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SYSTEMATIC RISK DURING 2008–2009 RECESSION IN EMERGING MARKETS: SOME EVIDENCE FROM V3 AND BALTIC ECONOMIES

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Abstract. Abrupt and profound swings in economic activity can result in changes in systematic component of risk premia of capital market assets. This can translate into adjustments in risk perception by the market agents, which may lead to significant changes in real investment development. We examine the issue of time-varying systematic risk on a micro level using the capital asset pricing model in an intertemporal setting. We formulate the hypothesis within a bivariate GARCH-in-mean model, which enables us to estimate the time-varying variances and covariances of the respective assets and market returns and thus the time-varying sensitivity to systematic risk. The results of the paper show that the reaction of assets' sensitivity to systematic risk varies across the sample and the changes were rather temporary. Based on the results, the downturn in economic activity witnessed in 2008 – 2009 should not be a drag on real investment.

Key words: CAPM, multivariate GARCH-in-mean, risk premium, time-varying beta.

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Introduction

Modern financial economic theory focuses primarily on assessing riskiness of various kinds of assets. This theoretical approach has been significantly supported by the world financial crises. The paper presents an estimation of time-varying sensitivities to systematic risk as captured by the beta coefficient in the standard capital asset pricing model (CAPM) framework. Our analysis is applied to V3 countries: the Czech Republic, Hungary, Poland and Baltic countries: Estonia, Latvia and Lithuana. Due to data insufficiency it was impossible to carry out the analysis for Slovakia. We follow two goals by pursuing such an issue.

First, the perception of systematic risk by market participants plays a prominent role in the decision making process concerning real investments. Higher sensitivity to systematic risk (higher CAPM beta) may translate into higher systematic risk as a whole and thus increase the cost of capital or/and limit the funds available to firms for investment. Part of this is implied by the Tobin's Q-theory, Hayashi (1982), and is also reflected in the production-based asset pricing theory, Cochrane (1991) and Cochrane (1996). This is closely linked to current approaches to examining the interlinkages between financial markets and real economy behavior within the intertemporal macroeconomic models, such as Bernanke, Gertler and Gilchrist (1999), Christiano, Motto and Rostagno (2005), Kiyotaki and Moore (2008), Gertler and Kiyotaki (2010). We are not able to explicitly test such a channel due to data limitations as will be apparent later in the paper.

Second, the estimates of time-varying CAPM beta coefficients provide useful information for investment projects evaluation. In this respect we think it is necessary to leave the static CAPM reasoning behind and fully appreciate the consequences the model has in a dynamic setting. Of course the notion of time-varying betas bears little significance for the evaluation of the long-term projects as the model presented cannot be principally used for out-of-sample predictions. However, the estimates we offer may be used indirectly in an analysis of short to midterm projects where the notion of time-varying betas in a recent history plays a role.

In a sense, modern models of financial economics were spurred by the formulation of consumption based asset pricing model (CCAPM) proposed independently by Lucas (1978) and Breeden (1979). It can be shown that all preceeding models of financial economics such as the classic CAPM by Sharpe (1964), Lintner (1965), (Mossin 1966) and Black (1972), Black-Scholes model put forward by Black Scholes (1973) and Merton (1973) and intertemporal capital asset pricing model by Merton (1973) are closely related to CCAPM. The analysis of risk premium has been at the center of attention since the issue of so-called equity premium puzzle coined by Mehra, Prescott (1985) and further extended by Weil (1989). The problem of equity premium puzzle points to the inability of standard representations of CCAPM to fit the data and the analysis of (time-varying) risk premium has been one of the dominant strands of research to solve the problem. The others focus on the specification of utility function and make use of either time inseparability such as Epstein, Zin (1989) or habit formation by Constantinides (1990) and Cochrane, Campbell (1999) or make use of heterogenous agents within the intertemporal framework which was in this context introduced by Constantinides, Duffie (1998). Generally modern intertemporal economic models focus on the interaction between the financial and real economy, relating the prices of financial assets to real factors, see for example Cochrane (2005) for a nice review.

Čihák, Mitra (2009) analyze the impact of the crisis on both financial and real sectors of emerging European economies. They present the increased risk by the higher sovereign spreads and show the dependance of higher sovereign spreads on both economic and financial risks.

Fedorova, Vaihekovski (2010) use a version of world CAPM and relate the excess returns of some of the eastern European stock markets to three sources of risk: global risk measured by the return of US stock market, emerging markets risk measured by aggregated emerging markets portfolio and exchange rate risk measured by trade-weighted US currency index and bilateral exchange rates to US dollar.

Guillaumin, Boukari (2010) use an international CAPM model and estimate capital market risk for several Central Eropean Economies which they decompose into global risk, currency risk and local risk. The estimate for the Czech economy puts most weight of the total price of risk on the price of currency risk.

The methodology used in the paper closely follows the analyses of Bali (2008), Bali and Engle (2010) who used multivariate GARCH-in-mean to estimate time-varying risk for both portfolios and individual issues on the US market. However, the theoretical model they build their analysis on is different. To our best knowledge, the application to Eastern European economies we present in this paper is novel and therefore we cannot directly compare the results with other studies.

The rest of the paper is organized as follows: in the first part necessary theoretical background to CAPM in an intertemporal framework is given, in the second part the econometrical model and data used in the estimations are presented, in the third part the results of the analysis are presented and the key findings are summarized in the conclusion.

1. Stochastic discount factor model and its restrictions

Stochastic discount factor model is based on a fundamental pricing equation, (see Smith, Wickens 2002); (Smith *et al* 2003 and Cuthbertson, Nitzsche 2004):

$$P_t = E_t\left[M_{t+1}X_{t+1}\right], \tag{1}$$

where P refers to a price of an asset at time t, E is an expectation operator, when expectations are taken with respect to information set available at time t, M is a stochastic discount factor transforming future pay-off X at time t+1 into price at time t. Thus, the price of an asset follows a stochastic process adapted to the available information set. The idea in equation (1) can be easily expressed using gross returns:

$$1 = E_t\left[M_{t+1}R_{t+1}\right], \tag{2}$$

where R_{t+1} is gross return on the asset between periods t and t+1. Applying formula for covariance and substituing for gross risk-free return, equation (2) can be further restated:

$$E_t\left(R_{t+1} - R_t^f\right) = -R_t^f \operatorname{cov}_t\left(M_{t+1}, R_{t+1} - R_t^f\right), \tag{3}$$

where R_t^f refers to gross risk-free return. If investors were risk-neutral, the expected gross return on an asset would be equal to gross risk-free return as the covariance term would be zero. In other words, gross excess returns would be zero. Therefore, risk-aversion is reflected by the covariance term and it is obvious that negative covariance between the stochastic discount factor and gross returns (or equivalently gross excess returns) pushes the expected gross returns on an asset above the gross risk-free return. The interpretation of the covariance term depends on the exact formulation of the model. Below a restriction on (2) leading to CAPM is pursued.

