 25 percent can be explained by this effect in the group EMA. Instead, spillover effects operate mainly through the indirect channel with return on capital and firms' capital market risk accounting for 44 and 32 percent, respectively.

5 Economic Explanation and Policy Implications

There are at least two potential more technical explanations for substantially different risk spillover channels between Advanced Economies and Emerging and Developing Economies. While for the EE an innovation in sovereign risk leads to a long-term spillover of approximately one, we detect overshooting for the group of AE. In combination with a stronger link between firms' capital market risk and capital expenditures, this indirect channel becomes comparatively more important for firms located in AEs. At the same time, the direct effect from a shock on the sovereign CDS spread on capital expenditures is weak for Advanced Economies and strong for Emerging and Developing Economies.

In an institutional context, it is also worth mentioning that the sources of risk spillovers from the sovereign to the corporates are indeed manifold. According to Augustin et al. (2016), there are six sources of spillovers which have different relevance across countries. While an increase in corporate taxes, "sovereign ceilings", a decrease in public expenditures and reduced financial aid, e.g., in the form of subsidies, are likely to have negative impacts on both Advanced Economies and Emerging and Developing Economies, other sources of spillovers might be particularly relevant for some country aggregates. To give an example, an increase in the likelihood of private firms being expropriated by a regime, which is induced by a rise in sovereign risk, can be envisaged for some Emerging and Developing Economies, while such a scenario would seem unlikely for Advanced Economies, considering our set of non-financial firms. Bank credits, on the other hand, are shown to be a possible source of risk for corporates which rely on them excessively. The latter concept is based on work from Acharya, Drechsler, and Schnabl (2014), Acharya, Eisert, Eufinger, and Hirsch (2014) and Gennaioli et al. (2012) and confirmed by Bedendo and Colla (2013) for corporates in the euro zone using firm-level data on CDS spreads. Furthermore, one might think of further sources of risk, which can be categorized into domestic and non-domestic sources of risk. An example for domestic risk could be political uncertainty on topics of high business relevance. A volatile exchange rate, on the other hand, might serve as a source for non-domestic risk.

The results support the theoretical hypothesis that different institutional frameworks in Advanced Economies and in Developing and Emerging Economies substantially influence their firms' investment behaviour. While firms domiciled in advanced countries absorb shocks to sovereign risk mainly through their individual firm risk, systemic risk seems more important in developing countries. These differences could at least partly be explained by institutional differences between the two country groups. Indeed, a lack of institutional security in combination with a strong connection between the government and the domestic corporates can rationalize the pronounced direct spillover in Emerging and Developing Economies. For Advanced Economies, on the other hand, given that our measure for a firm's capital market risk is proxied by its stock return volatility, the highly developed stock markets in this group of countries could serve as an explanation for a strong indirect channel. Furthermore, greater operational independence from the government in Advanced Economy firms can rationalize why spillover occurs with a lag through market mechanisms. Here, a strong spillover from sovereign to firms' capital market risk, and actual overshooting, in the first step followed by firms' reaction in carrying on investments leads to different importance of the direct and indirect channels.

We also find a different transmission mechanism for firms domiciled in emerging Asian countries compared to those located in other emerging markets. A possible explanation for this finding is that firms in emerging Asia are usually highly export-oriented, making non-domestic sources of risk, e.g., the global business cycle or exchange rate effects more relevant.

As a current example, illustrating the economic foundation above, consider the United Kingdom European Union membership referendum ("Brexit referendum"). Even though the evolved political uncertainty applies for both firms in the UK and for those located in other EU countries, it states a domestic source of risk. As argued above, firms in Advanced Economies adapt an increasing sovereign risk mainly through their capital market risk, and hence, the aftermaths on the firms' long-term investments are likely to occur with a lag. Nonetheless, to get a clear evidence on this, further research is needed.

