Time-varying global and local sources of risk in Russian stock market

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TIME-VARYING GLOBAL AND LOCAL SOURCES OF RISK IN RUSSIAN STOCK MARKET

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Comments are welcome

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Abstract

In this paper we study international asset pricing models and pricing of global and local sources of risk in the Russian stock market using weekly data from 1999 to 2006. In our empirical specification, we utilize and extend the multivariate GARCH-M framework of De Santis and Gérard (1998), by allowing conditional local influence as well. Similar to them we find global risk to be time-varying. Currency risk also found to be priced and highly time varying in the Russian market. Moreover, our results suggest that the Russian market is partially segmented and local risk is also priced in the market. The model also implies that the biggest impact on the US market risk premium is coming from the world risk component whereas the Russian risk premium is on average caused mostly by the local and currency risk components.

JEL-classification: G12, G15

Key words: international asset pricing models, segmentation, currency risk, multivariate GARCH-M, Russia

1   INTRODUCTION

During the last decade the stock markets throughout the world have become increasingly integrated, both in good and bad. Many economic and financial crises that have started in emerging markets have spread also to developed economies resulting in an increased volatility in stock and currency markets. A major source of the financial crisis in the emerging markets is the changes in the valuation of their currencies. As a result, the role of the exchange rate risk on the stock markets is of interest both to research and practitioners alike. Yet there remain some important unresolved issues, especially in the context of emerging markets.

Early research assumed that the currency risk is not priced in stock market as investors can diversify their investments across countries and currencies. For example, Jorion (1991) reports that currency risk is not priced in the US market. However, many researchers have later found currency risk to be priced. For example, De Santis and Gérard (1998) found that the currency risk to be priced on several major stock developed markets. Similar results have been derived also on from smaller developed markets (see, e.g., Vaihekoski, 2007a) and emerging markets (see, e.g., Phylaktis and Ravazzolo, 2004).

Another issue addressed in this study is the choice of asset pricing model when dealing with the emerging countries. Most studies dealing with international asset pricing models use data from large markets closely related to global financial markets and suggest fully integrated models, ignoring the domestic sources of risk. However, recent results from many emerging and smaller developed markets do not supported the fully integrated international CAPM. It seems that the partially segmented model by Errurza and Losq (1985) is more appropriate for these markets (see, e.g., Nummelin and Vaihekoski, 2002; Carrieri et al., 2006). These studies suggest that both local and world factors should influence equilibrium asset returns. Hence, local sources of risk are important to consider while investing internationally especially in the context of emerging markets and should be treated as separately from of the local currency risk.

In this study, we investigate whether time-varying global, local and currency risks are priced on one of the largest emerging market, Russia, using the multivariate GARCH-M framework of De Santis and Gérard (1998). We extend their approach to allow for conditional local influence similar to Antell and Vaihekoski (2007). Our investigation also extends the analysis of Russian stock market in Saleem and Vaihekoski (2007) by allowing for time-varying prices of risk and analyzing the size of the risk premia due to the time-varying sources of risks. There exists a few

studies that focus on the exchange rate related risk in the emerging stocks markets, such as, Latin America (see, e.g., Bailey and Chung, 1995), Asia (see, e.g., De Santis and Imrohoroglu, 1997; Gérard et al., 2003; Phylaktis and Ravazzolo, 2004), and Eastern Europe (see, e.g., Mateus, 2004). Work on Russian financial markets is still very scarce. Goriaev and Zabotkin (2006) is one exception. They found partial support for the pricing of currency risk using unconditional framework.

The Russian stock market is an interesting test laboratory for international asset pricing models because at least *a priori* the Russian economy has been greatly influenced the exchange rate of its currency and because its stock market has developed from a relatively closed market to an open market during the last two decades.[1] In addition, the Russian stock market has offered outstanding performance and excellent diversification opportunities for international investors. Overall, we believe Russia's institutional features and our sample period make the Russian stock market an interesting test laboratory for tests of conditional international asset pricing models.

Our results can be summarized as follows. Similar to De Santis and Gérard (1998) we find global risk to be time-varying. Currency risk also found to be priced and highly time varying in the Russian market. Our results show that Russian domestic risk is priced and time-varying, while local risk is not priced for the US market, suggesting that partially segmented asset pricing model is more suitable for the Russian market. Moreover, our model implies in-sample risk premium for the Russian equity market that is much higher then the US risk premium with three times higher amount of standard deviation. The model also implies that the biggest impact on the US market risk premium is coming from the world risk component whereas the Russian risk premium is on average caused mostly by the local and currency risk components.

The remainder of the paper is as follows. Section 2 explains the research methodology and theoretical background of the international asset pricing models. Section 3 presents the data in this study. Section 4 shows the empirical results. Section 5 concludes.

2   RESEARCH METHODOLOGY

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[1]   See, e.g., Anatolyev (2005) and Goriaev and Zabotkin (2006) for recent overviews of the Russian stock market development.

2.1 Theoretical background

The classical CAPM suggests that the expected equity returns are a function of only the country-specific local risk, if stock markets are fully segmented. However, due to rapid structural changes in the world economy, increased global trade, introduction of new financial trading and information handling techniques, formation of regional economic groups, increases in foreign investments, and so called globalization, most of the stock markets have become more or less integrated with each other. Hence, if markets were complete integrated, the international version of the CAPM suggests that the only systematic source of risk is global market risk. Assuming that investors do not hedge against exchange rate risk and a risk free asset exists, the conditional version of this international CAPM gives the following equation for the expected excess asset returns

$$\text{(1)} \qquad E[r_{i,t+1}|\Omega_t] = \beta_{i,t+1}(\Omega_t)\, E[r_{m,t+1}|\Omega_t]$$

where $E[r_{i,t+1}|\Omega_t]$ and $E[r_{m,t+1}|\Omega_t]$ are expected returns on asset i and the global market portfolio conditional on investor's information set Ω_t available at time t. Both returns are in excess of the local risk free rate of return r_{ft} for the period of time from t to $t+1$. The global market portfolio comprises all securities in the world in proportion to their capitalization relative to world wealth (see, e.g., Stulz, 1995). All returns are measured in one common currency.

Since the conditional beta is defined as $\text{Cov}(r_{i,t+1},r_{m,t+1}|\Omega_t)\text{Var}(r_{m,t+1}|\Omega_t)^{-1}$, we can use equation (1) to define the ratio $E[r_{m,t+1}|\Omega_t]\text{Var}(r_{m,t+1}|\Omega_t)^{-1}$, which can be considered as the conditional price of global market risk $\lambda_{m,t+1}$, conditioned on information available at time t.[2] It measures the compensation the representative investor must receive for a unit increase in the variance of the market return (see, e.g., Merton, 1980). Now the model gives the following restriction for the expected excess returns for any asset i:

$$\text{(2)} \qquad E[r_{i,t+1}|\Omega_t] = \lambda_{m,t+1}\text{Cov}(r_{i,t+1},r_{m,t+1}|\Omega_t),$$

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[2] The price of risk is sometimes also called as reward-to-risk, compensation for covariance risk, or aggregate relative risk aversion measure.

where the price of market risk should be positive if investors are risk-averse. Since the market portfolio is also a tradable asset, the model gives the following restriction for the expected excess return of the global market portfolio

$$(3) \qquad E[r_{m,t+1} | \Omega_t] = \lambda_{m,t+1} Var(r_{m,t+1} | \Omega_t)$$

$Var_t(\cdot)$ and $Cov_t(\cdot)$ are short-hand notations for conditional variance and covariance operators, all conditional on information Ω_t.