To derive the classic CAPM relation, the stochastic discount factor is assumed to be a linear function of return on wealth, see Cochrane (2001) or Duffie (2001) for a rigorous theoretical treatment:

$$M_{t+1} = a_t + b_t R_{t+1}^W, \tag{4}$$

where R_{t+1}^W is a gross return on wealth between periods t and t+1. Substituing for the stochastic discount factor in (3), the result may be stated as:

$$E_t\left(r_{t+1} - r_t^f\right) = \rho_t \operatorname{cov}_t\left(r_t^W - r_t^f, r_{t+1} - r_t^f\right), \tag{5}$$

where small letters denote simple (not gross) returns and ρ is a parameter dependent on risk-free rate and b from (4), which are both time-variant but known at time t. From equation (5) it is clear that the excess returns of an asset, the risk premium, is generated by the covariance between the (excess) returns on wealth and (excess) returns on an asset. This covariance is referred to as systematic risk and it is time-varying. Equation (5) can be easily restated as a beta model, for a comprehensive analysis of stochastic discount factor models see Cochrane (2001) or Cuthbertson, Nitzsche (2004):

$$E_t\left(r_{t+1} - r_t^f\right) = \frac{\operatorname{cov}_t\left(r_t^W - r_t^f, r_{t+1} - r_t^f\right)}{\operatorname{var}_t\left(r_t^W - r_t^f\right)} \rho_t \operatorname{var}_t\left(r_t^W - r_t^f\right) \equiv \beta_t E_t\left(r_{t+1}^W - r_t^f\right). \tag{6}$$

Thus, beta is expressed as a ratio of covariance between (excess) returns on wealth and (excess) returns on an asset and variance of (excess) returns on wealth. It is straightforward that beta is just an expression for a probability limit of a regression coefficient of a model where (excess) retuns on an asset are regressed on (excess) returns on wealth. The return on wealth is normally proxied by a return on market portfolio. The fact that all the parameters of the model are time-varying is crucial for both correct estimation of such a model and application of the model for analysis of financial markets. Indeed, in the original formulation of CAPM by Sharpe (1964) the model was static and, thus, all the coefficients were time-invariant. Although the CAPM formula was derived for real returns, it will be tested in nominal terms as daily data will be used.

2. Multivariate GARCH-in-Mean model and data

The approapriate test of the models requires estimating time-varying covarriance terms in a multidimensional setting. Multivariate GARCH-in-Mean accompanied by the BEKK model for the variance-covariance matrix by (Engle, Kroner 1995) is used in this paper. The mean equation takes on a form:

$$\mathbf{x_{t+1}} = \boldsymbol{\mu} + \boldsymbol{\lambda} vech\{\mathbf{H_t}\} + \boldsymbol{\varepsilon_{t+1}}, \tag{11}$$

$$\boldsymbol{\varepsilon_{t+1}} / I_t \sim N(\mathbf{0}, \mathbf{H_{t+1}}), \tag{12}$$

$$\mathbf{H_{t+1}} = \boldsymbol{\Omega}'\boldsymbol{\Omega} + \boldsymbol{\beta}'\mathbf{H_t}\boldsymbol{\beta} + \boldsymbol{\alpha}'\boldsymbol{\varepsilon_t}'\boldsymbol{\varepsilon_t}\boldsymbol{\alpha}, \tag{13}$$

where **x** is a vector of endogenous variables, **μ** is a vector of constants, **λ** is a matrix of coefficients whose first row is restricted to comply with the particular model and other elements are set to zero, *vech* is a mathematical operator which transforms the lower triangular component of matrix **H** into a vector, **ε** is a vector of residuals which follow multidimensional normal distribution with time-variant variance-covariance matrix **H**, **Ω** is a lower triangular matrix, **β** is a diagonal matrix and **α** is a diagonal matrix. Kočenda, Poghosyan (2010) use the framework of multivariate GARCH-in-mean to estimate time-varying risk premium in the foreign exchange market.

Vector **x** has two components in the estimation of CAPM (excess nominal returns on an asset and excess nominal returns on market). Matrix **λ** is 2×2 in case of CAPM and λ_{11} is set zero as there is no variance term in equation (5). Other restrictions of the matrices **Ω**, **β**, **α** are in the form of lower triangularity or diagonality which limits the number of estimated coefficients but the restrictions themselves are not in contradiction with the theory. Aktan *et al.* (2010) used a univariate GARCH models to capture the time-varying volatility of returns in Baltic economies.

In the first step of the analysis where time-varying risk premiums within the restriction of SDF model in the form of CAPM are estimated, daily data retrieved from Patria database and OMX web pages are used. The behavior of Prague Stock Exchange is captured by the evolution of the PX index, Budapest Stock Exchange is captured by the BUX index, Warsaw stock exchange by the WIG index and Baltic countries are captured by the common OMX index. The following table, Table 1, summarizes the individual assets used in the analysis. Based on our work, at least 5-year history is necessary for a satisfactory estimation. That is why not all issues entering a particular stock index could be used. As many data as possible were used in the analysis, therefore, the beginning of the sample is not the same in all cases. However, the end of the sample is October 31, 2011 for all the series. As far as the CAPM is concerned, there are two series which enter each model: excess nominal return on an asset and excess nominal return on market. Logarithmic approximation is used to compute the returns. To calculate the excess returns a proxy for risk-free asset is needed. Three month market interest rate is used in all four cases (in the case of Baltic countries an average of the three economies is used). The table below shows abbreviation, index and industry for every single company.

Table 1. The list of all observed companies

Code	Company	Index	Industry	Data since
KB	Komerční banka	PX	Finance	27.5.1998
CETV	Central European Media Enterprises	PX	Media	29.6.2005
CEZ	ČEZ	PX	Energetics	25.2.1999
EB	Erster Group Bank	PX	Finance	13.7.2004
ORCO	Orco Propety Group	PX	Development	3.3.2005
PM	Philip Morris ČR	PX	Tobacoo	10.11.2000
TEL	Telefónica Czech Republic	PX	Telecommunications	6.8.1998
UNI	Unipetrol	PX	Chemistry	6.1.1998
BAH	Bank Handlowy	WIG	Finance	10.8.2004
BAP	Bank Pekao	WIG	Finance	10.8.2004