6 Conclusion

This paper uses a panel vector autoregressive model extended by exogenous variables (PVARX) to describe the various effects that an increase in sovereign risk has on firms' investment activities. For this, we collect quarterly data on capital expenditures, stock return volatility and return on capital for more than 5,800 firms in the manufacturing sector of both Advanced Economies and Emerging and Developing Economies. Moreover, we obtain sovereign CDS spreads as an exogenous variable for the countries included for the period of Q1:2001 until Q4:2015.

We find the total effect of increased sovereign risk on firms' capital expenditures to have a moderate effect between 0 and -1 percent for most country aggregates. A decomposition the total elasticity into a direct and an indirect channel, however, reveals substantial differences across regions. For firms in Emerging and Developing Economies the "direct channel" from increased sovereign risk on their capital expenditures is of major importance. Firms located in an Advanced Economy, on the other hand, adopt increasing levels of sovereign risk mainly through their own capital market risk. For this group of firms, declines in investments occur predominantly through an "indirect channel".

The results bear strong economic implications on the effect of sovereign risk increases on firms' investment activities. While we generally observe significant spillover in most country aggregates, variation in the transmission mechanism between Advanced Economies and Emerging and Developing Economies might be explained by differences in the institutional frameworks, operational independence and stock exchange development.

A Auxiliary Descriptive Statistics

Table 5: Data descriptive statistics on the log-transformed variables

	Mean	SD	$Q_{0.25}$	Median	$Q_{0.75}$
Log capital expenditures	0.94	2.75	-0.83	0.95	2.83
Log stock return volatility	-3.69	0.62	-4.08	-3.74	-3.36
Log return on capital	0.04	0.17	0.01	0.05	0.10
Δ Log sovereign credit default swap	0.03	0.32	-0.14	-0.02	0.12

Notes: The table shows descriptive statistics of the log-transformed variables. To control for negative values in the return on capital, the value of 1 is added before the log-transformation takes place.

Table 6: Data descriptive statistics by region

	Capital expenditures (in 1,000 USD)		Annualised stock return volatility		Return on capital (in %)		SOV CDS spread (in basis points)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
AE	83,828	433,289	0.49	0.51	4.55	14.37	82.53	415.79
MAE	147,675	575,566	0.42	0.44	6.07	13.50	39.26	53.42
OAE	36,088	274,027	0.53	0.55	3.42	14.88	114.89	545.50
EA[1]	88,566	520,000	0.44	0.43	5.45	12.30	177.36	755.14
EE	37,082	388,523	0.50	0.54	6.88	11.92	240.14	448.51
EME	10,684	38,347	0.47	0.47	5.68	11.22	157.44	104.10
EMA	31,452	356,421	0.53	0.54	6.01	11.31	149.29	170.09
LAC	73,591	555,996	0.46	0.62	8.22	12.94	365.71	849.50
EMO	47,829	468,560	0.49	0.51	9.34	12.92	474.92	624.78
Total	63,091	414,677	0.49	0.52	5.59	13.39	152.45	437.67

Notes: The table shows descriptive statistics of the variables in levels by region. AE: Advanced Economies, MAE: Major Advanced Economies, OAE: Other Advanced Economies, EA: Euro Area, EE: Emerging and Developing Economies, EME: Emerging and Developing Europe, EMA: Emerging and Developing Asia, LAC: Latin America and the Caribbean and EMO: Other Emerging and Developing Economies. [1] Euro Area countries are contained in Major and Other Advanced Economies.

B The Weighting Procedure

As we find that some countries are inadequately represented in the dataset when comparing the economic size and the number of observations in the sample, we weight each observation to bring the dataset closer to the real composition. For this, we collect annual data on the gross domestic product (GDP) for each country and calculate the country- and year-specific weight by,

$$w_{it,c} = \sqrt{\frac{s^r_{it,c}}{s^s_{it,c}}}, \tag{11}$$

where s^r_{it} and s^s_{it} are the share of country i's GDP within the respective country aggregate c at time t and the share of observations in the sample, respectively. In doing this, we ensure that observations from under-represented countries are overweighted in the optimization process, the opposite applies for observations from countries that are over-represented in the sample.