As the returns are measured in the numeraire currency, the model also implies that the expected returns do not have to be the same for investors coming from different currency areas even though they do not price the currency risk. On the other hand, the price of global market risk is the same for all investors irrespective of their country of residence.[3]

However, if some assets deviate from pricing under full integration e.g. due to barriers or other forms of segmentation, their risk-adjusted expected return will differ from the international CAPM. If this is the case, Errunza and Losq (1985) suggested that asset prices are also affected by the local risk. As a result the pricing equation should include also the local market risk. Now the pricing equation can be written as follows:

$$(4) \qquad E[r_{i,t+1} | \Omega_t] = \lambda_{m,t+1}^w Cov(r_{i,t+1}, r_{m,t+1}^w | \Omega_t) + \lambda_{m,t+1}^l Cov(r_{i,t+1}, r_{m,t+1}^l | \Omega_t),$$

where $\lambda_{m,t+1}^w$ and $\lambda_{m,t+1}^l$ are the conditional prices of world and local market risk.

However, any investment in a foreign asset is always a combination of an investment in the performance of the asset itself and in the movement of the foreign currency relative to the domestic currency. Prior research show that if the purchasing power parity (PPP) does not hold, investors view real returns differently and they want to hedge against exchange rate risks.[4]

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[3] The price of global market risk is the average of the risk aversion coefficients for each national group, weighted by their corresponding relative share of global wealth. For more information, see the discussion in De Santis and Gérard (1997).

[4] Moreover, currency risk may enter indirectly into asset pricing, if companies are exposed to unhedged currency risk for example through foreign trade and/or foreign debt. Empirical evidence has found conflicting support for the pricing of the foreign exchange rate risk (see, e.g., Jorion 1990, 1991; Roll, 1992; De Santis and Gérard, 1997, 1998; Doukas et al., 1999).

Specifically, the risk induced by the PPP deviations is measured as the exposure to both the inflation risk and the currency risk associated with currencies. Assuming that the domestic inflation is non-stochastic over short-period of times, the PPP risk contains only the relative change in the exchange rate between the numeraire currency and the currency of $C+1$ countries (see, e.g., De Santis and Gérard, 1998). In this case the conditional asset pricing model for partially segmented markets implies the following restriction for the expected return of asset i in the numeraire currency

$$(5) \quad E_t[r_{i,t+1}] = \lambda_{m,t+1}^w \text{Cov}_t(r_{i,t+1}, r_{m,t+1}^w) + \sum_{c=1}^{C} \lambda_{c,t+1} \text{Cov}_t(r_{i,t+1}, f_{c,t+1}) + \lambda_{m,t+1}^l \text{Cov}_t(r_{i,t+1}, r_{m,t+1}^l),$$

where $\lambda_{c,t+1}$ is the conditional price of exchange rate risk for currency c. Note that the price of exchange rate risk is not restricted to be positive.

Now, the risk premium, e.g., for the local market risk premium can be written as follows

$$(6) \quad E_t[r_{m,t+1}^l] = \lambda_{m,t+1}^w \text{Cov}_t(r_{m,t+1}^l, r_{m,t+1}^w) + \lambda_{m,t+1}^l \text{Var}_t(r_{m,t+1}^l) + \sum_{c=1}^{C} \lambda_{c,t+1} \text{Cov}_t(r_{m,t+1}^l, f_{c,t+1}),$$

Finally, assuming that the exchange rate changes are not related to the local equity market return, the currency risk premia can be written as follows

$$(7) \quad E_t[f_{j,t+1}] = \lambda_{m,t+1}^w \text{Cov}_t(f_{j,t+1}, r_{m,t+1}^w) + \sum_{c=1}^{C} \lambda_{c,t+1} \text{Cov}_t(f_{j,t+1}, f_{c,t+1}),$$

Unfortunately, the model above is intractable in practice if C is large. Thus, one can either focus on a subset of currencies or use a more parsimonious measure for the currency risk. Ferson and Harvey (1993) and Harvey (1995) show how one can use a single aggregate exchange risk factor to proxy for the deviations from the PPP to the model. In this case, the model (5) boils down to a three-factor model.

2.2 Empirical formulation

In our empirical specification, we utilize the multivariate GARCH-M framework of De Santis and Gérard (1998) to model the investors' conditional expectations, covariances, and variances.[5] It allows for the time-varying variance-covariance process. However, we extend their approach to allow for conditional local influence similar to Antell and Vaihekoski (2007).

We take the point of view of US investors and use US dollar as the numeraire currency. We estimate the model using three test assets: world equity market, the U.S. and Russian equity market indices. The currency return is also modeled if the currency risk is included in the tested pricing model. The empirical model for the excess returns in USD is the following:

(8) $$r_{m,t+1}^{w} = \lambda_{m,t+1}^{w} h_{t+1}^{w} + e_{m,t+1}^{w},$$

(9) $$r_{m,t+1}^{US} = \lambda_{m,t+1}^{w} h_{t+1}^{US,w} + \lambda_{m,t+1}^{US} h_{t+1}^{US} + e_{m,t+1}^{US},$$

(10) $$r_{m,t+1}^{RF} = \lambda_{m,t+1}^{w} h_{t+1}^{RF,w} + \lambda_{m,t+1}^{RF} h_{t+1}^{RF} + \lambda_{t+1}^{FX} h_{t+1}^{RF,FX} + e_{m,t+1}^{RF},$$

(11) $$r_{t+1}^{FX} = \lambda_{m,t+1}^{w} h_{t+1}^{FX,w} + \lambda_{t+1}^{FX} h_{t+1}^{FX} + e_{m,t+1}^{FX},$$

and for the conditional variances as follows

(12) $$\varepsilon_{t+1} \sim \text{IID}(\mathbf{0}, H_{t+1}).$$

where lambdas are the conditional prices of risk and ε_{t+1} is a 4×1 vector of stacked innovations, i.e., $\varepsilon_{t+1} = [e_{m,t+1}^{w} \ e_{m,t+1}^{US} \ e_{m,t+1}^{RF} \ e_{m,t+1}^{FX}]'$. H_{t+1} is the variance-covariance matrix. Equations (8)–(11) are the empirical counterparts to equations (3), (6), and (7).

The process of ε_{t+1} can be identified by different methods. Here we use the Generalized Autoregressive Conditional Heteroskedasticity (henceforth GARCH) model. It has been considered to be the most successful model to capture the often exhibited features of financial returns, such as, volatility clustering, time-variation and non-normality by both academic researchers and market professionals. It has been frequently used in academic literature.[6]

However, the drawback of the first multivariate extension by Bollerslev et al. (1988) is the large number of parameters to estimate the difficulties to obtain a stationary covariance process and the problems to get a positive-definite (co)variance matrix. Many of these problems are circumvented by the BEKK (Baba, Engle, Kraft and Kroner) parameterization proposed by Engle and Kroner (1995):

$$(13) \qquad \mathbf{H}_{t+1} = \mathbf{C}'\mathbf{C} + \mathbf{A}'\boldsymbol{\varepsilon}_t\boldsymbol{\varepsilon}'_t \mathbf{A} + \mathbf{B}'\mathbf{H}_t\mathbf{B},$$

While specification (12) allows for rich dynamics and a positive-definite covariance matrix, the number of parameters still grows fairly large in higher-dimensional systems. Therefore, parameter restrictions are often imposed, for example diagonality or symmetricity restrictions. In order to simplify the estimation process, we adopt the covariance stationary specification of Ding and Engle (2001), and utilized for example by De Santis and Gérard (1997, 1998):

$$(14) \qquad \mathbf{H}_{t+1} = \mathbf{H}_0 \times (\mathbf{i}\mathbf{i}' - \mathbf{a}\mathbf{a}' - \mathbf{b}\mathbf{b}') + \mathbf{a}\mathbf{a}' \times \boldsymbol{\varepsilon}_t\boldsymbol{\varepsilon}'_t + \mathbf{b}\mathbf{b}' \times \mathbf{H}_t,$$

where $\mathbf{a}$ and $\mathbf{b}$ contain the diagonal elements of matrices $\mathbf{A}$ and $\mathbf{B}$, respectively. $\mathbf{H}_0$ is the unconditional variance-covariance matrix.

