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ASYMMETRIC EXCHANGE-RATE EXPOSURE IN BRIC COUNTRIES

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ASYMMETRIC EXCHANGE-RATE EXPOSURE IN BRIC COUNTRIES.

This work contributes to the literature on exchange-rate exposure in emerging markets. We studied datasets of exchange-listed companies from four BRIC countries and discovered that exchange rate movements in the US dollar and euro affected more than 10% of these firms between 2003 and 2013. The most interesting finding of this research is that stock returns behaved differently with increasing and decreasing currency rates. For capturing the asymmetric relationship of stock and exchange rate movements, we applied a nonlinear dynamic model, which significantly improved our results compared to the empirical findings of simple versions of the Adler Dumas (1984) and Jorion (1990) models.

We studied determinants of exposure to positive and negative currency movements separately. Although significant determinants in both cases were mostly similar, their weights were different. For example, the ratio of export sales was asymmetrically correlated to exchange rate exposures for all countries except Russia. For a better understanding of the sources of asymmetry in exchange rate exposure, we separately studied the positive and negative coefficients of currency exposure from the non-asymmetric model. This was never done before and natural in a way that determinants should affect positive and negative currency exposures differently. We found evidence of the contrasting impact of export sales and foreign debt in both cases.

Keywords: exchange rate exposure, currency markets, stock returns, asymmetric model, emerging markets.

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1. Introduction

During the past several decades direct investments in emerging countries have increased substantially. When valuing such investments, one cannot consider only the country risk premium since it does not reflect a wide range of uncertainty in emerging markets. Currency risk is another important source of uncertainty that affects the financial policy and cash flows of firms, as suggested by Shapiro (1974). Indeed, the volatility of cash flows dramatically increased during crisis periods in developing countries, when falling export sales coincided with rising foreign interest costs.

Adler and Dumas (1984) mentioned that exchange-rate risk exposure was typical not only for multinational firms but also for companies with low levels of involvement in foreign transactions. The authors developed a simple model for capturing the currency risk exposure for a given firm using a covariance between stock and currency returns. Since then, many researches have tried to improve this model by applying different technics.

According to pricing theory, Jorion (1990) added market risk as a factor in the model. But could only find significant currency exposure for a small portion of American companies. Similar disappointing results were obtained by Bodnar and Gentry (1993), Amihud (1994), Campa and Goldberg (1995), and Griffin and Stulz (2001).

Adler and Dumas (1984) and Bodnar et al. (2002) came to the theoretical conclusion that currency movements should be very important for a firm's value. Empirical finding contradicted such suggestions. Bartram and Bodnar (2007) called this effect the "exchange-rate puzzle". Later on, Bartram et al. (2010) discovered that the exchange-rate puzzle could be explained by extensive use of operational and financial hedging, which accounts for a 70% decrease in currency risk exposure. On the other hand, Francis et al. (2008) suggested that the source of the "exchange-rate puzzle" was the misspecification and theoretical drawbacks of applied models.

Contradicting results forced researches to modify models for capturing exchange-rate exposure. Bartov and Bodnar (1994) discovered that currency movements could predict stock returns. This finding was embedded in the models of Chow et al. (1997) and Bodnar and Wong (2003). They considered long-term intervals for estimation of currency risk exposure and obtained much better results. Booth and Rotenberg (1990) and Allayanis (1999) empirically confirmed that currency risk exposure changed over time and suggested that only dynamic models should be applied. Doidge et al. (2006) and Aggarwal and Harper (2010) included currency risk as an additional factor in the well-known three factor model of Fama and French (1993). The four-factor model of Aggarwal and Harper (2010) allowed for the detecting of exchange rate exposure even for domestic American firms. A

slightly different way of mimicking a portfolio's construction for the multifactor model was suggested by Kolari, Moorman, and Sorescu (2008). Authors assigned firms to portfolios according to the rate of currency exposure. Bartram (2004), Odegaard and Priestley (2007), and others considered the non-linear relation between stock returns and currency movements. Aysun and Guldi (2011) applied a non-parametrical method for estimating the arbitrary functional form of currency-risk exposure. Du and Hu (2012) included exchange rate volatility in the regression equation. Chaieb and Mazzotta (2013) considered a more sophisticated model where currency exposure varied over time according to the specific and exogenous variables of several firms.

Koutmos and Martin (2003) and Muller and Verschoor (2006) explained the low percentage of currency-exposed firms by the asymmetric influence of exchange rate movements on cash flows. Koutmos and Martin (2003) mentioned three reasons of possible asymmetry in currency exposure: the price-to-market effect, lagging hysteresis behavior, and asymmetric hedging behavior. Muller and Verschoor (2006) also advocated the different influence of rising and decreasing currency rates for stock returns. According to their empirical results, almost 30% of American firms were asymmetrically exposed to currency movements.