End of Table 1

Code	Company	Index	Industry	Data since
BRE	BRE Bank	WIG	Finance	10.8.2004
GETH	Getin Holding	WIG	Finance	10.8.2004
GLOBT	Globe Trade Ct	WIG	Development	10.8.2004
GRUPL	Grupa Lotos	WIG	Oil and gas	13.6.2005
KGHM	KGHM	WIG	Heavy industry	10.8.2004
KOEL	Kernel Holding	WIG	Agriculture	12.2.2004
PBG	PBG	WIG	Construction	10.8.2004
PGNIG	Polskie Górnictwo Naftowe i Gazownictwo	WIG	Oil and gas	24.10.2005
PKNO	PKN Orlen	WIG	Oil and gas	10.8.2004
PKOB	PKO Bank Polski	WIG	Finance	15.11.2004
TELP	Telekom Polska	WIG	Telecommunications	10.8.2004
ESZM	Eszak Magyar	BUX	Media	9.8.2004
FHB	FHB Jelzalogbank	BUX	Finance	9.8.2004
GERI	Gedeon Richter	BUX	Healthcare	9.8.2004
MOLM	MOL Magyar Olai	BUX	Oil and gas	9.8.2004
MTEL	Magyar Telekom	BUX	Telecommunications	9.8.2004
OTPB	OTP Bank	BUX	Finance	9.8.2004
RABA	Raba Automotive	BUX	Engineering	9.8.2004
SYNE	Synergon	BUX	IT	9.8.2004
TISZ	Tiszai Vegyi Kombinát	BUX	Chemistry	9.8.2004
PTR	Panevėžio statybos trestas	OMX Baltic	Development	1.5.2004
SFGAT	Silvano Fashion Group	OMX Baltic	Design	1.5.2004
SRS	Snoras	OMX Baltic	Finance	1.5.2004
TEO	TEO Lt	OMX Baltic	Telecommunications	1.5.2004

The analysis is carried out on annualized daily changes. Tables 2–5 give the basic characteristics of the series. One can see that half of the assets considered in the analysis realized negative excess returns on average. The distribution of all the series does not follow normal (the null of normal is rejected at 1% level by the standard Jarque-Bera test) and all of them are stationary (the null of unit root is rejected at 1% level by the standard ADF test except for inflation where it was rejected at 10% level).

Table 2. Czech Republic

	Mean	St. dev.	JB	ADF
PX – R^f	0,04016	3,95280	16210,74***	–48,051***
CETV – R^f	–0,30643	9,58513	16555,32***	–25,194***
CEZ – R^f	0,18995	5,30402	18899,47***	–42,653***
EB – R^f	–0,1574	7,19510	8849,83***	–30,871***
KB – R^f	0,05512	6,73060	18777,56***	–49,796***
ORCO – R^f	–0,41306	9,34410	14020,57***	–34,228***
PM – R^f	0,03399	4,65805	8018,32***	–50,907***
TEL – R^f	–0,04703	5,17859	5107,85***	–56,567***
UNI – R^f	0,03295	6,28562	10635,77***	–53,611***

Notes: Table shows means and standard deviations of the series. Then Jarque-Bera statistic and the t-statistic of augmented Dickey-Fuller test are given. The series are annualized daily changes.*, **, *** denotes rejection of the null at 10%, 5%, 1% level of significance, respectively.

Table 3. Hungary

	Mean	St. dev.	JB	ADF
BUX – R^f	–0,02335	4,61323	2558,41***	–31,536***
ESZM – R^f	0,01974	4,51451	4928,46***	–51,100***
FHB – R^f	–0,16078	6,36706	3801,32***	–43,543***
GERI – R^f	–0,00733	5,07945	546,08***	–32,667***
MOLM – R^f	0,01593	6,37809	1768,25***	–31,717***
MTEL – R^f	–0,13856	4,57063	2323,27***	–42,999***
OTPB – R^f	–0,10754	7,36918	2364,98***	–30,350***
RABA – R^f	–0,09575	5,78737	4252,32***	–41,835***
SYNE – R^f	–0,12114	6,84792	2384,51***	–40,162***
TISZ – R^f	–0,15558	5,35233	3604,51***	–45,957***

Notes: Table shows means and standard deviations of the series. Then Jarque-Bera statistic and the t-statistic of augmented Dickey-Fuller test are given. The series are annualized daily changes. *, **, *** denotes rejection of the null at 10%, 5%, 1% level of significance, respectively.

Table 4. Poland – Table shows means and standard deviations of the series. Then Jarque-Bera statistic and the t-statistic of augmented Dickey-Fuller test are given. The series are annualized daily changes

	Mean	St. dev.	JB	ADF
WIG – R^f	0,00956	4,39507	460,38***	–29,732***
BAH – R^f	–0,01931	5,28907	4608,12***	–38,850***
BAP – R^f	–0,01829	6,48183	1253,09***	–32,586***
BRE – R^f	0,08368	6,62333	1069,07***	–37,302***
GETH – R^f	0,14311	6,58261	3263,47***	–40,775***
GLOBT – R^f	–0,06026	7,17007	1181,03***	–42,543***
GRUPL – R^f	–0,05126	6,04755	925,56***	–35,531***
KGHM – R^f	0,15138	7,62477	1667,00***	–39,612***
KOEL – R^f	–0,03803	6,92008	2449,36***	–37,543***
PBG – R^f	0,03966	5,61989	702,18***	–41,397***
PGNIG – R^f	–0,02271	5,01985	170,33***	–31,147***
PKNO – R^f	0,03552	5,98736	291,83***	–31,788***
PKOB – R^f	–0,00679	5,75909	314,18***	–40,119***
TELP – R^f	0,03316	4,94551	549,29***	–45,567***

Notes: *, **, *** denotes rejection of the null at 10%, 5%, 1% level of significance, respectively.

Table 5. Baltic economies

	Mean	St. dev.	JB	ADF
OMX – R^f	–0,03244	3,37679	7013,99***	–37,510***
PTR – R^f	–0,01083	10,01613	1651849,3***	–40,085***
SFGAT – R^f	0,03476	9,40604	2371,21***	–34,730***
SRS – R^f	–0,45046	16,0544	4201721,3***	–43,201***
TEO – R^f	–0,14189	7,92961	118000,00***	–44,336***

Notes: Table shows means and standard deviations of the series. Then Jarque-Bera statistic and the t-statistic of augmented Dickey-Fuller test are given. The series are annualized daily changes. *, **, *** denotes rejection of the null at 10%, 5%, 1% level of significance, respectively.

3. Results

Tables 6–9 present the estimates of the bivariate GARCH-in-mean model laid out in part 2 of the paper. The parameter $\mu(1)$ is statistically insignificant in most cases and it is crucial for the relevance of the CAPM model. It means that there is no other variable which influences the excess returns on an asset (difference between returns on an asset and a risk-free rate) but the excess market returns (difference between returns on a market and a risk-free rate). On the other hand we observe at least 10% statistical significance of $\lambda(2)$ for the most surveyed companies. Therefore excessive return evidence is acknowledged. There is a strong proof of heteroskedasticity in the returns which is documented by the high significance of the estimated parameters of the BEKK equation.

