The Academy of Economic Studies
DOCTORAL SCHOOL OF FINANCE AND BANKING

HERD BEHAVIOR TOWARDS THE MARKET INDEX: *EVIDENCE FROM ROMANIAN STOCK EXCHANGE*

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Contents

Motivation – Why study Herd Behavior?

- When investing in a financial market where herding is present, **a larger number of securities are needed to achieve the same level of diversification** than in an otherwise normal market (*Chang, Cheng and Khorana, 2000*).

- Herding effect on stock price movements can lead to mispricing of securities since rational decision making is disturbed through the use of **biased views of expected return and risk** (*Hwang and Salmon, 2004*).

- The results about the existence of herd behavior are very useful for modeling stock behavior and provide information to the policymakers about whether or not they should be concerned about potential **destabilizing effects of herd behavior** (*Demirer and Kutan, 2006*).

Objectives

- The study of herd behavior towards market index in an emerging European country (Romania) using the cross-sectional variance of the betas from the CAPM model

- Determination of best estimation technique for time-varying systematic risk in terms of models' in-sample performance from:
    - GARCH Conditional Betas
    - Stochastic Volatility Conditional Betas
    - Kalman Filter Based Approaches

LITERATURE REVIEW

- There is a lack of a direct link between the theoretical discussion of herd behavior and the empirical specifications used to test for herding

- **Theoretical research** has tried to identify the reasons and mechanism through which herd can arise: ***Banerjee (1992); Bikhchandani, Hirshleifer and Welch (1992); Welch (1992); Avery and Zemsky (1998)***

- The **empirical herding literature** uses herding as a synonym for systematic or clustered trading. **Two streams of empirical literature** have been developed to investigate the existence of herding in financial markets:
  - The first stream analyzes the tendency of individuals or certain groups of investors to follow each other and trade an asset at the same time: ***Lakonishok, Shleifer & Vishny (1992); Wermers (1995)***
  - The second stream focuses on the market-wide herding: ***Christie & Huang (1995); Chang, Cheng & Khorana (2000); Hwang & Salmon (2001, 2004, 2008); Khan, Hassairi & Viviani (2011)***

METHODOLOGY - BETA HERDING

- Based on ***Hwang and Salmon (2004, 2008)***

CAPM: $E_t(r_{it}) = \beta_{imt} E_t(r_{mt})$ (1)

latent herding parameter

$$\frac{E_t^b(r_{it})}{E_t(r_{mt})} = \beta_{imt}^b = \beta_{imt} - h_{mt}(\beta_{imt} - 1) \quad (2)$$

- When $h_{mt} = 0$, there is no herding and the equilibrium CAPM holds
- When $h_{mt} = 1$, there is perfect herding towards the market portfolio
- When $0 < h_{mt} < 1$, beta herding exists in the market and the degree of herding depends on the magnitude of h_{mt}
- When $h_{mt} < 0$, there is reversed herding.

$$Std_c(\beta_{mt}^b) = Std_c(\beta_{mt})(1 - h_{mt}) \quad (3)$$

Taking logarithms of Eq.3 on both sides and making the following notations:

$\mu_m = E(log[Std_c(\beta_{mt})])$ and $H_{mt} = log(1 - h_{mt})$, we obtain:

$$\begin{cases} \log[Std_c(\beta_{imt}^b)] = \mu_m + H_{mt} + \upsilon_{mt} \quad \text{where } \upsilon_{mt} \sim iid\,(0, \sigma_{m\upsilon}^2) & (4) \\ H_{mt} = \phi_m H_{mt-1} + \eta_{mt} \quad \text{where } \eta_{mt} \sim iid\,(0, \sigma_{m\eta}^2) & (5) \end{cases}$$

state space model

METHODOLOGY - TIME-VARYING BETA

- *Hwang and Salmon (2008)*, as well as *Khan, Hassairi and Viviani (2011)* use the standard OLS technique