In addition, we need to select a model for the time-variation in the conditional price of risk coefficients. Following earlier research, we choose to model them as linear functions of the conditioning information variables. For the price of global market risk, we choose only global variables, whereas for the price of local market risk, we choose local variables. In the case of currency risk, we use both local and global information variables. As a result, we get the following equations for the prices of risk:

$$(15a) \qquad \lambda^w_{m,t+1} = Z^w_t \kappa_w,$$

$$(14b) \qquad \lambda^l_{m,t+1} = Z^l_t \kappa_l,$$

$$(14c) \qquad \lambda_{c,t+1} = Z^{wl}_t \kappa_c.$$

where Z^w_t is an $(1 \times L)$, Z^l_t is an $(1 \times L_l)$, and Z^{wl}_t is an $(1 \times (L+L_l-1))$ data vector for the global,

local, and combined instrument variables available to investors at time t, respectively. L (L_l) is the number of global (local) information variables, including a constant. Kappas are vectors of linear regression coefficients.

Overall, there is still no consensus on the metric to use in selecting between the variables and models. Simply maximizing the explanatory power of the model and variables raises the question of data mining. In addition, that approach is bound to be theoretically questionable and econometrically difficult to implement. The question of selecting the right information variables is even more problematic. In general, the question of relevant information variables should be addressed by economic reasoning. In practice, one hopes to select theoretically justified variables that are also able to capture at least a part of the predictability in the prices of risk.

Finally, to estimate the parameters we use maximum likelihood. Assuming conditional normality, and defining stacked residuals from equations (8)–(11) as vector $\mathbf{e}_t$ and the variance-covariance matrix $\mathbf{H}_t$ as specified in equation (13), we get the following time t log likelihood function (omitting the constant):

$$(16) \qquad \ln L_t = -\frac{1}{2}\ln|\mathbf{H}_t| - \frac{1}{2}\mathbf{e}_t{}'\mathbf{H}_t^{-1}\mathbf{e}_t .$$

To calculate the standard errors we use the quasi-maximum likelihood (QML) approach of Bollerslev and Wooldridge (1992). Given that the conditional mean and conditional variance are correctly specified, QML yields consistent and asymptotically normally distributed parameter estimates. Further, robust Wald statistics can straightforwardly be computed. We use the Berndt–Hall–Hall–Hausman (BHHH, 1974) algorithm for the optimization.

3 DATA

Our data set consist of 417 weekly observations from January 1999 to December 2006. The beginning of our sample period is after the Russian currency crises of 1998 as we believe that the period leading to the currency crisis was an extraordinary event and not typical as far as the way currency risk is studied here. Moreover, the sample period allows us to consider freely floating Russian Ruble during the whole time. We use weekly data in this study to get meaningful

statistical generalizations and to obtain a better picture of the movements of market return. Moreover, the use of weekly data is a tradeoff between the low number of observations in monthly data and the non-synchronous trading issues in daily data, especially in emerging markets.

Throughout the paper, we take the view of US investors. Thus, all returns are measured in US dollars and in excess of risk-free rate of return. As a proxy for U.S investors' risk-free return we use a one-month holding period return on Eurodollar in London measured in USD for month t+1 following the recommendations in Vaihekoski (2007b). All returns continuously compounded and in the estimations they are in percentage form.

3.1   Risk factors and test assets

To represent economic risks we employ two types of risk factors in our international asset pricing model, namely global market risk and exchange rate risk. Our first risk factor, global market risk, is measured by using the return on the global equity market portfolio. Global market portfolio returns are proxied by the total return on the Thomson Datastream Global Equity index with reinvested gross dividends.[7]

Our second source of risk is related to exchange rate changes. As a proxy for the exchange rate risk, we use a single bilateral currency exchange rate in order to detect if the USD/RUB exchange rate is relevant for the pricing of Russian stocks. If the US investors consider the value of RUB as a source for the currency risk, the exchange risk premium should have a systematic effect on pricing of Russian stocks. We use continuously compounded change in the U.S. dollar value of RUB as a measure of the currency risk.

Initially, we test the model using two assets in addition to the global market portfolio, namely the U.S. and Russian market portfolios. US is included to compare results with the earlier studies, e.g., by De Santis and Gérard (1998). The U.S. and Russia stock market returns are measured

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[7]   We use Datastream indices instead of widely used MSCI indices as weekly data on total returns for the MSCI indices are available only from year 2000. For example, the correlation between monthly returns for Datastream and MSCI world indices during our sample period is more than 98 percent.

using Thomson Datastream national total return indices in USD with reinvested gross dividends. Figure 1 shows their development during the sample period (all series scaled to start from 100).

We can see how the world and US stock markets go almost hand in hand whereas the Russian stock market shows clearly different behavior. Russian market has much higher volatility and it has shown tremendous development compared to the world in general. Moreover, its peaks do not seem to happen at the same time as in the world market. The difference can also be seen when one calculates the six month (26 week) correlation between the returns of the world equity market and both of the national markets (Figure 2). Over the whole sample, the correlation coefficient between the world and the USA market returns is 0.92, whereas the same number for the Russia is only 0.41. Interestingly, the correlation increases until year 2000 but after that it decreased for a few years until in 2005 it has started to increase again.

Table 1 contains summary statistics for the weekly asset returns. Panel A contains the first four moments of the raw data, i.e., mean, standard deviation, skewness and kurtosis. Mean and standard deviation are multiplied by 52 and the square root of 52 to show them in annual terms. To check the null hypothesis of normal distribution we calculate Jarque-Bera test statistic (p-values reported). In addition to that we also calculate autocorrelations of all returns series up to lag 26, representing 6 months period (lag 1, 2, 3 and 26 are reported). Finally, to investigate the null that autocorrelation coefficients up to 26 lags are zero, we compute Ljung and Box (1978) test statistic for each return series.

The annual mean USD return for the world equity factor is 7.285 per cent and for the local USA market is 3.610 per cent. Russia seems to have been a good investment for US investors as the annual mean return has been clearly higher 43.084 per cent. On the other hand, Russia has by far the highest standard deviation (36.680), and the world market portfolio the lowest as suggested by its low return. The change in the value of Russian currency in USD terms is -0.031 per cent per annum on average.

The Jarque-Bera statistic rejects the hypothesis of normality in all cases. None of the equity market showing evidence of significant first-order autocorrelation, except the US market. Panel B reports pairwise correlations among asset returns. All correlations in the table are below 0.5 except the correlation between USA and world (the value is 0.92). The correlation between US and Russian returns is even as low as 0.286 which can be considered to be really low in today's

integrated world. Given high returns and low correlation, Russian stock market has offered an attractive opportunity to US investors to diversify their portfolios internationally.

Since we use GARCH process to model the variance in the asset returns, we also test for the presence of the ARCH effect. Table 1 reports *p*-values for the Ljung-Box test statistic on the squared returns (26 lags) together with the ARCH LM-statistic (five lags) on each returns series. The results show evidence of autocorrelation pattern in squared residuals, which suggest that GARCH parameterization might be appropriate for the conditional variance processes.

3.2 Information variables

We use global and local predetermined forecasting variables to track predictable time-variation in asset returns, risk exposures, and the common rewards to risks. The instrument set is chosen to match that of Bekaert and Harvey (1995) and in particular De Santis and Gérard (1997, 1998). Originally, the instruments are chosen on the basis of parsimony, previous empirical studies (e.g., Ferson and Harvey, 1993), and theoretical content (e.g., Adler and Dumas, 1983).

Following, De Santis and Gérard (1998), who made some minor transformations to the variables from their (1997) paper to reduce the multicollinearity and to guarantee stationarity, we model the prices of risk as a function of a certain global instruments, which are designed to capture expectation about business cycle fluctuations and the underlying uncertainty in the market. The set of global instruments Z_{t-1}^{w} includes a constant, world index dividend yield in excess of one-month Eurodollar rate (XDYD), the change in the U.S. term premium (ΔUSTP), the change in the one-month Eurodollar rate (ΔEuro\$), and the U.S. default premium (USDP).

One-month Eurodollar rate quoted in London is taken from Datastream. USTP is the yield difference of the 10 year constant maturity bond and 3 month Treasury bill expressed in annual percentage terms. ΔUSTP is simply the first difference in the series. The U.S. default premium, USDP, is the difference in Moody's Baa minus Aaa bond yields. ΔUSTP and USDP are taken from Federal Reserve Economic database. World dividend yield is calculated by Datastream for their equity index. XDYD is the dividend yield minus the risk-free rate of return in percentage.