Table 6. Czech Republic bivariate GARCH-in-mean model

	μ(1)	μ(2)	λ(2)	Ω(1)	Ω(2)	Ω(3)	β(1)	β(2)	α(1)	α(2)	Log-L	AIC
CETV	0,09266	0,12442*	0,00177	0,90827***	0,41500***	0,45950***	0,95681***	0,89917***	0,27145***	0,42348***	–9254,876	11,632
	(0,14392)	(0,07167)	(0,00116)	(0,06064)	(0,05996)	(0,05705)	(0,00281)	(0,00823)	(0,00955)	(0,01738)		
CEZ	0,24802*	0,16018***	0,00106*	0,84142***	0,35244***	0,31805***	0,94064***	0,94003***	0,30527***	0,32407***	–16408,73	10,304
	(0,13952)	(0,05137)	(0,00062)	(0,04155)	(0,02510)	(0,02069)	(0,00333)	(0,00331)	(0,00961)	(0,00911)		
EB	0,16098	0,12214*	0,00391**	0,63206***	0,39763***	–0,34427***	–0,95177***	–0,93372***	0,28957***	0,32951***	–9578,23	10,433
	(0,09881)	(0,06348)	(0,00156)	(0,04434)	(0,04023)	(0,02594)	(0,00279)	(0,00440)	(0,00879)	(0,01112)		
KB	0,18653	0,20476***	0,00338*	1,11210***	0,40258***	0,40695***	–0,92591***	–0,93461***	0,33944***	0,32455***	–18115,06	10,734
	(0,12481)	(0,05374)	(0,00201)	(0,03443)	(0,02602)	(0,02640)	(0,00245)	(0,00354)	(0,00632)	(0,00822)		
ORCO	0,05345	0,14840**	0,00289	0,73566***	0,14461***	–0,44103***	–0,95617***	–0,93272***	0,28819***	0,34934***	–9750,03	11,647
	(0,13744)	(0,07404)	(0,00195)	(0,04354)	(0,04747)	(0,04286)	(0,00260)	(0,00541)	(0,01039)	(0,01415)		
PM	0,11461	0,32230***	0,01153***	1,19794***	0,20060***	–0,51753***	0,94409***	0,92733***	0,20929***	0,34393***	–15116,85	10,894
	(0,09150)	(0,06288)	(0,00441)	(0,05701)	(0,02235)	(0,04095)	(0,00474)	(0,00573)	(0,00939)	(0,01315)		
TEL	0,12317	0,22185***	0,00614**	0,68769***	0,29745***	0,33648***	0,93643***	0,93665***	0,34479***	0,33877***	–17210,35	10,223
	(0,08852)	(0,04906)	(0,00246)	(0,01928)	(0,02660)	(0,01984)	(0,00200)	(0,00331)	(0,00630)	(0,00862)		
UNI	0,10901	0,23620***	0,00749***	4,12875***	2,43401***	0,00879*	0,45579***	–0,59721***	0,51799***	0,49244***	–19080,44	11,316
	(0,07784)	(0,07116)	(0,00189)	(0,06587)	(0,086248)	(0,00501)	(0,01781)	(0,01260)	(0,01423)	(0,01613)		

Notes:. The parameters follow the notation presented earlier in the paper. *, **, *** denotes rejection of the null at 10%, 5%, 1% level of significance, respectively. No statistically significant residual autocorrelation or ARCH is present in the residuals of the model.

Table 7. Poland bivariate GARCH-in-mean model.

	μ(1)	μ(2)	λ(2)	Ω(1)	Ω(2)	Ω(3)	β(1)	β(2)	α(1)	α(2)	Log-L	AIC
BAH	0,11542	0,12194*	0,00152*	0,92977***	0,11918***	0,33170***	0,95517***	0,97423***	0,23721***	0,20906***	–10063,64	11,351
	(0,11631)	(0,06737)	(0,00081)	(0,07978)	(0,03198)	(0,04943)	(0,00577)	(0,00205)	(0,01382)	(0,00908)		
BAP	0,09042	0,10567**	0,00106*	0,99045***	0,43642***	0,39254***	0,94823***	0,95895***	0,27082***	0,23932***	–9676,92	10,915
	(0,12550)	(0,05163)	(0,00065)	(0,10583)	(0,05228)	(0,03707)	(0,00534)	(0,00426)	(0,01057)	(0,01108)		
BRE	0,26610*	0,11697*	0,00699*	0,78825***	0,24866***	0,26395***	0,95466***	0,97516***	0,26886***	0,20265***	–10022,15	11,304
	(0,16048)	(0,07272)	(0,00351)	(0,00330)	(0,07681)	(0,04376)	(0,00329)	(0,00182)	(0,01030)	(0,00788)		
GETH	0,33588*	0,09006**	0,00284*	1,19271***	0,25549***	0,33075***	0,95268***	0,96723***	0,24067***	0,23485***	–10255,62	11,567
	(0,17049)	(0,04329)	(0,00162)	(0,08845)	(0,03540)	(0,05067)	(0,00391)	(0,00290)	(0,00920)	(0,01085)		
GLOBT	0,06265	0,18144	0,00659*	0,90871***	0,23921***	0,40441***	0,96820***	0,96201***	0,21403***	0,25022***	–10440,18	11,775
	(0,15357)	(0,11983)	(0,00366)	(0,07515)	(0,04386)	(0,05135)	(0,00392)	(0,00404)	(0,01247)	(0,01251)		
GRUPL	0,13214	0,07221*	0,00847*	0,82187***	0,23426***	0,29506***	0,96525***	0,97132***	0,22391***	0,22328***	–9122,26	11,366
	(0,13767)	(0,04159)	(0,00455)	(0,08562)	(0,03683)	(0,05080)	(0,00380)	(0,00226)	(0,01155)	(0,00875)		
KGHM	0,22160	0,10903	0,03055*	0,87289***	0,25548***	0,23216***	0,96630***	0,97245***	0,23170***	0,22139***	–10188,42	11,491
	(0,15149)	(0,10664)	(0,01653)	(0,08624)	(0,03423)	(0,03686)	(0,00328)	(0,00182)	(0,01123)	(0,00847)		
KOEL	0,09453	0,10158	0,01016*	2,73494***	0,16741***	0,33456***	0,82251***	0,97225***	0,42533***	0,21967***	–10520,63	12,111
	(0,14283)	(0,10510)	(0,00562)	(0,16184)	(0,03915)	(0,06011)	(0,01745)	(0,00250)	(0,02069)	(0,01034)		
PBG	0,09674	0,13800*	0,00302*	0,71184***	0,14191***	0,36808***	0,96457***	0,96818***	0,23411***	0,23456***	–10169,86	11,470
	(0,10821)	(0,07815)	(0,00153)	(0,07468)	(0,03802)	(0,05662)	(0,00457)	(0,00302)	(0,01451)	(0,01078)		
PGNIG	0,04555	0,06200*	0,00616*	0,66401***	0,20044***	0,37850***	0,96656***	0,96764***	0,21824***	0,23518***	–8532,36	11,292
	(0,11475)	(0,03507)	(0,00355)	(0,07882)	(0,04183)	(0,06336)	(0,00440)	(0,00374)	(0,01393)	(0,01251)		
PKNO	0,06514	0,10454*	0,00172*	0,69489***	0,25516***	0,20783***	0,97379***	0,97681***	0,19484***	0,19942***	–9730,09	10,975
	(0,13128)	(0,06080)	(0,00090)	(0,07069)	(0,03410)	(0,03144)	(0,00237)	(0,00138)	(0,00966)	(0,00731)		
PKOB	0,12080	0,13062*	0,02758*	0,64840***	0,30971***	0,26935***	0,97005***	0,97152***	0,21221***	0,21418***	–9348,13	10,683
	(0,11845)	(0,07448)	(0,01444)	(0,07795)	(0,04367)	(0,03439)	(0,00354)	(0,00247)	(0,01244)	(0,00933)		
TELP	–0,02511	0,00557	0,03110*	3,20029***	1,40018***	0,00157*	0,68865***	0,87903***	0,26174***	0,31962***	–10143,3	11,440
	(0,11803)	(0,17551)	(0,01794)	(0,29071)	(0,26995)	(0,00083)	(0,06616)	(0,02049)	(0,03139)	(0,02991)		

Notes: The parameters follow the notation presented earlier in the paper. *, **, *** denotes rejection of the null at 10%, 5%, 1% level of significance, respectively. No statistically significant residual autocorrelation or ARCH is present in the residuals of the model.