- *Wang (2008)* adopts a rolling robust regression approch

- My approach is a comparison between 3 different modeling techniques:
    - GARCH Conditional Betas
    - Stochastic Volatility Conditional Betas
    - Kalman Filter Based Approaches

METHODOLOGY - TIME-VARYING BETA

GARCH CONDITIONAL BETAS

- **Model 1**: DCC bivariate GARCH model *(Engle and Sheppard, 2001)*

$$\begin{cases} r_t / \Omega_{t-1} \sim N(0, H_t) \\ H_t = D_t R_t D_t \\ D_t = diag\{h_{i,t}^{\frac{1}{2}}\} \\ h_{i,t} = \omega_i + \sum_{q=1}^{Q_i} \alpha_{i,q} r_{i,t-q}^2 + \sum_{p=1}^{P_i} \beta_{i,p} h_{i,t-p} \\ \varepsilon_t = D_t^{-1} r_t \\ Q_t = (1 - \sum_{n=1}^{N} \alpha_n - \sum_{m=1}^{M} \beta_m) \bar{Q} + \sum_{n=1}^{N} \alpha_n (\varepsilon_{t-n} \varepsilon'_{t-n}) + \sum_{m=1}^{M} \beta_m Q_{t-m} \\ R_t = Q_t^{*-1} Q_t Q_t^{*-1} \end{cases}$$

- **Model 2**: FIDCC bivariate GARCH model

$$\begin{cases} r_t / \Omega_{t-1} \sim N(0, H_t) \\ H_t = D_t R_t D_t \\ D_t = diag\{h_{i,t}^{\frac{1}{2}}\} \\ [1 - \beta(L)] h_{i,t} = \omega_i + [1 - \beta(L) - \phi(L)(1 - L)^d] r_{i,t}^2 \\ \varepsilon_t = D_t^{-1} r_t \\ Q_t = (1 - \sum_{n=1}^{N} \alpha_n - \sum_{m=1}^{M} \beta_m) \bar{Q} + \sum_{n=1}^{N} \alpha_n (\varepsilon_{t-n} \varepsilon'_{t-n}) + \sum_{m=1}^{M} \beta_m Q_{t-m} \\ R_t = Q_t^{*-1} Q_t Q_t^{*-1} \end{cases}$$

$$\widehat{\beta}_{it}^{GARCH} = \frac{Cov(r_{it}, r_{mt})}{Var(r_{mt})}$$

BETA
STOCHASTIC VOLATILITY CONDITIONAL BETAS

- **Model 3**: SV model with causal volatility and dynamic correlation (Johansson, 2009; Yu and Meyer, 2006)

$$\begin{cases} r_t / h_t = diag\left(exp\ (h_t / 2)\right)\varepsilon_t,\ \varepsilon_t \sim N\left(0,\ \Sigma_{\varepsilon,t}\right) \\ \Sigma_{\varepsilon,t} = \begin{pmatrix} 1 & \rho_t \\ \rho_t & 1 \end{pmatrix} \\ h_{t+1} = \gamma + \Gamma(h_t - \gamma) + \eta_t, \eta_t \sim N(0,\ diag\ (\sigma^2_{\eta 1,t}, \sigma^2_{\eta 2,t})) \\ \qquad with\ h_0 = \gamma \\ z_{t+1} = \delta_0 + \delta_1\left(z_t - \delta_0\right) + \sigma_\rho \upsilon_t,\ \upsilon_t \sim N\left(0,\ 1\right) \\ \rho_t = \dfrac{\exp(z_t) - 1}{\exp(z_t) + 1}\ with\ z_0 = \delta_0 \end{cases}$$