We augment the global information set with four variables when modeling the time variation in the price of local market and currency risk. The first two are used in the case of the currency risk, and the latter two in the case of local market risk. These variables are the change in Russian short term interest rates (ΔLRF), the change in the price of oil (ΔOPEC), the local market dividend yield in excess of the one-month Eurodollar rate (XRDY), and the change in emerging markets bond index spread for Russia (ΔEMBS).

The change in Russian short term interest rates (ΔLRF) and the change in the price of oil (ΔOPEC) are expected to reflect investors' expectations regarding the Russian currency. For example, the use of short term interest rates reflects the well known economic concept of uncovered interest rate parity and also used widely in previous literature (see, e.g., Ferson and Harvey, 1993). The change in oil prices has been used earlier in studies linking crude oil prices and exchange rates. For example, Akram (2004), Bergvall (2004), as well as Amano and van Norden (1998) find that oil prices significantly affect the relative values of currencies in several industrial countries. Moreover, oil has arguably played an important role in reconstruction of Russian economy since the financial crisis of 1998. In the same fashion, we select two country-specific variables to model the time-variation in the price of local market risk. The local dividend yield, XRDY, and the change in the yield spread of Russian government bonds over US government bonds, ΔEMBS, are expected to reflect riskiness of Russian economy over and above the volatility reflected directly in the pricing formula.

One month Russian interbank rate is used to calculate ΔLRF. ΔOPEC stand for log difference in the price of crude oil in Russian ruble calculated by Organization of the Petroleum Exporting Countries. Thus, it reflects the change in the USD market price of the oil as well as changes in the RUBUSD exchange rate. Time series are taken from Datastream. XRDY is calculated similar to the world dividend yield. ΔEMBS is the log difference in the spread of Russian benchmark external debt instruments' over US T-bonds. It measures the credit risk premium over US Treasury bonds. The time series is originally from Cbonds (www.cbonds.info) which is the leading provider of information on fixed income markets of Russia, Ukraine and CIS countries.

Panel A of Table 2 presents the descriptive statistics of our instrument variables. All variables show evidence of nonnormality which has to taken into account in the estimation. However, from the estimation's point of view, it is important that the information variables do not suffer from multicollinearity. The pairwise correlation matrix of the instruments in Panel B of Table 2

shows that the variables contain sufficiently orthogonal information, suggesting that none of our information variable is redundant.

4   EMPIRICAL RESULTS

4.1   Conditional international CAPM with constant prices of risk

Our goal is to study the full three-factor conditional model with time-varying prices of risk. However, following prior research and to compare our results with Saleem and Vaihekoski (2007), we begin our analysis by assuming that the investors do not price the currency risk. In addition, we introduce the additional assumption that the prices of global and local market risk are constant.[8] This corresponds to equation (2) for the fully integrated world CAPM and equation (4) for the partially segmented APM specification.

Panel A in Table 3 contains QML estimates for the asset pricing models under full integration and partial segmentation. For full integration, the point estimate for the price of market risk is equal to 3.80 (*p*-value 0.098).[9] It is close to the value 3.60 that Saleem and Vaihekoski (2007) got using monthly data and sample period from 1995 to 2006. Unlike them, but similar to De Santis and Gérard (1998), the price of world risk is not found significant. This could be due to the different sample period or the weekly data used.

In the partial segmentation specification, where the risk premium for each country depends not only on the covariance with the world portfolio but also on country specific market risk factor, the price of world market risk is still 0.037 and insignificant. On the other hand, the price of local market risk coefficient is found to be -0.001 (*p*-value 0.987) for the USA, and 0.022 (*p*-value 0.006) for Russia. Thus, in line with the previous research, market specific risk does not seem to be priced on the US market, whereas it is highly significant in Russian market, supporting the partially segmented APM for emerging markets.

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[8]   This restriction has been imposed in many studies of the conditional CAPM (e.g., Giovannini and Jorion, 1989; Chan et al., 1992).

[9]   Reported value 0.038 due to percentage returns used.

The estimated parameters for the GARCH process (i.e., all elements in the vectors **a** and **b**) are all statistically significant, making the variance process clearly time-varying. In addition, the estimates satisfy the stationarity conditions for all the variance and covariance processes. Moreover, in line with the studies that use GARCH models all processes display high persistence and the estimates of the b_i coefficients (which link second moments to their lagged value) are considerably larger than the corresponding estimates of the a_i which link second moments to their past innovations (shocks).

Panel B of Table 3 shows some diagnostic test statistics for the standardized residuals, defined as $z_t = \varepsilon_t / \sigma_t$. Theoretically they should be mean zero with unit variance if the model is correctly specified. There is clear evidence of misspecification for the Russia in the fully integrated specification as the average standardized residual (0.133) clearly deviates from zero. Interestingly, this problem disappears for the most part in the partial segmentation model (average standardized residual is 0.022). This is another indication that the model is better specified if market specific risk is included. The rest of the diagnostics are similar for both specifications. The values for skewness and kurtosis for the standardized residuals are highly significant for both markets. The same is true for the Jarque-Bera test statistic which leads to reject the hypothesis of normality in all cases. Overall these results suggest that, although the GARCH parameterization can accommodate some of the kurtosis in the data, the evidence against normality warrants the use of QML inferential procedures in our analysis.

4.2 Conditional international CAPM with time varying price of global risk

Next, we estimate a model where we allow the price of world risk to be time-varying. Table 4 shows the quasi-maximum likelihood estimates of the conditional international CAPM with time-varying price of global risk where the U.S. and Russia are assumed to be either fully integrated to the world market or partially segmented. The price of world risk is a linear function of four global instrument variables besides the constant, namely the world index dividend yield in excess of the one-month Eurodollar rate (XDYD), the change in the U.S. term premium (ΔUSTP), the change in the one-month Eurodollar rate (ΔEuro$), and the U.S. default premium (USDP). All information variables are demeaned in the estimation.

The parameter estimates are very similar between the full integration and the partial segmentation specifications. The constant parameters for the world price of risk are equal to 0.043 and 0.041, but are still insignificant at conventional 5 percent level of significance (p-values 0.079 and 0.094). Since the information variables have been demeaned, the constant can be interpreted as the average unconditional value for the price of world covariance risk.

Three out of four information variables are found to be significant predictors for the price of world risk under partially segmented model, namely the excess dividend yield (p-value 0.004), long term US term premium (p-value 0.003) and one month euro dollar deposit (p-value 0.054). The Wald $\chi^2(4)$ clearly rejects the null of joint insignificance indicating – similar to De Santis and Gérard (1998) – that the price of world covariance risk is time-varying.

In the segmented version of the CAPM, the coefficient for market specific risk for USA is -0.001 (p-value 0. 977) and for Russia 0.22 (p-value 0.006) reveals the same story as in the previous model. Consistent with our expectations, we have clear evidence in favor of the hypothesis that the local risks is needed to price returns in the Russian market, however, US market does not account for the domestic risk.

Moreover, the results show that the conditional second moments are appropriately described by the multivariate GARCH process discussed earlier in the paper. Again, all the parameters in the vectors **a** and **b** are highly statistically significant for both markets. The point estimates reveal that all the variance and covariance processes in H_t are stationary and highly persistent. Finally, the magnitude of b_i and a_i's coefficients is also found appropriate.

The misspecification statistics in Panel B of Table 4 are very much in line with the corresponding statistics reported in Table 3, confirming again that the GARCH (1, 1) specification that we use is flexible enough to capture the dynamics of the conditional second moments and the use of QML inferential procedures is justified.