Table 8. Hungary bivariate GARCH-in-mean model

	μ(1)	μ(2)	λ(2)	Ω(1)	Ω(2)	Ω(3)	β(1)	β(2)	α(1)	α(2)	Log-L	AIC
ESZM	–0,06139	0,07641**	0,00236*	2,81161***	0,61301***	0,10947***	0,61039***	0,95638***	0,49659***	0,25994***	–10175,06	11,323
	(0,09248)	(0,03298)	(0,00126)	(0,11380)	(0,04977)	(0,02410)	(0,03235)	(0,00493)	(0,01812)	(0,01381)		
FHB	–0,03173	0,16036**	0,00342*	1,76680***	0,42579***	0,56524***	0,88227***	0,94562***	0,38944***	0,28044***	–10476,75	11,658
	(0,11949)	(0,07722)	(0,00182)	(0,09564)	(0,03736)	(0,07016)	(0,00764)	(0,00563)	(0,01174)	(0,01409)		
GERI	0,02396	0,18792***	0,00526*	0,73398***	0,47743***	0,52507***	0,96675***	0,94125***	0,20689***	0,29258***	–9925,11	11,048
	(0,10918)	(0,05459)	(0,00309)	(0,07220)	(0,06309)	(0,04625)	(0,00433)	(0,00608)	(0,01281)	(0,01419)		
MOLM	0,19689	0,17437*	0,00192*	1,03766***	0,58275***	0,43621***	0,95116***	0,94127***	0,25308***	0,28955***	–9744,88	10,845
	(0,12445)	(0,09475)	(0,00104)	(0,07660)	(0,05301)	(0,03865)	(0,00447)	(0,00581)	(0,01216)	(0,01333)		
MTEL	–0,05011	0,14346*	0,00219*	1,18703***	0,50633***	0,67780***	0,93792***	0,92453***	0,21869***	0,32294***	–9857,55	10,97
	(0,10383)	(0,08047)	(0,00125)	(0,12545)	(0,04704)	(0,05874)	(0,01173)	(0,00726)	(0,01822)	(0,01505)		
OTPB	0,05052	0,12948	0,05655**	5,60989***	3,40566***	0,42160***	0,11827***	0,41215***	0,57289***	0,43177***	–10011,75	11,141
	(0,13719)	(0,10608)	(0,02219)	(0,07005)	(0,08226)	(0,06310)	(0,02678)	(0,02600)	(0,02121)	(0,01867)		
RABA	0,06849	0,10022*	0,00225*	1,24524***	0,28253***	0,57499***	0,92864***	0,94612***	0,30300***	0,29182***	–10371,68	11,542
	(0,12785)	(0,05605)	(0,00128)	(0,07205)	(0,03685)	(0,05278)	(0,00582)	(0,00553)	(0,01197)	(0,01469)		
SYNE	–0,07482	0,26738**	0,00998*	2,25013***	0,39232***	0,54599***	0,83489***	0,95081***	0,44633***	0,26685***	–10670,25	11,874
	(0,13772)	(0,11917)	(0,00520)	(0,10765)	(0,04098)	(0,07037)	(0,01146)	(0,00535)	(0,01683)	(0,01286)		
TISZ	–0,04476	0,12789*	0,00659*	0,92596***	0,16101***	0,63011***	0,95457***	0,94469***	0,23620***	0,29364***	–10332,37	11,498
	(0,10670)	(0,06827)	(0,00356)	(0,07259)	(0,03528)	(0,06139)	(0,00490)	(0,00620)	(0,01233)	(0,01594)		

Notes: The parameters follow the notation presented earlier in the paper. *, **, *** denotes rejection of the null at 10%, 5%, 1% level of significance, respectively. No statistically significant residual autocorrelation or ARCH is present in the residuals of the model.

Table 9. Baltic economies bivariate GARCH-in-mean model. paper

	μ(1)	μ(2)	λ(2)	Ω(1)	Ω(2)	Ω(3)	β(1)	β(2)	α(1)	α(2)	Log-L	AIC
PTR	0,16152	0,14506***	0,00081*	2,81716***	0,12901***	0,31412***	0,73344***	0,92136***	0,76090***	0,40633***	–11301,07	11,351
	(0,12514)	(0,05129)	(0,00048)	(0,07381)	(0,02451)	(0,02924)	(0,00908)	(0,00377)	(0,00674)	(0,01114)		
SFGAT	0,29188	0,17531***	0,01013*	0,68832***	0,05041*	0,25358***	0,97201***	0,94360***	0,23210***	0,33482***	–11573,2	11,624
	(0,19291)	(0,05286)	(0,00535)	(0,03451)	(0,02793)	(0,02487)	(0,00131)	(0,00343)	(0,00650)	(0,01113)		
SRS	–0,40086	0,16470***	0,01322*	12,14995*	0,13933	0,28482***	0,76295**	0,92221***	0,05802**	0,39398***	–13048,44	13,104
	(1,06006)	(0,05973)	(0,00685)	(7,02103)	(0,08849)	(0,04363)	(0,36981)	(0,00463)	(0,02837)	(0,00463)		
TEO	–1,58067	0,13295**	0,01882**	2,58912***	0,90495***	0,00189**	0,04231*	0,90495***	2,45655***	0,48785***	–10858,69	10,907
	(0,85364)	(0,06601)	(0,00765)	(0,07662)	(0,00548)	(0,00094)	(0,02170)	(0,00548)	(0,02465)	(0,01664)		

Notes: The parameters follow the notation presented earlier in the paper. *, **, *** denotes rejection of the null at 10%, 5%, 1% level of significance, respectively. No statistically significant residual autocorrelation or ARCH is present in the residuals of the model.