C Specification Tests

Table 7: Durbin-Wu-Hausman endogeneity test for the sovereign CDS spread in the respective country aggregate

Country aggregate	Endogenous variable		
	κ_t	σ_t	ρ_t
Advanced Economies	0.000 (0.9946)	0.078 (0.7807)	0.066 (0.7976)
Major Advanced Economies	0.003 (0.9539)	0.179 (0.6720)	0.153 (0.6961)
Other Advanced Economies	0.027 (0.8703)	0.000 (0.9897)	0.145 (0.7035)
Euro Area	0.264 (0.6076)	0.011 (0.9184)	0.095 (0.7578)
Emerging and Developing Economies	0.542 (0.4618)	0.005 (0.9430)	0.004 (0.9476)
Emerging and Developing Europe	0.155 (0.6941)	0.010 (0.9206)	0.189 (0.6640)
Emerging and Developing Asia	1.622 (0.2028)	0.002 (0.9625)	0.004 (0.9474)
Latin America and the Caribbean	0.151 (0.6973)	0.086 (0.7695)	0.438 (0.5079)
Other Emerging and Developing Economies	0.597 (0.4396)	0.043 (0.8351)	0.043 (0.8356)

Note: The table shows the results of a Durbin-Wu-Hausman endogeneity test with the null hypothesis that the suspected endogenous regressor can be considered exogenous. In this case, the test statistic is distributed as chi-squared with one degree of freedom. The figures show the test statistic and the respective p-value in parentheses. κ_t = capital expenditures, σ_t = stock return volatility and ρ_t = return on capital.

Table 8: Pesaran test for stationarity of the panel series

	None	Constant	Trend
Capital expenditures (κ_t)	-1.85 (0.01)	-2.23 (0.01)	-2.68 (0.01)
Stock return volatility (σ_t)	-3.30 (0.01)	-2.59 (0.01)	-2.92 (0.01)
Return on capital (ρ_t)	-2.87 (0.01)	-2.66 (0.01)	-3.40 (0.01)

Note: The test assumes non-stationarity of the panel series under the null hypothesis considering a constant, a trend or none of them in the process. Entries show the test statistics and the respective p-values in parentheses.

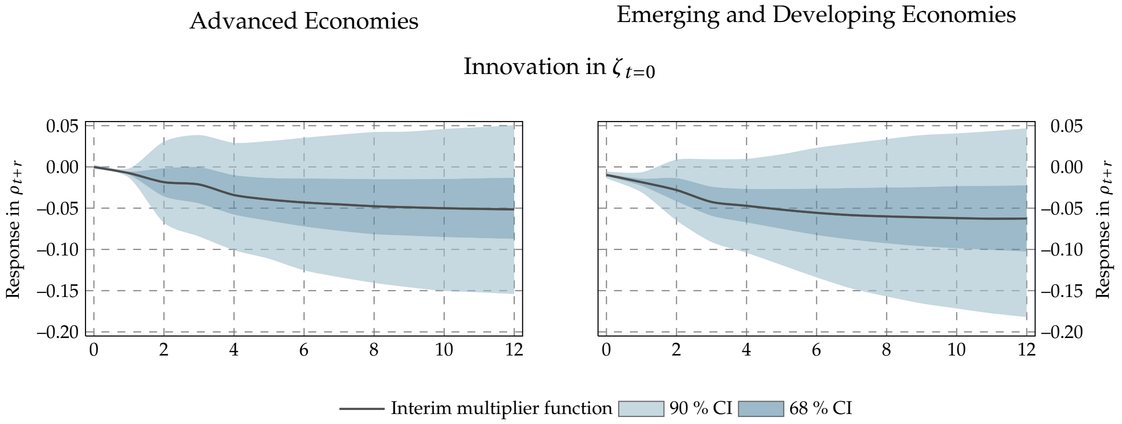
Table 9: KPSS test for stationarity of the CDS spread series