4.3   Conditional partially segmented IAPM with currency risk

As stated before, the currency movements have played an important role in the Russian economy and Russian companies as well as for the investors. This suggests *a priori* that the foreign

exchange risk may be priced in the Russian stock market. To test this, we add the currency risk component into our partially segmented model, i.e. equations (8)–(11). Furthermore, we allow all prices of risk to be time-varying with the exception of the price of local market risk in the USA. The global information set is similar to earlier specifications, but when modeling the price of currency risk we also utilize the global instrument set besides the two local information variables, ΔLRF and ΔOPEC. Moreover, the price of local market risk in Russia is conditioned on two local variables, XRDY and ΔEMBS. The parameter estimates are reported in Panel A of Table 5. Panel B shows results from the Wald-tests for the significance of the price of risk parameters as well as for the time variation in them.

The global market risk is found to be priced and time-varying (*p*-values from Wald-tests are less than 0.001 and 0.005, respectively). Similar to earlier studies, the results show that the currency risk is also priced in the Russian stock market. The constant terms for the price of currency risk -0.169 is highly significant. Due to demeaned information variables, the constant can again be interpreted as the unconditional average. Moreover, similar to the results of De Santis and Gérard (1998) the Wald test statistic reject assumption of constant price of currency risk (*p*-value is 0.003). Especially the two local variables are found to be driving the variation. Studying the signs of the two local instruments shows that higher oil prices tend to lower the price of fx-risk, whereas higher short-term interest rates in Russia increase the price. The signs of the local variables are as expected.

The local risk is found to be priced in the Russian stock market, but not on the US market, suggest that the partially segmented asset pricing model is suitable for the Russian market. In addition, our results suggest that the price of local market risk is time varying similar to Antell and Vaihekoski (2007). Hypothesis of constant specification is clearly rejected (*p*-value from Wald test is 0.001).

The magnitude and significance of the variance parameters (not reported) are very much in line with the values in previous tables. The misspecification diagnostics are reported in Panel C. Interestingly, the average standardized pricing errors for all assets seems to be smallest for this model giving further confidence for the model. In other respect, the results are in line with the corresponding diagnostics in previous tables.

4.4 Prices of risk and risk decomposition

The prices of world, currency and local Russian market risk were found significant and time-varying. Using the parameter estimates in Table 5 and the instrument variables, we can calculate the time series for the prices of risk and for the decomposed risk premia. Panel A in Table 6 shows the descriptive statistics for the three time-varying prices of risk as defined in equations (14a-c). The average price of world risk is 0.036. The price of local market risk for Russia averages to 0.034, while the currency price of risk parameter is negative, -0.166. The standard deviation is highest for the price of currency risk, and lowest for the local risk parameter. This can be seen if the conditional prices of risk are graphed (available upon request from the authors). They are all clearly time-varying.[10]

We can also calculate the conditional risk premium (excess return) implied by the asset pricing model. For this purpose we again use the parameter estimates from our ultimate model in Table 6. This risk premium can then be further decomposed into world and local premiums. For Russia there is also the currency premium. Descriptive statistics of the risk premia and its decomposition for the USA and Russia are shown in Panel B of Table 6.

The average monthly world risk premium is 0.087 per cent with a standard deviation of 0.548 per cent. The annualized values are 4.524 and 3.952 per cent, respectively. Especially the implied standard deviation is much lower than the annualized value reported in Table 2 (15.182 per cent). The average weakly US total risk premium is considerably less, 0.049 per cent per weak (annualized 2.548 per cent). It is clearly less that 6.5 per cent in De Santis and Gérard (1998). However, their sample covers different time period. While the historical standard deviation of the US equity premium data was 17.175 per cent, it is much lower for the estimated risk premium series, 4.312 per cent (0.598 per cent per week).

The average Russian equity risk premium is more than thirteen times that of the USA. On average it is 0.648 per cent per week (annualized 33.696 per cent) with a relatively low standard deviation of 12.172 per cent per annum (1.688 per cent per week) – three times that of the USA. It seems that our formulation is able to produce fairly realistic estimates for the equity market risk premium with reasonable standard deviation at least in-sample.

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[10] Note, however, that these series have been created with all information variables, not just those that were found significant. Thus, part of the variation can be said to be pure noise.

We can also use our model to calculate conditional world betas for Russia and the USA. Dividing the world component of the Russian and the US implied risk premium with the implied world risk premium, we get the conditional world beta. Figure 6 shows the implied time-varying world betas for Russia and the USA. As expected, the conditional world beta for the US is close to one throughout the sample period (average 1.009). However, conditional world beta for the Russian varies much more across time, even though the average is less than for the US, 0.834. The same result can be observed using simple rolling beta approach. Observing lower world beta for Russia is most likely caused by the lower exposure to global risks, and higher exposure to local risks.

5   SUMMARY AND CONCLUSIONS

In this paper we study the world asset pricing models and the pricing of global, local, and currency risk in the Russian and US stock markets using weekly data from 1999 to 2006. We start our investigation after the Russian currency crises, as the period leading to the crisis can be considered as exceptional and even chaotic. We take the view of a US investor investing both domestically and internationally. All returns are expressed in US Dollars. Our main interest is the pricing in the Russian stock market as it offers an interesting test laboratory for many aspects of the international asset pricing models.

In our empirical specification, we utilize the multivariate GARCH-M framework of De Santis and Gérard (1998). The pricing model is specified using the price of risk specification. Initially, we assume that the prices of risk as constant, but our main interest is in models where we allow the prices of risk to be time-varying.

The results show that the unconditional price of world risk is positive with a reasonable, but insignificant value, which is in line with De Santis and Gérard (1998). Using a time-varying specification for the price of world and currency risk, we find the global risk to be time-varying. Currency risk also found to be priced and highly time varying in the Russian stock market. Furthermore, our results show that the Russian stock market prices the domestic risk and that the price is time-varying, whereas the local risk is not priced for the USA market. These findings are partly conflicting with De Santis and Gérard (1997) who found that the local risk was not priced in any of the major developed stock markets in their study. On the other hand, our results are consistent with Antell and Vaihekoski (2007) who found the local risk to be priced in a small

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stock market, namely Finland. Hence one should consider partially segmented asset pricing models for emerging stock markets.

Finally, the model implies a continuously compounded risk premium of 4.524 percent per annum for the world equity market and 2.548 per cent per annum for the US market on average. Corresponding average in-sample risk premium for the Russian equity market is surprisingly high, 33.696 per cent, which is almost 13 times higher then that of USA. The biggest impact on the US risk premium is coming from the world risk component whereas the Russian risk premium is on average caused mostly by the local and currency risk components.

The implications of our results are very useful for both companies and international investors who are interested to invest in emerging markets or diversify their portfolios internationally. For instance, our results confirm the need of an appropriate model specification which takes into account both currency risk and local market risk as independent pricing factors. In particular, one has to separate local market risk from the currency risk in investment and risk management decisions in the context of emerging markets because of their unique market features and more volatile exchange rates. Finally, low level of international integration of Russian market and implied high expected returns, at least within our sample, make the Russian market very attractive for international investors.

We believe that emerging markets need further research in regards of different sources of risks associated with them. It would be especially interesting to study the out-of-sample performance of these models and to examine the implications for the asset management. However, these questions are left for future study.