- **Model 4**: SV model with causal volatility, dynamic correlation and t error distribution

$$\begin{cases} r_t / h_t = diag\left(exp\ (h_t / 2)\right)\varepsilon_t,\ \varepsilon_t \sim \mathbf{t}\left(0,\ \Sigma_{\varepsilon,t}, \upsilon\right) \\ \Sigma_{\varepsilon,t} = \begin{pmatrix} 1 & \rho_t \\ \rho_t & 1 \end{pmatrix} \\ h_{t+1} = \gamma + \Gamma(h_t - \gamma) + \eta_t, \eta_t \sim N(0,\ diag\ (\sigma^2_{\eta 1,t}, \sigma^2_{\eta 2,t})) \\ \qquad with\ h_0 = \gamma \\ z_{t+1} = \delta_0 + \delta_1\left(z_t - \delta_0\right) + \sigma_\rho \upsilon_t,\ \upsilon_t \sim N\left(0,\ 1\right) \\ \rho_t = \dfrac{\exp(z_t) - 1}{\exp(z_t) + 1}\ with\ z_0 = \delta_0 \end{cases}$$

$$\widehat{\beta}_{it}^{SV} = \frac{\rho_t^i(\exp(h_{stock\,i,t}))^{1/2}}{(\exp(h_{market,t}))^{1/2}}$$

METHODOLOGY - TIME-VARYING BETA

KALMAN FILTER BASED APPROACHES

The state space approach allows to model and to estimate the time-varying structure of beta directly

- **Model 5**: Beta develops as a random walk

$$\begin{cases} r_{it} = \beta_{it}^{KF\ RW} r_{mt} + \varepsilon_{it} \\ \beta_{it}^{KF\ RW} = \beta_{i,t-1}^{KF\ RW} + \eta_{it} \end{cases}$$

- **Model 6**: Beta develops as a mean-reverting process

$$\begin{cases} r_{it} = \beta_{it}^{KF\ MR} r_{mt} + \varepsilon_{it} \\ \beta_{it}^{KF\ MR} = \bar{\beta}_i + \phi_i (\beta_{i,t-1}^{KF\ MR} - \bar{\beta}_i) + \eta_{it} \end{cases}$$

$$\mathrm{E}(\eta_{it}\eta_{iT}^{'}) = \begin{cases} \sigma_{\eta i}^{2}\ , for\, t = T \\ 0, otherwise \end{cases}$$

$$\mathrm{E}\left(\varepsilon_{it}\varepsilon_{iT}^{'}\right) = \begin{cases} \sigma_{i}^{2}\ , for\, t = T \\ 0, otherwise \end{cases}$$

$$\mathrm{E}\left(\varepsilon_{it}\eta_{iT}^{'}\right) = 0 \qquad \text{for all t and T}$$

DATA

- Weekly adjusted returns of stocks listed on Bucharest Stock Exchange, covering the period from January 2003 to March 2012 (***65 stocks***)
  - The de-listed companies (either as a cause of bankruptcy or by own choice) have not been excluded from the study, trying to avoid in this way selection bias
  - The newly listed stocks during the considered period are included in the analysis from the time they entered the market
  - The only condition for a stock to be kept in the study was to have at least 1 year of trading history

- Weekly return of market index BETC (reflects the evolution of all listed stocks, except Investment Funds)

- Deposit facility rate as the risk free rate

ESTIMATION - TIME-VARYING BETA

GARCH CONDITIONAL BETAS

- The estimation was carried out in ***Matlab***, using 2 toolboxes provided by Kevin Sheppard (MFE, UCSD)
- 11 specifications were tested for conditional variances:
  - DCC (1, 1 , p ,q) with p, q < 3
  - FIDCC (1, 1, p, d, q) with p, q < 2
- The best specification for conditional variances was determined based on the Akaike information criteria

KALMAN FILTER BASED APPROACHES

- The estimation was carried out in ***Eviews***
- The best specification for the transition equation was determined based on the Akaike information criteria