Country	Level	1st. Diff.	Country	Level	1st. Diff.	Country	Level	1st. Diff.	Country	Level	1st. Diff.
Argentina	0.19 (0.10)	0.44 (0.06)	France	0.61 (0.02)	0.16 (0.10)	Malta	0.68 (0.01)	0.17 (0.10)	Slovakia	0.12 (0.10)	0.13 (0.10)
Australia	0.84 (0.01)	0.15 (0.10)	Germany	0.53 (0.04)	0.15 (0.10)	Mexico	0.67 (0.02)	0.10 (0.10)	Slovenia	0.56 (0.03)	0.14 (0.10)
Austria	0.16 (0.10)	0.23 (0.10)	Ghana	0.29 (0.10)	0.13 (0.10)	Morocco	0.61 (0.02)	0.12 (0.10)	South Africa	0.45 (0.06)	0.08 (0.10)
Bahrain	0.60 (0.02)	0.09 (0.10)	Greece	0.62 (0.02)	0.20 (0.10)	Netherlands	0.61 (0.02)	0.11 (0.10)	South Korea	0.62 (0.02)	0.12 (0.10)
Belgium	0.28 (0.10)	0.16 (0.10)	Hong Kong	0.15 (0.10)	0.09 (0.10)	New Zealand	0.19 (0.10)	0.13 (0.10)	Spain	0.76 (0.01)	0.14 (0.10)
Brazil	0.86 (0.01)	0.15 (0.10)	Hungary	0.43 (0.06)	0.17 (0.10)	Nigeria	0.36 (0.09)	0.12 (0.10)	Sri Lanka	0.72 (0.01)	0.10 (0.10)
Bulgaria	0.39 (0.08)	0.14 (0.10)	Iceland	0.40 (0.08)	0.12 (0.10)	Norway	0.73 (0.01)	0.15 (0.10)	Sweden	0.17 (0.10)	0.16 (0.10)
Canada	0.73 (0.01)	0.07 (0.10)	India	0.93 (0.01)	0.16 (0.10)	Oman	0.18 (0.10)	0.13 (0.10)	Switzerland	0.79 (0.01)	0.16 (0.10)
Chile	0.59 (0.02)	0.12 (0.10)	Indonesia	0.56 (0.03)	0.24 (0.10)	Pakistan	0.81 (0.01)	0.12 (0.10)	Taiwan	0.59 (0.02)	0.19 (0.10)
China	0.51 (0.04)	0.07 (0.10)	Ireland	0.29 (0.10)	0.17 (0.10)	Peru	0.58 (0.02)	0.12 (0.10)	Thailand	0.68 (0.02)	0.12 (0.10)
Colombia	0.39 (0.08)	0.20 (0.10)	Israel	0.45 (0.06)	0.11 (0.10)	Philippines	0.50 (0.04)	0.09 (0.10)	Trinidad & Tobago	0.70 (0.01)	0.11 (0.10)
Costa Rica	0.41 (0.07)	0.10 (0.10)	Italy	0.30 (0.10)	0.17 (0.10)	Poland	0.88 (0.01)	0.25 (0.10)	Tunisia	0.56 (0.03)	0.11 (0.10)
Croatia	0.48 (0.05)	0.15 (0.10)	Jamaica	0.14 (0.10)	0.15 (0.10)	Portugal	0.36 (0.09)	0.22 (0.10)	Turkey	0.23 (0.10)	0.08 (0.10)
Cyprus	0.16 (0.10)	0.09 (0.10)	Japan	0.38 (0.09)	0.29 (0.10)	Qatar	0.95 (0.01)	0.05 (0.10)	Ukraine	0.49 (0.04)	0.17 (0.10)
Czech Republic	0.15 (0.10)	0.11 (0.10)	Jordan	0.28 (0.10)	0.18 (0.10)	Romania	0.60 (0.02)	0.17 (0.10)	Utd. Arab Emirates	0.76 (0.01)	0.21 (0.10)
Denmark	0.10 (0.10)	0.09 (0.10)	Kazakhstan	0.57 (0.03)	0.08 (0.10)	Russia	0.40 (0.08)	0.27 (0.10)	Utd. Kingdom	0.21 (0.10)	0.19 (0.10)
Egypt	0.46 (0.05)	0.12 (0.10)	Latvia	0.46 (0.05)	0.13 (0.10)	Saudi Arabia	0.10 (0.10)	0.09 (0.10)	United States	0.72 (0.01)	0.09 (0.10)
Estonia	0.34 (0.10)	0.06 (0.10)	Lithuania	0.43 (0.06)	0.09 (0.10)	Serbia	0.20 (0.10)	0.10 (0.10)	Venezuela	0.69 (0.01)	0.13 (0.10)
Finland	0.49 (0.04)	0.05 (0.10)	Malaysia	0.72 (0.01)	0.16 (0.10)	Singapore	0.61 (0.02)	0.22 (0.10)	Vietnam	0.58 (0.02)	0.14 (0.10)