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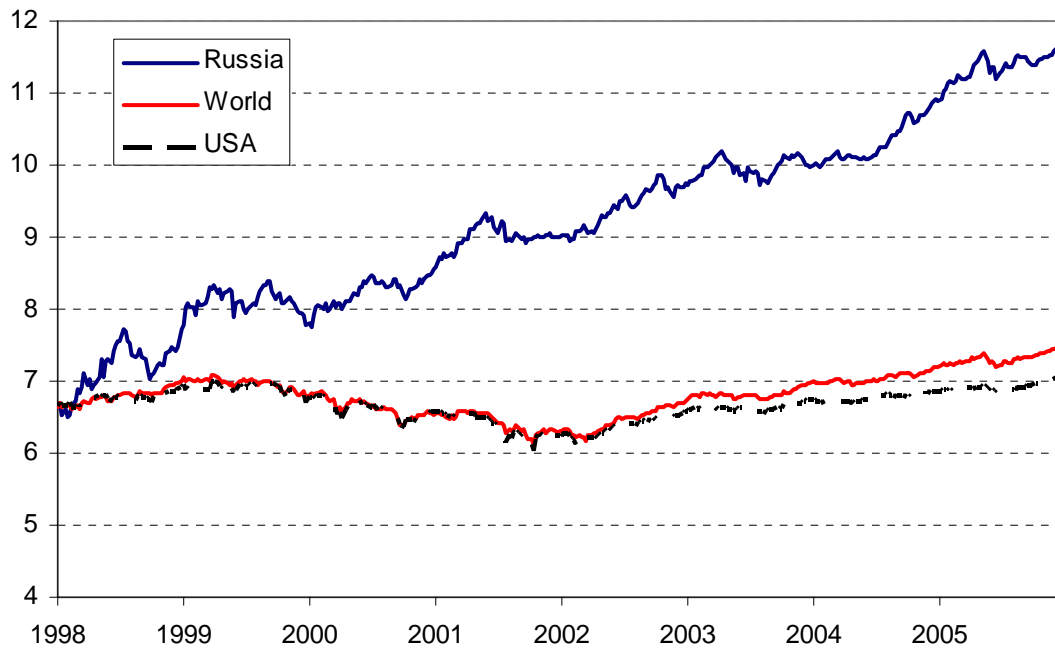
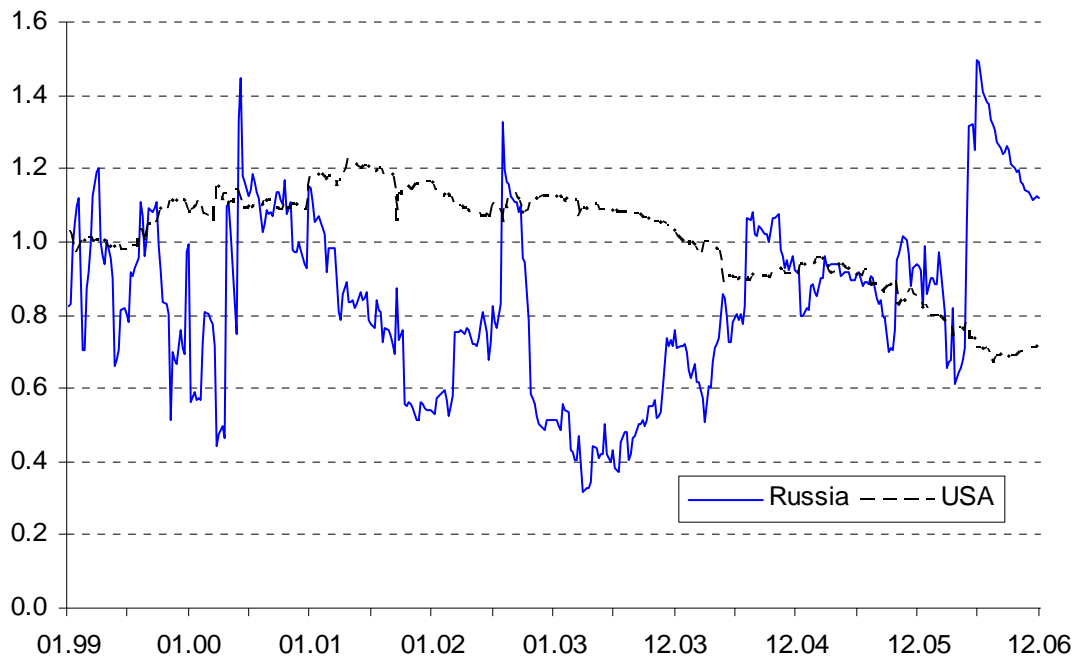**Figure 1. Development of weekly global, US and Russian equity market indices in USD terms from 1999 to 2006.** Graph shows the log base-2 of indices scaled to start from 100 (December 30, 1998).
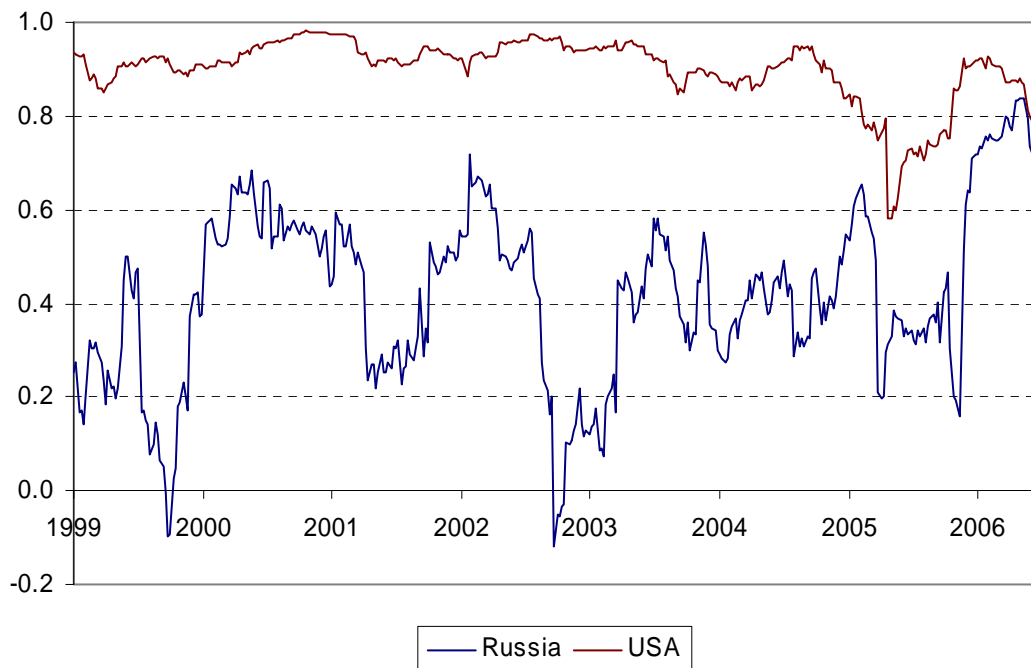
Figure 2. Six month (26 week) rolling correlation between Russia and USA against the world market portfolio.

Figure 3. Time-varying world betas for the US and Russian stock markets (based on parameter estimates in Table 5).

Table 1. Descriptive statistics for the weekly asset returns.

Descriptive statistics are calculated for the weekly asset continuously compounded returns. The global market portfolio is proxied by the DataStream world index. The US market return is proxied by the DataStream US index in USD. The Russian market return is proxied by the DataStream Russian index in USD. USD/RUB is the logarithmic difference in the USD value of one Ruble. The Risk-free rate is proxied by the one month Eurodollar rate. All returns are measured in USD. The mean and standard returns are annualized (multiplied with 52 and the square root of 52, respectively). The sample size is 417 weekly observations from January 1999 to December 2006. The p-value for the Jarque-Bera test statistic of the null hypothesis of normal distribution is provided in the table. Q(26) and Q^2(26) are the Ljung-Box (1978) statistics for the (squared) returns. ARCH LM test (p-value reported) is to check the ARCH effect up to lag 5.

Assets	Mean (%)	Std. dev. (%)	Skewness	Excess Kurtosis	Normality (p-value)	Autocorrelation[a] ρ_1	ρ_2	ρ_3	Q(26)[b]	Q^2(26)[b]	ARCH LM[b]
Panel A: Summary statistics											
World market portfolio	7.285	15.182	-0.358	4.209	<0.001	-0.055	0.004	0.122	0.259	<0.001	<0.001
U.S.	3.610	17.175	0.021	4.807	<0.001	-0.123*	-0.006*	0.088*	0.027	<0.001	<0.001
Russia	43.084	36.680	-0.428	5.489	<0.001	-0.052	0.018	0.036	0.124	<0.001	<0.001
USD/RUB	-0.031	0.060	-4.580	41.303	<0.001	-0.006	0.064	-0.048	<0.001	0.047	0.127
Risk-free rate (Eurodollar)	3.530	0.267	0.110	1.514	<0.001	0.997**	0.993**	0.990**	<0.001	<0.001	<0.001
Panel B: Pairwise correlations	World	USA	Russia	USD/RUB	Risk-free rate						
World market portfolio	1	0.920	0.403	0.087	-0.030						
USA		1	0.286	0.010	-0.012						
Russia			1	0.122	0.001						
USD/RUB				1	-0.088						
Risk-free rate					1						

[a] Autocorrelation coefficients significantly (1%, 5%) different from zero are marked with asterisks (**, *).