ESTIMATION - TIME-VARYING BETA
STOCHASTIC VOLATILITY CONDITIONAL BETAS

- The estimation was carried out in ***WinBUGS***

- Prior distribution for the parameters

  (Chang, Qian & Jian, 2011; Meyer & Yu, 2006; Meyer & Yu, 2000; Kim, Shephard & Chib, 1998)

$$
\begin{aligned}
&\gamma_1 \sim N(0,\ 25)\\
&\gamma_2 \sim N(0,\ 25)\\
&\gamma_{11}^* \sim beta(20,1.5), \gamma_{11}^* = (\gamma_{11}+1)/2\\
&\gamma_{22}^* \sim beta(20,1.5), \gamma_{22}^* = (\gamma_{22}+1)/2\\
&\gamma_{12} \sim N(0,\ 10)\\
&\gamma_{21} \sim N(0,\ 10)\\
&\sigma_{\eta 1}^2 \sim Igamma(2.5, 0.025)\\
&\sigma_{\eta 2}^2 \sim Igamma(2.5, 0.025)\\
&\delta_0 \sim N(0.7,\ 10)\\
&\delta_1^* \sim beta(20,1.5), \delta_1^* = (\delta_1+1)/2\\
&\sigma_{\rho}^2 \sim Igamma(2.5, 0.025)\\
&\upsilon^* \sim \chi_{(4)}^2, \upsilon^* = \upsilon/2
\end{aligned}
$$

- The comparison between the two proposed specifications of the SV model was realized through deviance information criteria (**DIC**)

RESULTS - TIME-VARYING BETA

GARCH CONDITIONAL BETAS

- GARCH specification chosen by the AIC for modeling conditional variances in DCC(1,1) GARCH model:

Specification	Stock
GARCH(1,0)	RTRA, BRK, COMI, ELGS, IMP, SOCP, STZ, TLV
GARCH(2,0)	-
GARCH(0,1)	ART, CBC, CGC, RMAH, RPH
GARCH(1,1)	ALR, ALU, ARTE, ARM, BRD, CEON, CMF, EFO, FLA, MEF, MJM, MPN, OLT, PEI, PPL, RRC, SNO, SRT, TBM, VESY, VNC, ZIM
GARCH(2,1)	AMO, APC, ARS, ATB, AZO, BIO, BCC, BRM, CMP, COFI, DAFR, ECT, EPT, EXC, OIL, PCL, PREH, ROCE, SCD, SNP, SPCU, TEL, TUFE, UAM
GARCH(0,2)	ELMA, ENP
GARCH(1,2)	ALT, COTR, PTR
GARCH(2,2)	-
FIGARCH(0,d,1)	-
FIGARCH(1,d,0)	-
FIGARCH(1,d,1)	-

RESULTS - TIME-VARYING BETA

GARCH CONDITIONAL BETAS – TESTING FOR CONSTANT CORRELATION

- I used the test proposed by Engle and Sheppard (2001):

$$H_0 : R_t = \bar{R}$$

$$H_1 : vech^u(R_t) = vech^u\left(\bar{R}\right) + \beta_1 vech^u(R_{t-1}) + \beta_2 vech^u(R_{t-2}) + \ldots + \beta_p vech^u(R_{t-p})$$

  - Let $Y_t = vech^u[\upsilon_t \upsilon_t' - I_k]$, where $\upsilon_t = (D_t^{-1} r_t)' \bar{R}^{-1/2}$
  - Under the null of constant correlation, the residuals should be i.i.d., and the constant and the lagged parameters in the vector autoregression:

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \ldots + \beta_s Y_{t-p} + \eta_t \quad \text{should be zero.}$$

  - The test statistic is thus given by:

$$\frac{\hat{\delta} X' X \hat{\delta}'}{\hat{\delta}^2} \sim \chi^2\ (p+1)$$

where $\hat{\delta}$ are the estimated regression parameters and X is a matrix consisting of the regressors.