Notes: The test statistic refers to a KPSS test considering level stationarity under the null hypothesis. The respective p-value (restricted to the interval of 0.01 and 0.10) is displayed in parentheses.

D Supplemental Estimates

Figure 3: Interim multipliers from an innovation in sovereign risk on firms' profitability



Notes: ρ_t = return on capital and ζ_t = sovereign CDS spread. The figures show interim multiplier functions, i.e., the cumulative response of one endogenous variable at time $t + r$ after a one-standard deviation shock on an exogenous variable at time t.

Table 10: Parameter estimates by country aggregate (1)

	AE			MAE			OAE		
	κ_t	σ_t	ρ_t	κ_t	σ_t	ρ_t	κ_t	σ_t	ρ_t
Q_1	-0.130^{***} (0.002)	-0.024^{***} (0.002)		-0.147^{***} (0.003)	-0.027^{***} (0.003)		-0.113^{***} (0.002)	-0.021^{***} (0.003)	0.005^{***} (0.001)
Q_2			0.006^{***} (0.002)		-0.013^{***} (0.001)	0.005^{***} (0.002)	0.028^{***} (0.003)		0.008^{***} (0.003)
Q_3	0.027^{***} (0.001)		0.007^{***} (0.002)	0.026^{***} (0.001)		0.006^{***} (0.002)	0.042^{***} (0.001)	-0.018 (0.021)	0.009^{***} (0.003)
Q_4	0.149^{***} (0.002)			0.164^{***} (0.002)			0.155^{***} (0.003)		-0.006^{***} (0.002)
κ_{t-1}	0.399^{***} (0.011)	-0.013 (0.010)		0.388^{***} (0.014)	-0.014 (0.010)	0.003 (0.004)	0.423^{***} (0.017)	-0.015 (0.022)	
κ_{t-2}	0.113^{***} (0.010)			0.145^{***} (0.012)			0.045^{***} (0.015)		
κ_{t-3}	0.038^{***} (0.010)			0.031^{***} (0.012)			0.066^{***} (0.018)		
κ_{t-4}	0.128^{***} (0.009)		-0.005 (0.005)	0.145^{***} (0.011)		-0.007 (0.006)	0.075^{***} (0.014)	0.006 (0.006)	
σ_{t-1}	-0.066^{***} (0.011)	0.318^{***} (0.010)		-0.056^{***} (0.012)	0.314^{***} (0.011)	-0.005 (0.008)	-0.094^{***} (0.022)	0.330^{***} (0.024)	
σ_{t-2}	-0.036^{***} (0.013)	0.102^{***} (0.010)		-0.049^{***} (0.014)	0.101^{***} (0.011)			0.119^{***} (0.021)	
σ_{t-3}	-0.041^{***} (0.011)	0.094^{***} (0.005)		-0.040^{***} (0.012)	0.098^{***} (0.006)			0.069^{***} (0.008)	
σ_{t-4}		0.018^{**} (0.007)			0.016^{*} (0.008)	0.007 (0.007)	-0.045^{*} (0.026)	0.035^{**} (0.016)	-0.008 (0.012)
ρ_{t-1}	0.253^{***} (0.053)	-0.082^{***} (0.010)	0.322^{***} (0.020)	0.234^{***} (0.069)	-0.068^{***} (0.011)	0.281^{***} (0.027)	0.345^{***} (0.071)	-0.097^{***} (0.023)	0.403^{***} (0.021)
ρ_{t-2}	0.151^{***} (0.052)		0.086^{***} (0.017)	0.193^{***} (0.070)		0.069^{***} (0.023)		-0.044^{***} (0.009)	0.094^{***} (0.021)
ρ_{t-3}									0.019 (0.021)
ρ_{t-4}	0.052 (0.042)	-0.049^{***} (0.019)	0.141^{***} (0.006)	0.082 (0.054)	-0.060^{**} (0.025)	0.152^{***} (0.006)			0.107^{***} (0.012)
ζ_{t-0}		0.318^{***} (0.006)			0.322^{***} (0.006)			0.316^{***} (0.012)	-0.009^{***} (0.004)
ζ_{t-1}		0.107^{***} (0.003)	-0.007^{***} (0.003)		0.139^{***} (0.004)	-0.006 (0.004)			
ζ_{t-2}		0.103^{***} (0.002)	-0.008 (0.045)		0.111^{***} (0.003)	-0.007 (0.063)		0.086^{***} (0.004)	-0.011 (0.030)
ζ_{t-3}		0.065^{***} (0.002)			0.076^{***} (0.003)		-0.047^{***} (0.002)	0.060^{***} (0.003)	
ζ_{t-4}	-0.047^{***} (0.002)	0.031^{***} (0.002)	-0.009 (0.027)	-0.055^{***} (0.002)	0.025^{***} (0.002)	-0.012 (0.040)		0.019^{***} (0.003)	