Decreasing currency risk exposure could be an important risk-management task, especially for firms in emerging markets. Implementing appropriate hedging procedures requires knowledge of the determinants of currency risk exposure, which have been studied by many researchers. Allayannis and Ihrig (2001), Dominguez and Tesar, (2006), and He and Ng (1998) were among those who tried to find evidence on which factors played a more important role in a company's exposure to currency risk. Export sales, foreign debt, size, growth, financial leverage, operational margin, and other factors were considered in the literature.

Empirical tests of currency risk exposure in emerging markets were also contradictory and dependent on the choice of a model. Vassalou (2000) studied 10 emerging markets and did not find significant exchange risk exposure. Carrieri and Majerbi (2006) considered real currency returns and obtained much better results. They explained the high percentage of currency-exposed companies by an incomplete diversification of currency risk in emerging markets. Muller and Verschoor (2006) and Junior (2011) confirmed that firms from developing countries are more vulnerable to currency risk than American companies. Saleem and Vaihekoski (2010) applied a dynamic model and agreed with other authors that currency movements affect stock returns in emerging markets, including Russian.

The rest of this paper is organized as follows. In Section 2 we consider several models for the estimation of currency risk exposure in BRIC countries, including the dynamic asymmetric model,

along with versions of Adler and Dumas (1984) and Jorion (1990) models. In Sections 3 and 4 we describe our dataset and obtain estimators of currency exposure. We also test the asymmetry of coefficients in the model. In Section 5, by checking for different kinds of asymmetry, we study not only the determinants of exposure to positive and negative currency movements separately, but positive and negative coefficients of currency exposure from the non-asymmetric model. In closing, we make several important conclusions.

2. Modelling exchange rate exposure.

First of all, we follow Jorion (1990) and consider a two-factor model, allowing for changing of risk exposures over time. For the i -th stock and each time interval $(T - 1, T)$, we suggest a time-series regression of the form:

$$r_{i,t} = \beta_{0,i} + \beta_{1,i,T}r_{x,t} + \beta_{2,i,T}r_{m,t} + \varepsilon_{i,t}, \text{ where} \quad (1)$$

$r_{i,t}$ is a stock return for the period of $(t - 1, t) \in (T - 1, T)$;

$r_{x,t}$ is a currency return for the period of $(t - 1, t)$;

$\beta_{1,i,T}$ is a coefficient of currency risk exposure;

$r_{m,t}$ is the market portfolio return for a period of $(t - 1, t) \in (T - 1, T)$;

$\beta_{2,i,T}$ is a coefficient of the market risk exposure;

$\varepsilon_{i,t}$ are iid error terms.

The main difference between model (1) and the model of Jorion (1990) is that coefficients of exposure are changing with T .

According to Shapiro (1977), the coefficient of market exposure could partially account for currency risk exposure. We did not find significant correlation between market portfolio returns and currency returns. But we think that both market risk and currency risk could decrease the significance of each other's beta-coefficients. Moreover since the local version of CAPM does not provide reliable empirical evidence for emerging markets, we assume that model (1) might be entirely inappropriate for capturing risk exposure.

That is why we considered another specification of a model that is similar to Adler and Dumas's (1984) version. In other words, we consider:

$$r_{i,t} = \beta_{0,i} + \beta_{1,i,T}r_{x,t} + \varepsilon_{i,t}. \quad (2)$$

Finally, we used a third model that accounts for the asymmetry of currency risk exposure, as in Koutmos and Martin (2003). Indeed, increasing or decreasing the exchange rate could differently affect a firm's value. For example, net export companies, with large export sales, small import costs, and

little foreign interest payments, could be influenced more by domestic currency appreciation during periods of stable economic growth. This was the case of Russian steel producers during 2004-2005. Profit margins of export-oriented companies decreased significantly when steel prices stabilized and the dollar-ruble exchange rate fell sharply. The value of these firms also decreased during periods of dollar appreciation because of an outflow of foreign investors.

Following Koutmos and Martin (2003), we divide a currency return $r_{x,t}$ into two components: $r_{x,t}^{pos} = r_{x,t}I(r_{x,t} \geq 0)$ and $r_{x,t}^{neg} = r_{x,t}I(r_{x,t} < 0)$, which correspond to positive and negative exchange rate movements.