Figures 1–34 present time-varying betas based on the estimates of the GARCH-in-means models. The models were run on daily data so that the estimates of time-varying betas are quite volatile. For easier visual interpretation, smoothed estimates are included. The betas are based on the estimates of time-varying covariances and variances directly obtained during the estimation of the GARCH-in-mean models. The results are very persuasive in this case as sharp increases in variances of assets's and market's returns and also covariances between assets's and market's returns are evident in 2008 and 2009. This is a clear evidence of increased risk in that period. Of course, not all risk is also systematic risk. This information in the form of sensitivity to systematic risk is captured by the beta coefficients. We do not present figures with the estimates of time-varying variances and covariances due to space limitations.

Quarter averages were used to analyze the evolutions of betas during 2008 to 2010. The figures are not included in the paper due to limited space. Based on this analysis, we can roughly divide the model output into three groups. First, companies with increasing beta coefficients during 2008–2009. Those are especially banks, namely EB, KB (Czech Republic), BAH, BAP, BRE (Poland), FHB, OTPB (Hungary) and SRS (Baltic countries). This can be explained by a procyclical behavior of the industry. Second, companies with no lasting changes in betas during the entire period, typically energetics and telecommunications. And the third group of companies is anticyclical behaved, for example tobacoo industry (PM) in the Czech Republic. The strength of beta reaction on the Polish and Hungarian stock markets is a little reduced especially when compared to the case of the Czech market. This can be explained by much lower openness of the economy in the case of Poland and certainly by the fact that Poland did not go through a recession at all. The key problem of the Hungarian economy was foreign indebtedness of households, which is an issue not directly tied with the firms' sector. Clearly, other aspects must be taken into account besides the industry a firm operates in.

In the above analysis we captured the systematic risk by beta coefficients, which we stress is just one of many aspects of the issue on both theoretical and empirical level. There are many dimensions of systematic risk, whereas we have dealt with issues related to stock markets only. For a broader, mainly conceptual, analysis of systematic risk as part of systemic risk we refer to Bullard *et al.* (2009). An interesting broader analysis may be found in Acharya *et al.* (2011), who claim that systematic risk might have significant impact on the behavior of financial institutions including their clients that would further worsen and deepen the systematic risk exposure. The initial shock can trigger a credit crunch irrespective of the market fundaments. The significant and unique role within the process of spreading out systematic shock presents institutional and regulatory setup. Some of regulatory measures create moral hazard and hereby excessive risk-taking in financial sector.

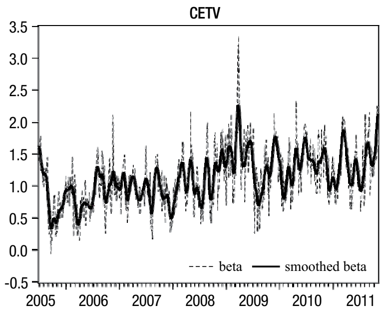

Fig. 1

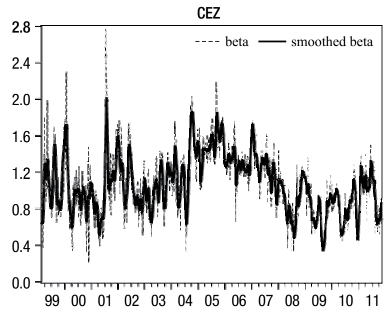

Fig. 2

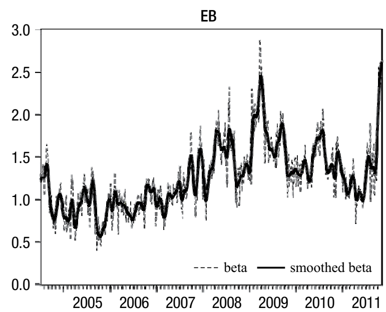

Fig. 3

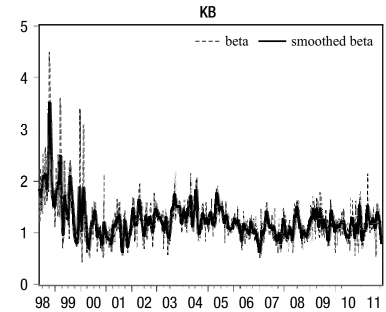

Fig. 4

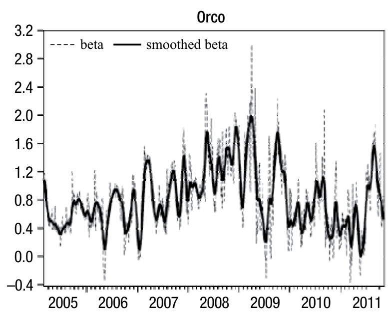

Fig. 5

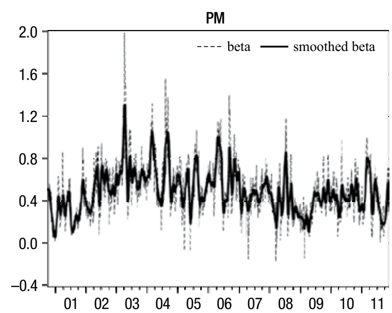

Fig. 6

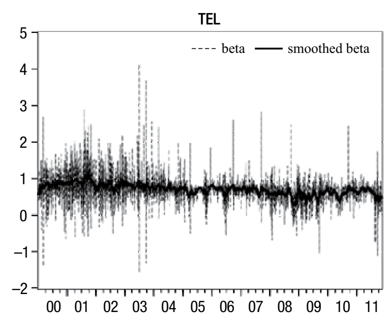

Fig. 7

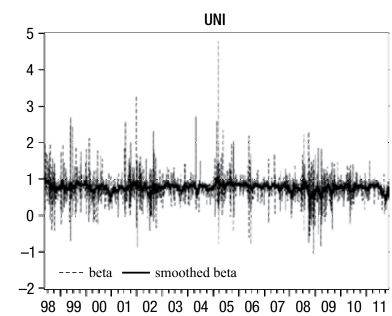

Fig. 8

Figs 1–8. Czech Republic, time-varying betas

Notes: Betas are based on the estimates of time-varying covariances between excess assets' and market's returns and time-varying variance of excess market's returns. Smoothed beta is the original estimate smoothed by Hoddrick-Prescott filter with λ equal to 100. We present the smoothed betas for the sole purpose of easier interpretation.