Notes: κ_t = capital expenditures, σ_t = stock return volatility, ρ_t = return on capital and ζ_t = sovereign CDS spread. ***, ** and * denote significance at the 1, 5 and 10 percent levels, respectively. Standard errors in parentheses. Blank fields indicate that these parameters can be excluded from the model without loss of information in the sense of the BIC. AE: Advanced Economies, MAE: Major Advanced Economies, OAE: Other Advanced Economies.

Table 11: Parameter estimates by country aggregate (2)

	EA			EE			EME		
	κ_t	σ_t	ρ_t	κ_t	σ_t	ρ_t	κ_t	σ_t	ρ_t
Q_1	-0.151^{***} (0.002)	-0.028^{***} (0.003)		-0.210^{***} (0.001)		0.004^{***} (0.001)	-0.241^{***} (0.002)		
Q_2	0.024^{***} (0.003)		0.004^{*} (0.002)		0.039^{***} (0.001)	0.007^{**} (0.003)	0.053^{***} (0.006)	0.078^{***} (0.002)	0.011 (0.008)
Q_3	0.053^{***} (0.001)	-0.032 (0.027)	0.012^{***} (0.003)			0.007^{***} (0.002)	0.053^{***} (0.002)		0.013^{*} (0.007)
Q_4	0.179^{***} (0.003)	-0.036^{***} (0.002)		0.220^{***} (0.001)	0.019^{***} (0.002)	-0.009^{***} (0.001)	0.249^{***} (0.004)	0.025^{***} (0.006)	-0.022^{***} (0.003)
κ_{t-1}	0.387^{***} (0.022)			0.312^{***} (0.010)	-0.014 (0.023)		0.311^{***} (0.019)	-0.010 (0.048)	-0.003 (0.006)
κ_{t-2}	0.074^{***} (0.017)		-0.003 (0.007)	0.133^{***} (0.010)			0.107^{***} (0.019)		
κ_{t-3}	0.064^{***} (0.020)			0.081^{***} (0.009)	-0.009 (0.007)	-0.001 (0.003)	0.087^{***} (0.017)		
κ_{t-4}	0.125^{***} (0.017)		-0.004 (0.009)	0.108^{***} (0.008)		-0.002 (0.017)	0.072^{***} (0.015)		
σ_{t-1}	-0.062^{***} (0.020)	0.332^{***} (0.021)	-0.005 (0.013)	-0.076^{***} (0.019)	0.282^{***} (0.024)	-0.003 (0.024)	-0.081^{**} (0.039)	0.301^{***} (0.056)	