We can then write the following regression:

$$r_{i,t} = \beta_{0,i,T} + \beta_{1,i,T}^+ r_{x,t}^{pos} + \beta_{1,i,T}^- r_{x,t}^{neg} + \varepsilon_{i,t}, \text{ where} \quad (3)$$

$\beta_{1,i,T}^+$ and $\beta_{1,i,T}^-$ are coefficients of positive and negative exchange rate exposure.

We run regressions (1), (2), and (3) and compare empirical results.

3. Data

Because of lack of empirical evidence on currency risk exposure in emerging markets, we decided to conduct our study on exchange-traded firms in BRIC markets. Company data was obtained from Standard&Poor's Capital IQ. We also took information on exchange rates and domestic exchange indexes from Bloomberg and some macro-variables from IHS Global Insight.

We did not consider companies with annual sales below USD 3,000,000 and a monthly average trade volume below 1% of market capitalization. Hence, very small and illiquid firms were excluded from our empirical analysis. After adjustments, our dataset consisted of 108 Russian, 94 Brazilian, 1462 Chinese, and 987 Indian firms. We studied observations on a 10-year period from January 2003 to April 2013. Because of restrictions on conversion of the yuan (or renminbi), which was pegged to the US dollar during 2003-2005, we excluded data on Chinese firms for that period.

According to Chow, Lee, and Solt (1997), an appropriate choice of intervals between observations plays a very important role for estimating short-term and long-term exposure to exchange rate risk. That is why we considered 1-, 4-, and 12-week returns for stocks, currencies, and indexes. The dataset was picked from different industries, including energy resources, mining, retail, and others.

4. Estimation of exchange rate risk exposure

We studied exposure to US dollar and euro movements in BRIC countries separately. We run time series regressions (1), (2), and (3) in STATA. Since from April 2010 to April 2013 the risk-free rates in the considered emerging markets exceeded market indexes, we did not subtract them from

stocks and market returns. We used 1-year periods ($T - 1, T$) for regressions on weekly and monthly returns and the entire 10-year period for regressions on quarter returns. It is common practice to consider a regression model with $R^2 > 0.5$ to be reasonably well fit to the data, which is why we omitted currency exposures from regressions with a smaller determination.

As expected, domestic index returns in model (1) decreased the significance of exchange-rate exposure (see Table 1).

Table 1. Ratio of exposed firms, $r_{i,t} = \beta_{0,i} + \beta_{1,i,T} \cdot r_{x,t} + \beta_{2,i,T} \cdot r_{m,t} + \varepsilon_{i,t}$.

	Ratio of regressions with $R^2 > 0.5$	Ratio of $\beta_{1,i,T}$ significant at 5% level (US Dollar)	Ratio of $\beta_{1,i,T}$ significant at 5% level (Euro)
Weekly returns			
Brazil	93.7%	1.94%	1.21%
Russia	90.1%	1.96%	1.93%
India	95.9%	2.21%	0.35%
China	96.7%	2.53%	0.08%
Monthly returns			
Brazil	94.1%	2.25%	2.88%
Russia	93.3%	2.36%	1.05%
India	93.6%	1.16%	1.67%
China	90.7%	3.33%	2.22%
Quarterly returns			
Brazil	88.8%	1.56%	0.91%
Russia	96.9%	1.96%	1.41%
India	92.2%	2.00%	2.43%
China	87.6%	3.37%	2.01%

We can conclude that there was a high correlation between stock returns and market returns, but currency movements affect the values of only a small percentage of firms, according to model (1). The number of exposed stock returns substantially increases while testing model (2) (see Table 2.1).

Table 2.1. Ratio of exposed firms, $r_{i,t} = \beta_{0,i} + \beta_{1,i,T} \cdot r_{x,t} + \varepsilon_{i,t}$.

	Ratio of regressions with $R^2 > 0.5$	Ratio of $\beta_{1,i,T}$ significant at 5% level (US Dollar)	Ratio of $\beta_{1,i,T}$ significant at 5% level (Euro)
Weekly returns			
Brazil	9.92%	9.32%	8.85%
Russia	18.24%	16.49%	14.11%
India	11.64%	10.43%	10.57%
China	13.54%	12.44%	10.18%
Monthly returns			
Brazil	8.25%	7.24%	6.63%

Russia	17.38%	15.38%	14.30%
India	12.29%	10.73%	11.69%
China	10.80%	9.62%	7.46%
Quarterly returns			
Brazil	7.39%	5.99%	5.85%
Russia	17.63%	16.20%	13.47%
India	11.81%	10.48%	10.49%
China	10.03%	9.46%	8.01%

On average, from 6% to 16% of firms were exposed to currency risk in BRIC countries. For Russia the fraction of significantly affected firms was the highest at about 15%. Surprisingly, some Chinese companies were also exposed to exchange rate fluctuations after 2005, despite currency restrictions. A slightly greater number of exposed firms were discovered on shorter weekly and monthly time intervals. This fact contradicts the hypothesis of long-term effects of exchange-rate influence.