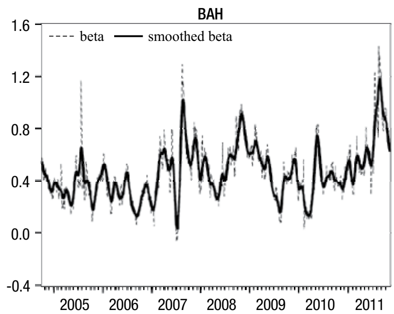

Fig. 9

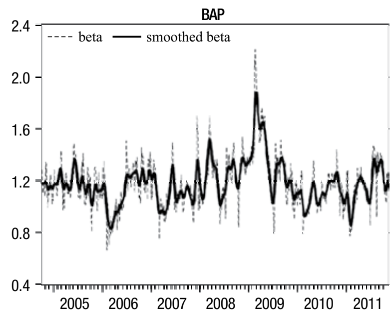

Fig. 10

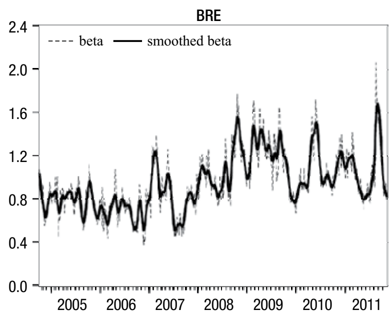

Fig. 11

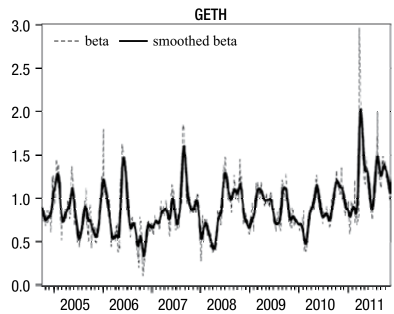

Fig. 12

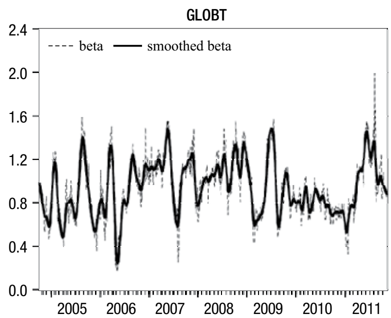

Fig. 13

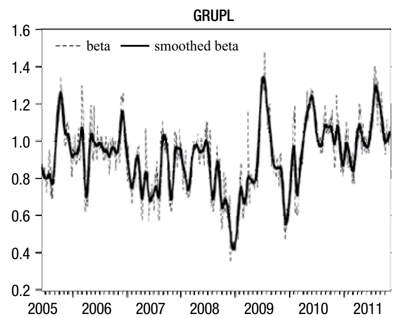

Fig. 14

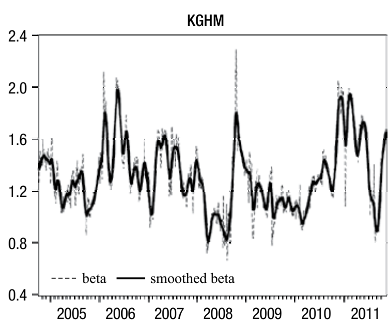

Fig. 15

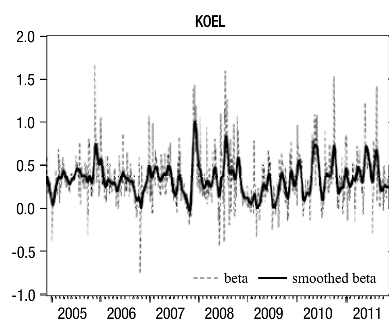

Fig. 16

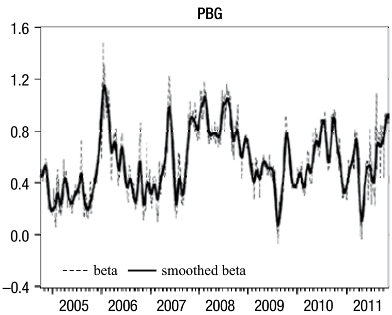

Fig. 17

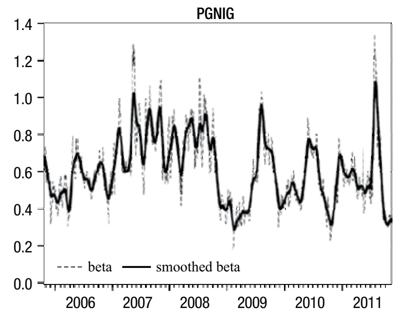

Fig. 18

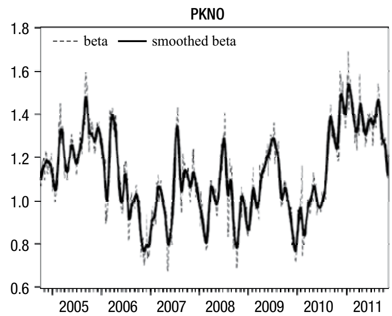

Fig. 19

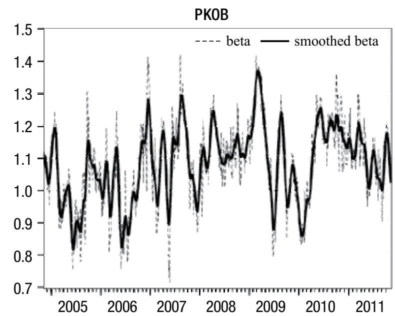

Fig. 20

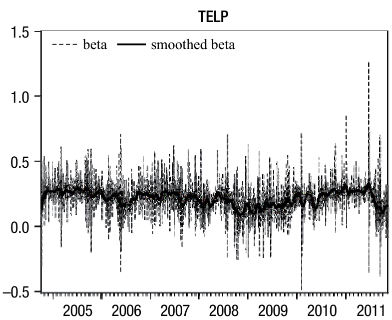

Fig. 21

Figs 9–21. Poland, time-varying betas

Notes: Betas are based on the estimates of time-varying covariances between excess assets' and market's returns and time-varying variance of excess market's returns. Smoothed beta is the original estimate smoothed by Hoddrick-Prescott filter with λ equal to 100. We present the smoothed betas for the sole purpose of easier interpretation.