[b] The p-value for the Ljung and Box (1978) test statistics for the null that autocorrelation coefficients up to 26 lags are zero.

Table 2. Descriptive statistics of the weekly information variables data.

The global information set contains: world index dividend yield in excess of one-month Eurodollar rate (XDYD), the change in the U.S. term premium (ΔUSTP), the change in the one-month Eurodollar rate (ΔEuro$), and the U.S. default premium (USDP). The local information set for Russia contains the following variables: Dividend yield for the Russian equity index in excess of one-month Eurodollar rate times 100 (XRDY), change in emerging market bond index spread for Russia (ΔEMBS), change in the RUB price of oil (ΔOPEC), and the change in the one-month Russian interbank interest rate (ΔLRF). All variables are lagged by one month The sample size is 417 weekly observations from January 1999 to December 2006.

Information variables	Mean	Standard Deviation	Skewness	Excess Kurtosis	Normality (p-value)	Autocorrelation[a]				Q(26)[b]
						ρ_1	ρ_2	ρ_3	ρ_{12}	
Panel A: Summary statistics										
XDYD	0.980	0.151	-0.574	2.048	<0.001	0.995*	0.990*	0.985*	0.839*	<0.001
ΔUSTP	-0.001	0.134	0.833	7.487	<0.001	0.005	0.083	0.117*	0.057	0.228
ΔEuro$	0.000	0.002	-1.550	41.699	<0.001	0.168*	0.207*	0.117*	0.097*	<0.001
USDP	0.917	0.205	0.836	2.970	<0.001	0.977*	0.952*	0.926*	0.576*	<0.001
XRDY	0.669	0.215	0.868	3.554	<0.001	0.972*	0.941*	0.909*	0.176*	<0.001
ΔEMBS	0.006	0.030	0.514	11.010	<0.001	-0.028	-0.112	0.250*	0.032*	<0.001
ΔOPEC	0.005	0.045	-0.458	4.667	<0.001	0.109*	0.037	0.073*	0.042	0.080
ΔLRF	-0.002	0.038	-0.656	25.239	<0.001	-0.038	-0.181*	-0.068*	-0.058*	0.005
Panel B: Pairwise correlations	XDYD	ΔUSTP	USDP	ΔEuro$	XRDY	ΔEMBS	ΔOPEC	ΔLRF		
XDYD	1	-0.031	0.449	0.053	0.430	-0.115	-0.057	0.048		
ΔUSTP		1	0.033	-0.248	0.070	-0.107	0.014	-0.048		
USDP			1	-0.077	0.346	-0.037	0.001	0.037		
ΔEuro$				1	-0.136	-0.070	0.055	0.156		
XRDY					1	0.020	-0.056	0.039		
ΔEMBS						1	0.087	-0.106		
ΔOPEC							1	0.015		
ΔLRF								1		

[a] Autocorrelation coefficients significantly (5%) different from zero are marked with an asterisk (*).

[b] The *p*-value for the Ljung and Box (1978) test statistic for the null that autocorrelation coefficients up to 26 lags are zero.

Table 3. Conditional fully integrated and partially segmented ICAPM with constant prices of risk

Quasi-maximum likelihood estimates of the conditional international CAPM with constant prices of risk, where the U.S. and Russia are assumed to be either fully integrated to the world market or partially segmented which leads to a two-factor model. In the latter case, the empirical pricing equation is as follows

$$r_{i,t+1} = \lambda_m^w \text{Cov}_t(r_{i,t+1}, r_{m,t+1}^w) + \lambda_m^l \text{Cov}_t(r_{i,t+1}, r_{m,t+1}^l) + \varepsilon_{i,t+1}$$

where λ^w and λ^l are prices of world and local market risk, respectively. Stacked residuals from the three mean equations, $\boldsymbol{\varepsilon}_{i,t+1}$, are assumed to be distributed IID($\mathbf{0}$, $\mathbf{H}_{t+1}$). The conditional covariance matrix $\mathbf{H}_{t+1}$ follows GARCH(1,1) specification as in Ding and Engle (2001). The sample size is 417 weekly observations from January 1999 to December 2006. Data for the country indices and the world portfolio are calculated by Datastream. Continuously compounded returns are in excess of the local risk-free rate of return (one-month holding period return on Eurodollar in London) and in percentage form, measured in US dollar. QML standard errors are in parentheses. Coefficients significantly (5% or 1%) different from zero are marked with an asterisk (*) and two asterisks (**).

	Full Integration				Partial Segmentation		
	U.S.	Russia	World		U.S.	Russia	World
Panel A: Parameter estimates							
World market price of risk, λ_w			0.038				0.037
			(0.023)				(0.023)
Local market price of risk, λ_l					-0.001	0.022**	
					(0.007)	(0.008)	
a_i	0.228**	0.171**	0.227**		0.232**	0.169**	0.231**
	(0.036)	(0.037)	(0.034)		(0.036)	(0.035)	(0.034)
b_i	0.968**	0.983**	0.964**		0.966**	0.983**	0.963**
	(0.013)	(0.009)	(0.015)		(0.013)	(0.009)	(0.015)
Panel B: Diagnostic tests							
Average standardized residual	-0.063	0.133	-0.031		-0.062	0.022	-0.030
Standard deviation of z	0.96	0.98	0.98		0.96	0.98	0.98
Skewness of z	-0.19	-0.41**	-0.47**		-0.19	-0.42**	-0.47**
Excess kurtosis of z	0.73**	1.59**	0.74**		0.73**	1.62**	0.74**
Jarque-Bera test for normality	11.11**	53.57**	24.00**		11.19**	56.10**	24.06**
Q(26)	34.49	18.72	29.43		34.40	18.54	29.49
Q²(26)	25.95	29.82	26.30		25.49	28.30	25.84
Absolute mean pricing error	1.78	3.74	1.59		1.78	3.67	1.59
Likelihood function		-6.280				-6.270	

Table 4. Conditional fully integrated and partially segmented ICAPM with time-varying price of global risk

Quasi-maximum likelihood estimates of the conditional international CAPM with time varying price of global market risk where the U.S. and Russia are assumed to be either fully integrated to the world market or partially segmented which leads to a two-factor model. The price of global market risk is a linear function of conditioning global instrument variables, $\lambda_{m,t+1}^w = \mathbf{Z}_t^w \mathbf{\kappa}_w$. The global instruments include a constant, the world index dividend yield in excess of the one-month Eurodollar rate (XDYD), the change in the U.S. term premium (ΔUSTP), the change in the one-month Eurodollar rate (ΔEuro\$), and the U.S. default premium (USDP). In the case of segmented APM, the empirical pricing equation is as follows

$$r_{i,t+1} = \lambda_{m,t+1}^w \text{Cov}_t(r_{i,t+1}, r_{m,t+1}^w) + \lambda_m^l \text{Cov}_t(r_{i,t+1}, r_{m,t+1}^l) + \varepsilon_{i,t+1}$$

where λ^w and λ^l are prices of world and local market risk, respectively. Stacked residuals from the three mean equations, $\varepsilon_{i,t+1}$, are assumed to be distributed IID($\mathbf{0}$, $\mathbf{H}_{t+1}$). The conditional covariance matrix $\mathbf{H}_{t+1}$ follows GARCH(1,1) specification as in Ding and Engle (2001). The sample size is 417 weekly observations from January 1999 to December 2006. Data for the country indices and the world portfolio are calculated by Datastream. Continuously compounded returns are in excess of the local risk-free rate of return (one-month holding period return on Eurodollar in London) and in percentage form, measured in US dollar. QML standard errors are in parentheses, p-values in brackets. Coefficients significantly (5% or 1%) different from zero are marked with an asterisk (*) and two asterisks (**).