The US dollar influenced stock returns in emerging markets more severely than did the euro, except for China (see Table 2.2).

Table 2.2 Average exposure, $r_{i,t} = \beta_{0,i} + \beta_{1,i,T} \cdot r_{x,t} + \varepsilon_{i,t}$.

Weekly returns	Average $\beta_{1,i,T}$ significant at 5% level (US Dollar)	Average $\beta_{1,i,T}$ significant at 5% level (Euro)
Brazil	-0.73	-0.43
Russia	-0.91	-0.46
India	-0.95	-0.11
China	0.12	0.24

Russian, Brazilian, and Indian stock returns decreased with the rising US dollar and euro. This fact could be explained by a correlation of depreciating domestic currencies and an outflow of foreign investments. In China, on the contrary, depreciation of the yuan could be linked to positive shifts in the competitiveness of export companies, which usually increase stock prices in the market. Small values of currency exposure in China were connected to ongoing restrictions on the convertibility of the yuan and interventions of the People's Bank of China.

Positive and negative currency movements could affect net export and net import firms differently in asymmetric manner. The time series model (3), developed by Koutmos and Martin (2003), allows us to test the hypothesis about asymmetric exchange rate exposure.

Table 3. Ratio of asymmetrically exposed firms, $r_{i,t} = \beta_{0,i,T} + \beta_{1,i,T}^+ r_{x,t}^{pos} + \beta_{1,i,T}^- r_{x,t}^{neg} + \varepsilon_{i,t}$.

	Ratio of regressions with $R^2 > 0.5$	Ratio of $\beta_{1,i,T}^+$ significant at 5% level (US Dollar)	Ratio of $\beta_{1,i,T}^+$ significant at 5% level (Euro)	Ratio of $\beta_{1,i,T}^-$ significant at 5% level (US Dollar)	Ratio of $\beta_{1,i,T}^-$ significant at 5% level (Euro)
Weekly returns					
Brazil	14.81%	6.11%	7.25%	7.18%	7.56%
Russia	28.24%	12.86%	15.31%	10.74%	13.19%
India	18.70%	9.81%	10.11%	10.98%	9.59%
China	21.09%	4.92%	14.76%	7.86%	8.40%
Monthly returns					
Brazil	10.98%	3.47%	5.73%	4.51%	5.97%
Russia	26.41%	13.62%	12.14%	9.05%	12.45%
India	16.38%	6.54%	8.04%	8.00%	6.46%
China	16.45%	5.16%	9.79%	5.88%	6.10%
Quarterly returns					
Brazil	11.71%	3.87%	6.35%	4.92%	5.52%
Russia	25.21%	16.71%	18.27%	11.06%	12.90%
India	15.19%	7.50%	7.53%	8.60%	6.45%
China	15.32%	1.46%	12.90%	6.15%	7.72%

The ratio of Russian firms affected by the ruble's depreciation against the dollar and the euro is higher. Indeed, unlike other markets, the Russian market is strongly influenced by oil prices. The rising US dollar against the ruble often coincided with decreasing BRENT quotes, which reached very high levels during the studied period. That is why expectations of a sharp fall in oil prices prevail expectations of a possible further increase. From Table 3 we can conclude that quarterly asymmetry is more meaningful compared to differences on shorter periods. We may suggest that there are long-term asymmetric exposure effects in the Russian market. We ran Chow tests and obtained significant differences in values of $\beta_{1,i,T}^+$ and $\beta_{1,i,T}^-$ for all countries.

Empirical tests of (2) and (3) showed significant exposure to currency movements in BRIC markets. Russian stock prices were affected more than others because of a possible strong dependency on oil prices and the remote implementation of hedging technics in Russian firms. For a more thorough investigation of reasons for currency exposure, we study its determinants in the next section.

5. Determinants of exchange-rate exposure.

Sometimes researches consider exogenous factors as determinants of currency exposure. But the prime target of our study is the financial parameters of specific firms. After discovering the relationship between a company's financials and exchange-rate exposure, we will not only be able to

forecast the reaction of stock returns and currency movements, but also understand how to hedge exchange-rate risk. Jorion (1990) was one of the first to suggest that the percentage of export sales in total revenue could be a significant factor of currency exposure. Since then, Bodnar and Gentry (1993), Muller and Verschoor (2006), and Hsin, Shiah-Hou, and Chang (2007) considered different determinants such as the percentage of export sales, foreign debt as a share of total debt, industry, size and growth proxies, quick liquidity, derivative usage, profit mark-up, R&D costs, and some others.