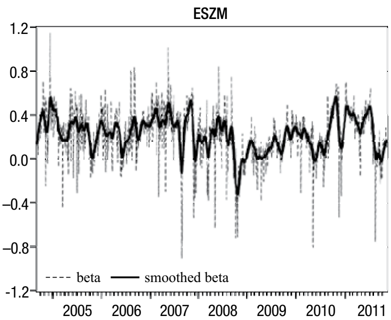

Fig. 22

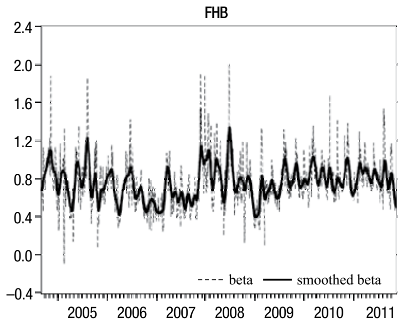

Fig. 23

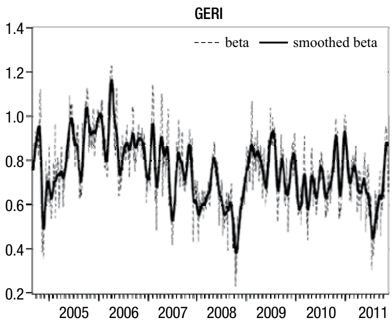

Fig. 24

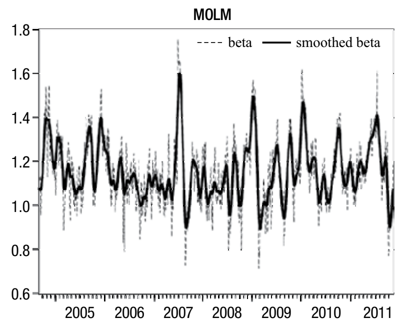

Fig. 25

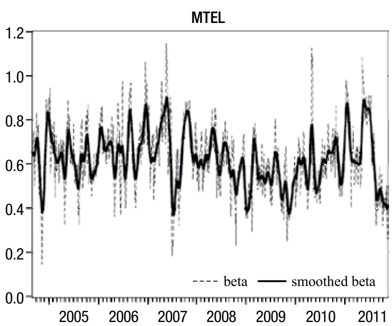

Fig. 26

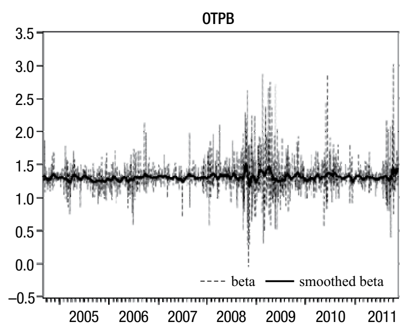

Fig. 27

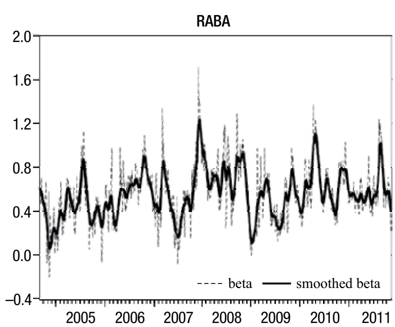

Fig. 28

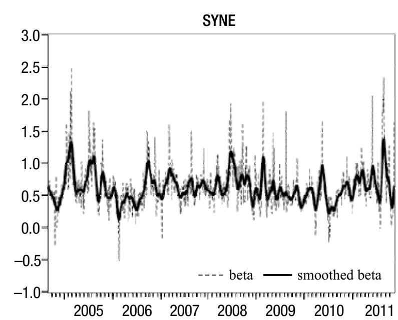

Fig. 29

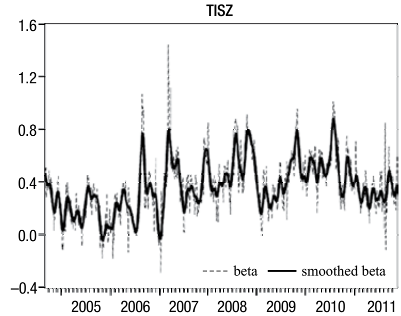

Fig. 30

Fig.s 22–30. Hungary, time-varying betas

Notes: Betas are based on the estimates of time-varying covariances between excess assets' and market's returns and time-varying variance of excess market's returns. Smoothed beta is the original estimate smoothed by Hoddrick-Prescott filter with λ equal to 100. We present the smoothed betas for the sole purpose of easier interpretation.

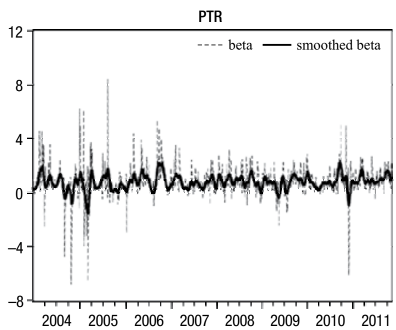

Fig. 31

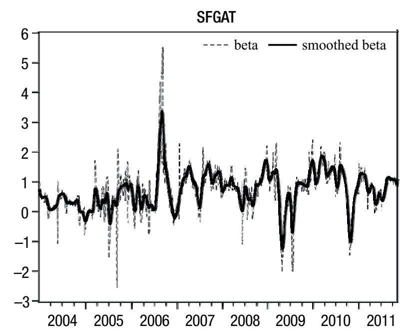

Fig. 32

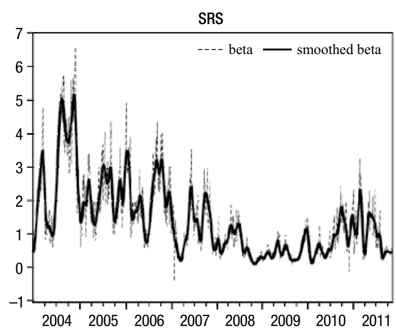

Fig. 33

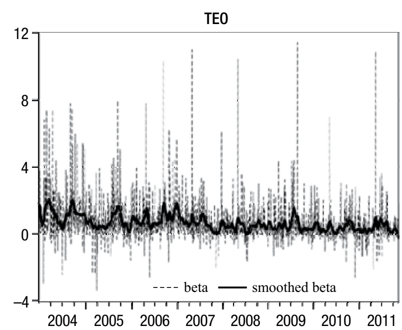

Fig. 34

Figs 31–34. Baltic countries, time-varying betas

Notes: Betas are based on the estimates of time-varying covariances between excess assets' and market's returns and time-varying variance of excess market's returns. Smoothed beta is the original estimate smoothed by Hoddrick-Prescott filter with λ equal to 100. We present the smoothed betas for the sole purpose of easier interpretation.

Conclusions

The prime goal of the paper was to show that a dynamic view of the originally static CAPM model may be useful for the analysis on both macro and micro level.

Bivariate GARCH-in-mean model was used to estimate time-varying variances and covariances of the excess returns on assets and markets to obtain time-varying Sharpe's betas of the selected issues. The estimates of the models were along the lines of the theoretical concept, however, due to data limitations the number of issues which could be used in the analysis was limited. Also, due to data limitations we were not able to include Slovakia in the sample economies.

The estimates of time-varying variances and covariances of assets' and markets' returns point to the significantly increased risk during the recession. However, part of that risk was unique not influencing the assets's prices according to CAPM. We analyzed the other part of the overall risk, systematic risk, with the help of sensitivity to systematic risk as measured by the betas.

The results show that a recession of the real economy may have an impact on the sensitivity of the assets' returns to markets' returns. The reaction seems to be dependent on the industry a firm operates in. However, other apsects must be taken into account when analyzing the results. We analyzed this result informally based on the estimates of time-varying betas as not enough information was available to use a more formal analysis.

On a micro level, the results show that possible changes of betas should be included in the process of the evaluation of investment projects, especially short to mid-term projects, as some information may be available in these cases that can be used to make sound assumptions about betas evolution in the future. Clearly, the fact that betas are time-varying should play no role in a typical firm's evaluation as the usual assumption of the so-called going concern renders these findings useless.

On a macro level, the increases in betas seem not to be permanent, therefore the increased sensitivity to systematic risk during the recession in 2008–2009 should not, by itself, significantly hinder investment into physical capital. Of course, the required return on physical investment, which is generally influenced by the sensitivity to systematic risk, is not the only significant variable entering the decision-making process. Naturally, negative expectations of firms with respect to the future of the economic environment influence the expectations of cash flow from the particular investment project, which would lower the investment into physical capital despite the sensitivity to systematic risk being on its pre-crisis level.

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