σ_{t-2}		0.137^{***} (0.019)			0.106^{***} (0.021)			0.131^{**} (0.053)	
σ_{t-3}		0.068^{***} (0.009)			0.071^{***} (0.007)				
σ_{t-4}	-0.068^{***} (0.023)	0.021 (0.015)			0.017 (0.021)				
ρ_{t-1}	0.504^{***} (0.102)	-0.184^{***} (0.020)	0.267^{***} (0.031)	0.396^{***} (0.077)	-0.084^{***} (0.025)	0.180^{***} (0.037)			0.149^{**} (0.061)
ρ_{t-2}	0.264^{***} (0.086)		0.166^{***} (0.037)	0.355^{***} (0.079)		0.070^{**} (0.035)	0.231 (0.160)		0.158^{***} (0.055)
ρ_{t-3}				0.236^{**} (0.094)		0.074^{**} (0.032)	0.409^{**} (0.163)		0.046 (0.053)
ρ_{t-4}		-0.093^{***} (0.035)	0.204^{***} (0.011)	0.120 (0.083)		0.168^{***} (0.015)		-0.113^{*} (0.063)	0.231^{***} (0.024)
ζ_{t-0}		0.354^{***} (0.010)	-0.008^{*} (0.005)		0.335^{***} (0.016)	-0.010^{***} (0.004)		0.286^{***} (0.020)	
ζ_{t-1}		0.022^{***} (0.005)			0.039^{***} (0.004)	-0.006^{*} (0.004)			
ζ_{t-2}		0.069^{***} (0.003)	-0.009 (0.038)	-0.057^{***} (0.001)	0.079^{***} (0.001)	-0.006 (0.029)		0.047^{***} (0.004)	-0.021 (0.044)
ζ_{t-3}	-0.040^{***} (0.002)	0.080^{***} (0.002)			0.088^{***} (0.001)	-0.010 (0.025)		0.052^{***} (0.005)	
ζ_{t-4}			-0.006 (0.022)	-0.088^{***} (0.001)			-0.128^{***} (0.002)		

Notes: κ_t = capital expenditures, σ_t = stock return volatility, ρ_t = return on capital and ζ_t = sovereign CDS spread. ***, ** and * denote significance at the 1, 5 and 10 percent levels, respectively. Standard errors in parentheses. Blank fields indicate that these parameters can be excluded from the model without loss of information in the sense of the BIC. EA: Euro Area, EE: Emerging and Developing Economies, EME: Emerging and Developing Europe.

Table 12: Parameter estimates by country aggregate (3)