We believe that export sales and foreign debt could significantly and asymmetrically affect currency exposure. For an illustration of this suggestion, we come back to the example of Russian steel-makers. Before the crisis, these companies were net exporters and suffered from an appreciation of the ruble. That is why they extensively used foreign debt with floating rates and even hedged by selling dollar forwards. After the crisis hit Russia in 2008, steel-makers faced not only rapidly contracting export sales, but also a sharp increase in dollar-denominated interest payments and huge losses in currency derivatives. In that situation, the Russian government took some measures to protect the suffering industry, which allowed it to avoid the bankruptcy of major players in the industry and thereby keep unemployment rates low.

From our point of view, another interesting determinant of currency exposure is the coefficient of quick liquidity, introduced in the model by He and Ng (1998). We believe that large amounts of cash denominated in foreign currency could protect from domestic currency depreciation. The size of a company should also play a significant role, according to Muller and Verschoor (2006). Small firms often cannot appropriately hedge their currency position, especially in emerging markets where the cost of domestic debt for them is very high and currency derivatives are unavailable. That is why a small firm's exposure could be higher. We separately highlighted only the resource-extracting and finance sectors in our model because only a few public firms exist in other industry sectors in Russia. Steel-makers in this case mainly belong to the resource-extracting sector since most of them own mining assets.

We ran regressions (3) on weekly BRIC data for each year from 2003 to 2013. Since we wanted to study only determinants of firms that were exposed to currency risk, we considered significance at the 5%-level only for coefficients $\beta_{1,i,T}^+$ and $\beta_{1,i,T}^-$ and included them as dependent variables in our next model:

$$\begin{aligned} \beta_{i,T} = & \gamma_{0,T} + \gamma_1 \cdot FSales_{i,T-1} + \gamma_2 \cdot FDebt_{i,T-1} + \gamma_3 \cdot Quick_{i,T-1} + \\ & + \gamma_4 \cdot Resource_i + \gamma_5 \cdot Finance_i + \gamma_6 \cdot LSales_{i,T-1} + \varepsilon_{i,T}, \text{ где} \end{aligned} \quad (4)$$

$\beta_{i,T}$ are significant at the 5%-level for coefficients $\beta_{1,i,T}^+$ and $\beta_{1,i,T}^-$, obtained from (3) for the i -th firm and a period of $(T - 1, T)$;

$\gamma_j, j = 0, \dots, 6$ are coefficients of sensitivity to determinants of currency exposure;

$FSales_{i,T}$ is the ratio of export sales in total sales for the i -th firm and a previous period of $(T - 2, T - 1)$;

$FDebt_{i,T-1}$ is the ratio of foreign debt in total debt for the i -th firm and a previous period of $(T - 2, T - 1)$;

$Quick_{i,T-1}$ is a coefficient of quick liquidity for the i -th firm and a previous period of $(T - 2, T - 1)$;

$Resource_i$ is a dummy variable that is equal to 1 if the i -th firm is from the resource-extracting sector and 0 if otherwise;

$Finance_i$ is a dummy variable that is equal to 1 if the i -th firm is from financial sector and 0 if otherwise;

$LSales_{i,T-1}$ is log of sales for the i -th firm and a previous period of $(T - 2, T - 1)$.

We tested model (4) on our panel data of public companies from BRIC countries for 10 years. We use annual values for determinants of currency exposure, except for industry dummies, which remained constant for each firm. Interestingly, Russian companies from the dataset on average had the highest ratio of export sales at 33.4%, compared to Chinese, Indian, and Brazilian firms with 30.6%, 21.8% and 11.3% of export sales, respectively. Large export sales in Russian companies could be explained by prevailing resource-extracting firms in the dataset. Russian companies also had the largest level of foreign debt. High ratios of export sales and foreign debt support the test result of models (2) and (3), where the fraction of Russian companies influenced by currency returns were the highest.

In Table 4 we include estimations of asymmetric currency exposure sensitivity to different factors after regression (4).