	Full Integration			Partial Segmentation		
	U.S.	Russia	World	U.S.	Russia	World
Panel A: Parameter estimates						
World market price of risk, λ_w						
Constant, κ_0			0.043			0.041
			(0.025)			(0.025)
Excess dividend yield, κ_{XDYD}			0.224**			0.229**
			(0.079)			(0.079)
Default premium, κ_{USDP}			-0.193			-0.195
			(0.152)			(0.151)
ΔOne-month rate, $\kappa_{\Delta Euro\$}$			31.301			32.336**
			(16.300)			(16.753)
ΔLong term premium, $\kappa_{\Delta USTP}$			0.572**			0.578**
			(0.192)			(0.191)
Local market price of risk, λ_l				-0.001	0.022**	
				(0.008)	(0.008)	
a_i	0.208**	0.174**	0.208**	0.211**	0.171**	0.211**
	(0.046)	(0.047)	(0.050)	(0.043)	(4.151)	(0.045)
b_i	0.974**	0.982**	0.971**	0.974**	0.983**	0.970**
	(0.015)	(0.012)	(0.020)	(0.014)	(0.011)	(0.018)
Panel B: Diagnostic tests						
Average standardized residual	-0.052	0.137	-0.022	-0.047	0.025	-0.017
Standard deviation of z	0.960	0.970	0.990	0.96	0.98	0.99
Skewness of z	-0.150	-0.400**	-0.440**	-0.15	-0.41**	-0.43**
Excess kurtosis of z	0.750**	1.520**	0.960**	0.74**	1.55**	0.96**
Jarque-Bera test for normality	10.820**	49.330**	28.120**	10.57**	52.10**	28.24**
Q(26)	32.360	18.570	21.710	32.15	18.57	21.60
Q^2(26)	27.630	30.050	25.900	27.69	28.45	25.53
Absolute mean pricing error	1.700	3.770	1.530	1.70	3.69	1.53
Likelihood function		-6.250			-6.241	

Panel C: Robust Wald tests for joint significance

	Integrated model		Part. segmentation	
Price of world market risk is constant, χ^2(4)	16.646**	[0.002]	16.658**	[0.002]
Asset specific risk not priced, χ^2(2)			8.183**	[0.017]

Table 5. Conditional partially segmented ICAPM with time-varying prices of global, currency, and local risk.

Quasi-maximum likelihood estimates of a three-factor conditional international CAPM with time varying price of global and currency risk where the U.S. and Russia equity markets are assumed to be partially segmented. The prices of risk are linear functions of conditioning instrument variables. The global instrument set includes a constant, the world index dividend yield in excess of the one-month Eurodollar rate (XDYD), the change in the U.S. term premium (ΔUSTP), the change in the one-month Eurodollar rate (ΔEuro\$), and the U.S. default premium (USDP). Currency instrument set includes also the change in crude oil prices in Rubles (ΔOPEC) and the change in the one-month Russian interest rate (ΔLRF). The price of Russian local market risk is conditioned on the Russian dividend yield in excess of the one-month Eurodollar rate (RXDY) and the change n emerging market bond index spread for Russia (ΔEMBS). The empirical pricing equation is as follows

$$r_{i,t+1} = \lambda_{m,t+1}^w \mathrm{Cov}_t(r_{i,t+1}, r_{m,t+1}^w) + \lambda_{c,t+1}\mathrm{Cov}_t(r_{i,t+1}, f_{c,t+1}) + \lambda_{m,t+1}^l \mathrm{Cov}_t(r_{i,t+1}, r_{m,t+1}^l) + \varepsilon_{i,t+1}$$

where lamdas denote the time-varying prices of world, currency, and local risk, all linear on the abovementioned information variables. Stacked residuals from the four mean equations are assumed to be distributed IID($\mathbf{0}$, $\mathbf{H}_{t+1}$). The conditional covariance matrix $\mathbf{H}_{t+1}$ is assumed to be a GARCH(1,1) process parameterized following Ding and Engle (2001) specification. The sample size is 417 weekly observations from January 1999 to December 2006. Data for the country equity indices and the world portfolio are calculated by Datastream. Continuously compounded returns are in excess of the local risk-free rate of return (one-month holding period return on Eurodollar in London). All returns are in percentage form, measured in US dollar. QML standard errors are in parentheses, p-values in brackets. Coefficients significantly (5% or 1%) different from zero are marked with an asterisk (*) and two asterisks (**).

Panel A. Parameter estimates for the prices of risk

	Constant	XDYD	USDP	ΔEuro\$	ΔUSTP	ΔLRF	ΔOPEC	RXDY	ΔEMBS
Partially segmented APM									
Price of world risk, λ_{wt}	0.036	0.234**	-0.244*	33.975*	0.627**				
	(0.026)	(0.079)	(0.136)	(19.382)	(0.217)				
Price of currency risk, λ_{ct}	-0.169*	0.176	-0.695*	10.693	-0.071	2.925**	-2.490**		
	(0.084)	(0.175)	(0.361)	(28.762)	(0.309)	(1.271)	(0.986)		
Constant price of local risk, λ_l									
USA	-0.004								
	(0.009)								
Price of local risk, λ_{lt}									
Russia	0.034**							0.087*	-1.053**
	(0.011)							(0.044)	(0.363)

Panel B: Robust Wald-tests

Is the price of global market risk priced, $\chi^2(5)$?	22.809	[<0.001]
Is the price of global market risk time-varying, $\chi^2(4)$?	14.859	[0.005]
Is the price of currency risk priced, $\chi^2(7)$?	49.723	[<0.001]
Is the price of currency risk time varying, $\chi^2(6)$?	19.980	[0.003]
Are the constants of asset specific risk jointly equal to zero, $\chi^2(2)$?	10.458	[0.005]
Is the price of Russian market risk priced, $\chi^2(3)$?	11.323	[0.003]
Are all the parameters of asset specific risk jointly equal to zero, $\chi^2(4)$?	18.697	[0.001]

Panel C: Diagnostic tests

	USA	Russia	Currency	World
Average standardized residual	-0.027	0.025	-0.044	-0.005
Standard deviation of z	0.960	0.970	1.060	0.980
Skewness of z	-0.130	-0.330	-3.010	-0.410
Excess kurtosis of z	0.780**	1.820**	30.980**	0.960**
Jarque-Bera test for normality	11.160**	62.950**	<99.999**	27.020**
Q(26)	20. 940*	5.260	25.170**	12.610
Q²(26)	20.670*	14.340	0.250	24.360*
Absolute mean pricing error	1.690	3.420	0.450	1.530
Likelihood function	-7.107			

Table 6. Descriptive statistics for the price of world risk, currency risk and local risk, and risk premium decomposition

Panel A reports the implied conditional prices of risk. Panel B reports the implied risk premiums for the USA and Russia. The risk premiums are based on the parameter estimates for the partially segmented model specification with time-varying global, local, and currency risk in Table 5.

	Mean	Std. dev.	Skewness	Excess kurtosis	Minimum	Maximum
Panel A: Implied price of risk						
Price of world risk, λ_{wt}	0.036	0.119	0.017	0.841	-0.390	0.568
Price of currency risk, λ_{ct}	-0.166	0.250	8.442	128.478	-0.672	3.638
Price of local risk, λ_{lt}	0.034	0.065	0.705	6.071	-0.142	0.429
Panel B: Implied risk premium						
Risk premium for the World						
Total risk	0.087	0.548	-0.007	3.104	-2.059	2.629
Risk premium for the USA						
Total risk	0.049	0.598	-0.022	3.541	-2.300	2.777
World component	0.068	0.596	0.020	3.603	-2.267	2.806
Local component	-0.019	0.010	-0.200	-1.215	-0.040	-0.006
Risk premium for Russia						
Total	0.648	1.688	0.983	11.436	-6.256	14.405
World component	0.050	0.451	-1.195	6.712	-2.985	1.638
Currency component	-0.120	0.334	-3.757	19.311	-2.462	1.345
Local component	0.726	1.638	1.514	13.448	-5.314	14.605