	EMA			LAC			EMO		
	κ_t	σ_t	ρ_t	κ_t	σ_t	ρ_t	κ_t	σ_t	ρ_t
Q_1	-0.223^{***} (0.001)	-0.014^{***} (0.004)	0.007^{***} (0.001)	-0.212^{***} (0.001)	0.034^{***} (0.004)		-0.162^{***} (0.001)		0.004^{***} (0.001)
Q_2	-0.040^{***} (0.003)	0.029^{***} (0.001)	0.009^{*} (0.005)		0.074^{***} (0.002)	0.007^{*} (0.004)			0.005 (0.006)
Q_3		-0.017 (0.030)	0.008^{**} (0.004)			0.010^{**} (0.004)			
Q_4	0.251^{***} (0.002)		-0.012^{***} (0.002)	0.172^{***} (0.002)	0.047^{***} (0.004)		0.188^{***} (0.002)		
κ_{t-1}	0.309^{***} (0.013)	-0.007 (0.034)		0.322^{***} (0.028)			0.300^{***} (0.026)	-0.050 (0.052)	
κ_{t-2}	0.146^{***} (0.013)			0.170^{***} (0.021)			0.113^{***} (0.037)	0.024 (0.058)	-0.004 (0.017)
κ_{t-3}	0.076^{***} (0.012)			0.101^{***} (0.026)	-0.027 (0.017)	-0.004 (0.009)	0.055^{**} (0.024)		
κ_{t-4}	0.122^{***} (0.011)	-0.007^{***} (0.003)	-0.003 (0.016)	0.073^{***} (0.022)			0.083^{***} (0.020)		-0.003 (0.077)
σ_{t-1}	-0.076^{***} (0.025)	0.361^{***} (0.032)		-0.111^{***} (0.025)	0.238^{***} (0.060)	-0.005 (0.025)		0.204^{***} (0.055)	-0.004 (0.060)
σ_{t-2}		0.143^{***} (0.031)		0.059^{**} (0.025)	0.129^{***} (0.040)				
σ_{t-3}		0.064^{***} (0.011)			0.034^{**} (0.017)		-0.046 (0.046)	0.114^{***} (0.015)	
σ_{t-4}		0.044^{***} (0.016)		-0.043^{*} (0.023)	0.039 (0.027)	-0.006 (0.029)		-0.090 (0.056)	
ρ_{t-1}	0.512^{***} (0.120)	-0.076^{**} (0.037)	0.165^{***} (0.028)	0.430^{**} (0.176)	-0.217^{***} (0.058)	0.226^{**} (0.096)	0.278 (0.239)		0.343 (0.233)
ρ_{t-2}	0.446^{***} (0.129)		0.073^{***} (0.027)	0.269 (0.176)		0.116 (0.091)	0.369^{**} (0.181)	0.265^{***} (0.015)	-0.144 (0.151)
ρ_{t-3}	0.168 (0.161)		0.064^{**} (0.030)			0.075 (0.093)	0.224 (0.146)		0.183 (0.191)
ρ_{t-4}			0.121^{***} (0.013)	0.218 (0.157)		0.176^{***} (0.031)	0.277^{*} (0.159)		0.171^{*} (0.091)
ζ_{t-0}		0.237^{***} (0.011)	-0.020^{***} (0.004)		0.396^{***} (0.028)			0.393^{***} (0.085)	
ζ_{t-1}			-0.009^{**} (0.004)	-0.083^{***} (0.012)	0.061^{***} (0.012)		-0.111^{***} (0.009)	0.133^{***} (0.008)	
ζ_{t-2}		0.067^{***} (0.002)	-0.006 (0.045)	-0.116^{***} (0.002)				0.090^{***} (0.002)	-0.012 (0.052)
ζ_{t-3}		0.102^{***} (0.002)	-0.014 (0.031)		0.133^{***} (0.002)			0.044^{***} (0.002)	-0.007 (0.065)
ζ_{t-4}	-0.053^{***} (0.001)	-0.047^{***} (0.002)		-0.083^{***} (0.002)			-0.104^{***} (0.001)	0.158^{***} (0.002)	

Notes: κ_t = capital expenditures, σ_t = stock return volatility, ρ_t = return on capital and ζ_t = sovereign CDS spread. ***, ** and * denote significance at the 1, 5 and 10 percent levels, respectively. Standard errors in parentheses. Blank fields indicate that these parameters can be excluded from the model without loss of information in the sense of the BIC. EMA: Emerging and Developing Asia, LAC: Latin America and the Caribbean and EMO: Other Emerging and Developing Economies.

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