Table 4. Regression coefficients after testing the model on panel data.

$$\beta_{i,T} = \gamma_{0,T} + \gamma_1 \cdot FSales_{i,T-1} + \gamma_2 \cdot FDebt_{i,T-1} + \gamma_3 \cdot Quick_{i,T-1} + \gamma_4 \cdot Resource_i + \gamma_5 \cdot Finance_i + \gamma_6 \cdot LSales_{i,T-1} + \varepsilon_{i,T}$$

	$\beta_{1,i,T}^+$ (US Dollar)				$\beta_{1,i,T}^-$ (US Dollar)			
	Brazil	Russia	India	China	Brazil	Russia	India	China
Const	-0.0988	-0.9152*	-1.0355**	1.1493***	0.0503	-0.2142**	-0.6435*	-0.4050*
Fsales	0.8731**	0.7926***	0.5118**	0.9664***	-0.2826**	-0.7631***	-0.8885**	-0.4581***
FDebt	-0.4203**	-0.5126*	-0.3312**	-0.0136	0.6866***	0.6424**	0.3484*	0.1084*

Quick	-0.0480	-0.0579**	0.0518*	0.0489*	-0.0250	-0.0011	-0.0482*	0.0041
Resource	-0.6974**	-0.5046***	-0.2299	0.3159*	-0.8975*	-0.7619**	0.1900	0.2322*
Finance	-0.3297*	-0.4521**	-0.1159	0.0057	-0.0130	0.2049*	-0.0025	-0.0273
LSales	0.4131	0.0090*	0.0322**	0.2662**	-0.4469	-0.1021**	-0.0637*	-0.1116**
R ² overall	0.3568	0.3631	0.2182	0.2571	0.3501	0.3312	0.2282	0.2632
Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	$\beta_{1,i,T}^+$ (Euro)				$\beta_{1,i,T}^-$ (Euro)			
	Brazil	Russia	India	China	Brazil	Russia	India	China
Const	0.0451*	0.114**	0.0656***	0.0656*	-0.1734*	0.0782	-0.5779**	0.3809*
Fsales	0.6112***	0.6128***	-0.0340	1.0210***	-0.5815***	-0.6401**	-0.6557*	-0.8426**
FDebt	-0.3228***	-0.4314***	-0.0611*	-0.0618*	0.3548**	0.4137***	0.0816*	0.2128
Quick	0.0417*	-0.0053*	0.0005	0.0390*	0.0179	0.0179	0.0459*	-0.0430
Resource	-0.6348*	0.0288***	-0.0173*	0.1338***	-0.2095**	-0.1526**	-0.0567	0.1422*
Finance	0.0272	0.0604	0.0324	0.0324	0.0285	0.0021	0.0151	-0.0416
LSales	0.0428*	0.0062*	0.0892**	0.0019***	-0.0563	0.0979*	-0.3804*	-0.0556**
R ² overall	0.2093	0.3489	0.1528	0.1967	0.1843	0.3354	0.1427	0.2167
Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

*, **, *** significance at 10%, 5% and 1% level

We now briefly summarize the results provided above in Table 4. The export sales ratio was significant and, unsurprisingly, positively correlated with the weekly currency exposure in BRIC countries. Moreover, its influence was asymmetrical with relation to exposure to US dollar rates in all countries except for Russia, probably because of the dependency of oil prices. For example, a 10% annual increase in the export sales ratio, along with a 10% rise in the US dollar to the Brazilian real rate, followed a 0.87% increase in the capitalization of Brazilian firms. On the other hand, a 10% increase in the export sales ratio and a 10% decrease in dollar to real rate followed only a 0.28% decrease of its market capitalization. Hence stocks of large exporters were more attractive investment objectives in Brazil. In India, export sales were also significant and asymmetric, but companies with higher exports are considered more risky by investors. It is probable that the asymmetric behavior of currency exposure can be shown only on longer intervals (monthly and quarterly), when fundamental factors are more meaningful than oil prices for Russian companies. Euro exposures were mostly symmetrically affected by the export sales ratio.

As expected, the foreign debt ratio was negatively and asymmetrically correlated with US dollar exposure coefficients in Brazil and Russia. In India, its influence was also significant, but almost symmetric. Foreign debt was small (around 10% on average), and hence the non-significant determinant of currency exposure for Chinese companies. Size could be a determinant of exchange rate exposure in India and China. Finally the quick ratio was significant mostly for Russian companies, but it is hard to say if its influence was asymmetric.

Asymmetry could arise not only because of different directions of currency movements. Currency exposure itself could be positive or negative. Moreover, determinants of positive and negative exchange rate exposure could provide different effects. For example, a foreign debt ratio could affect negative currency exposure more. Researching this kind of asymmetry, we ran a simple regression (2) and obtained different coefficients $\beta_{1,i,T}$, which we divided into positive $\beta_{i,T}^{pos} = \beta_{1,i,T}I(\beta_{1,i,T} \geq 0)$ and negative $\beta_{i,T}^{neg} = \beta_{1,i,T}I(\beta_{1,i,T} < 0)$ ones. We obtained another two specifications of the asymmetric model:

$$\begin{aligned} \beta_{i,t}^{pos} = & \gamma_0^+ + \gamma_1^+ \cdot FSales_{i,T-1} + \gamma_2^+ \cdot FDebt_{i,T-1} + \gamma_3^+ \cdot Quick_{i,T-1} + \\ & + \gamma_4^+ \cdot Resource_i + \gamma_5^+ \cdot Finance_i + \gamma_6^+ \cdot LSales_{i,T-1} + \varepsilon_{i,T} \end{aligned} \quad (5)$$

$$\begin{aligned} \beta_{i,T}^{neg} = & \gamma_0^- + \gamma_1^- \cdot FSales_{i,T-1} + \gamma_2^- \cdot FDebt_{i,T-1} + \gamma_3^- \cdot Quick_{i,T-1} + \\ & + \gamma_4^- \cdot Resource_i + \gamma_5^- \cdot Finance_i + \gamma_6^- \cdot LSales_{i,T-1} + \varepsilon_{i,T}. \end{aligned} \quad (6)$$

Since the interpretation of regression coefficients γ_j^+ and γ_j^- is not completely clear, we decided to check for asymmetry by running Chow's test for models (5) and (6). The hypothesis on the equality of coefficients γ_j^+ and γ_j^- beside export sales and foreign debt ratios (for $j = 1,2$) was rejected.

6. Conclusion.

We found that approximately 10% of firms in the dataset of BRIC countries during 2003-2013 period are exposed to exchange-rate risk. Stock returns were affected differently by positive and negative currency movements, which allowed us to suggest an asymmetric influence of exchange-rate risk.

Significant determinants of asymmetric exposure included export sales ratio, the percentage of foreign debt, industrial sector, and size of a firm. Export sales were positively correlated and foreign debt was negatively correlated with exposure to exchange rate movements of the US dollar and euro. Both export sales and foreign debt ratios asymmetrically influenced the short-term exposure coefficients in all but Russian markets. Russian firms were strongly affected by exchange rate movements, but asymmetrical effects might be traced only during longer periods.

Finally, we suggest that implementation of operational and financial hedging in BRIC firms must account for different kinds of asymmetry of currency exposure. On the other hand, investors in BRIC markets should keep in mind that currency risk is important and its relation to stock prices is non-linear and asymmetric.

Our future work might include empirical tests for different time periods to check the sustainability of currency exposure determinants over time. We also want to compare our results with evidence from developed countries.

References.

1. Adler, M., & Dumas, B. (1980). Foreign Exchange Risk Management. *Currency Risk and the Corporation*, 145-158.
2. Adler, M., & Dumas, B. (1984). Exposure to Currency Risk: Definition and management. *Financial Management*, 41-50.
3. Aggarwal, R., Harper, J. T. (2010). Foreign Exchange Exposure of "Domestic" Corporations. *Journal of International Money and Finance*, 1619-1636.
4. Aggarwal, R., Chen, X., Yur-Austin, J. (2011). Currency Risk Exposure of Chinese Corporations. *Research in International Business and Finance*, 266-276.
5. Bartov, E., & Bodnar, G. M. (1994). Firm Valuation, Earnings Expectations, and the Exchange-Rate Exposure Effect. *Journal of Finance*, 1755-1785.
6. Bishop, E. (2004). Chapter 7 – Foreign exchange risk. In E. Bishop, *Finance of International Trade* (pp. 107-112). Amsterdam: Elsevier Ltd.
7. Bodnar, G. M., & Gentry, W. M. (1993). Exchange Rate Exposure and Industry Characteristics: Evidence from Canada, Japan and the USA. *Journal of International Money and Finance*, 29-45.
8. Booth, L., & Rotenberg, W. (1990). Assessing Foreign Exchange Exposure: Theory and Application Using Canadian Firms. *Journal of International Financial Management and Accounting*, 1-22.
9. Butler, K. C. (2012). *Multinational Finance: Evaluating Opportunities, Costs, and Risks of Operations* (5th ed.). John Wiley & Sons.
10. Carrieri, F., & Majerbi, B. (2006). The Pricing of Exchange Risk in Emerging Stock Markets. *Journal of International Business Studies*, 372-391.
11. Chen, N.-F., Roll, R., & Ross, S. A. (1986). Economic Forces and the Stock Market. *The Journal of Business*, 383-403.
12. Chow, E. H., Lee, W. Y., & Solt, M. E. (1997). The Exchange-Rate Risk Exposure of Asset Returns. *Journal of Business*, 105-123.
13. Chrisophe, S. E. (1997). Hysteresis and the Value of the U.S. Multinational Corporation. *Journal of Business*, 435-462.

14. Cornell, B., & Shapiro, A. C. (1983). Managing Foreign Exchange Risks. *Midland Corporate Finance Journal*, 16-31.
15. De Santis, G., & Gerard, B. (1998). How Big is the Premium for Currency Risk? *Journal of Financial Economics*, 375-412.
16. Dominguez, K. M., & Tesar, L. L. (2001). A Re-Examination of Exchange Rate Exposure. *The American Economic Review*, 396-399.
17. Drucker, P. F. (2010). *The Frontiers of Management: Where Tomorrow's Decisions Are Being Shaped Today*. Harvard Business Press.
18. Dumas, B., & Solnik, B. (1993). Exchange Rate Exposure and Industry Characteristics: Evidence from Canada, Japan, and the USA. *Journal of International Money and Finance*, 29-45.
19. Griffin, J. M., & Stulz, R. M. (2001). International Competition and Exchange Rate Shocks: a Cross-Country Industry Analysis of Stock Returns. *The Review of Financial Studies*, 215-241.
20. He, J., & Ng, L. K. (1998). The Foreign Exchange Exposure of Japanese Multinational Corporations. *The Journal of Finance*, 733-753.
21. Horst, E., & Gösta, J. (2007). German Exchange Rate Exposure at DAX and Aggregate Levels, International Trade and the Role of Exchange Rate Adjustment Costs. *German Economic Review*, 344-374.
22. Hsin, C.-W., Shiah-Hou, S.-R., & Chang, F.-Y. (2007). Stock Return Exposure to Exchange Rate Risk: a Perspective from Delayed Reactions and Hedging Effects. *Journal of Multinational Financial management*, 384-400.
23. IHS Gloval Insight. (n.d.).
24. Jorge, M. D., & Augusto, M. A. (2011). Financial Risk Exposures and Risk Mangement: Evidence from European Nonfinancial Firms. *RAM. Revista de Administração Mackenzie*, 68-97.
25. Jorion, P. (1990). The Exchange-Rate Exposure of U.S. Multinationals. *The Journal of Business*, 331-345.
26. Jorion, P. (1991). The Pricing of Exchange Rate Risk in the Stock Market. *The Journal of Financial and Quantitative Analysis*, 363-376.
27. Knetter, M. (1994). Is Export Price Adjustment Asymmetric: Evaluating the Market Share and Marketing Bottlenecks Hypothesis. *Journal of International Money and Finance*, 55-70.

28. Koutmos, G., & Martin A. D. (2003). Asymmetric Exchange Rate Exposure: Theory and Evidence. *Journal of International Money and Finance*, 365-383.
29. Ljungqvist, L. (1994). Hysteresis in International Trade: a General Equilibrium Analysis. *Journal of International Money and Finance*, 387-399.
30. Martin, A. D. (2004). Assymmetric Exchange Rate Exposure. *Canadian Investment Review*, 13.
31. Martin, A. D., & Mauer, L. J. (2005). A Note on Common Methods Used to Estimate Foreign Exchange Exposure. *Journal of International Financial Markets, Institutions and Money*, 125-140.
32. Muller, A., & Verschoor, W. F. (2006). European Foreign Exchange Risk Exposure. *Eropean Financial Management*, 195-220.
33. Olufern, T. (2011). Exchange Rate Risk Exposure of Nigerian Listed Firms: an Empirical Examination. *International Business Research*, 219-225.
34. Phylaktis, K., & Ravazzolo, F. (2004). Curreny Risk in Emerging Equity Markets. *Emerging Markets Review*, 317-339.
35. Saleem, K., & Vaihekoski, M. (2010). Time-Varying Global and Local Sources of Market and Currency Risks in Russian Stock Market. *International Review of Economics and Finance*, 686-697.
36. Shapiro, A. C. (1974). Echange Rate Changes, Infaltion, and the Value of the Multinational Corporation. *The Journal of Finance*, 485-502.
37. Shapiro, A. C. (1977). Defining Exchange Risk. *The Journal of Business*, 37-39.
38. Shin, H.-H., & Soenen, L. (1998). Exposure to Currency Risk by US Multinatonsals Corporations. *Journal of Multinational Finance Management*, 195-207.

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