RESULTS - TIME-VARYING BETA

GARCH CONDITIONAL BETAS – TESTING FOR CONSTANT CORRELATION

- Engle and Sheppard's test results:

Symbol	*p-value*	*Symbol*	*p-value*	*Symbol*	*p-value*	*Symbol*	*p-value*
ALR	0.0150	***CEON***	0.0132	***IMP***	0.0009	***SCD***	0.0004
ALT	0.0512	***CGC***	0.0345	***MEF***	0.0163	***SNO***	0.0001
ALU	0.0072	***CMF***	0.0812	***MJM***	0.0001	***SNP***	0.0003
AMO	0.0021	***CMP***	0.0010	***MPN***	0.0033	***SOCP***	0.0000
APC	0.0056	***COFI***	0.0100	***OIL***	0.0003	***SPCU***	0.0001
ARS	0.0502	***COMI***	0.0005	***OLT***	0.0004	***SRT***	0.0004
ARTE	0.0007	***COTR***	0.0387	***PCL***	0.1165	***STZ***	0.0040
ART	0.0026	***DAFR***	0.0227	***PEI***	0.0002	***TBM***	0.0102
ATB	0.0012	***ECT***	0.0017	***PPL***	0.0015	***TEL***	0.0023
AZO	0.0582	***EFO***	0.0309	***PREH***	0.0162	***TLV***	0.0106
ARM	0.0137	***ELGS***	0.0008	***PTR***	0.0423	***TUFE***	0.0058
BIO	0.0281	***ELMA***	0.0061	***RMAH***	0.0399	***UAM***	0.0041
BCC	0.0246	***ENP***	0.1024	***ROCE***	0.0001	***UZT***	0.0561
BRD	0.0065	***EPT***	0.0193	***RPH***	0.0960	***VESY***	0.0042
BRK	0.0009	***EXC***	0.0952	***RRC***	0.0044	***VNC***	0.0174
BRM	0.0007	***FLA***	0.0363	***RTRA***	0.0285	***ZIM***	0.0723
CBC	0.0076						

- The null of constant correlation, is rejected by the test with a probability of 90% in favor of a time varying correlation matrix

RESULTS - TIME-VARYING BETA

STOCHASTIC VOLATILITY CONDITIONAL BETAS

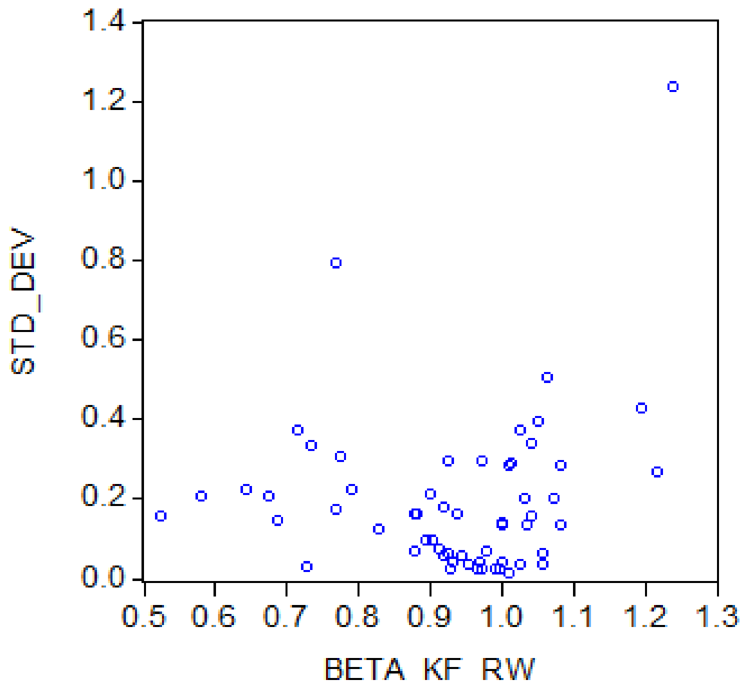
- With no exception, the second specification considered (the excess return shocks modeled by a t distribution) is chosen
- The conditional correlation parameters indicate persistent correlation patterns between the stocks and the market, with a posterior mean larger than 0.5 in all cases

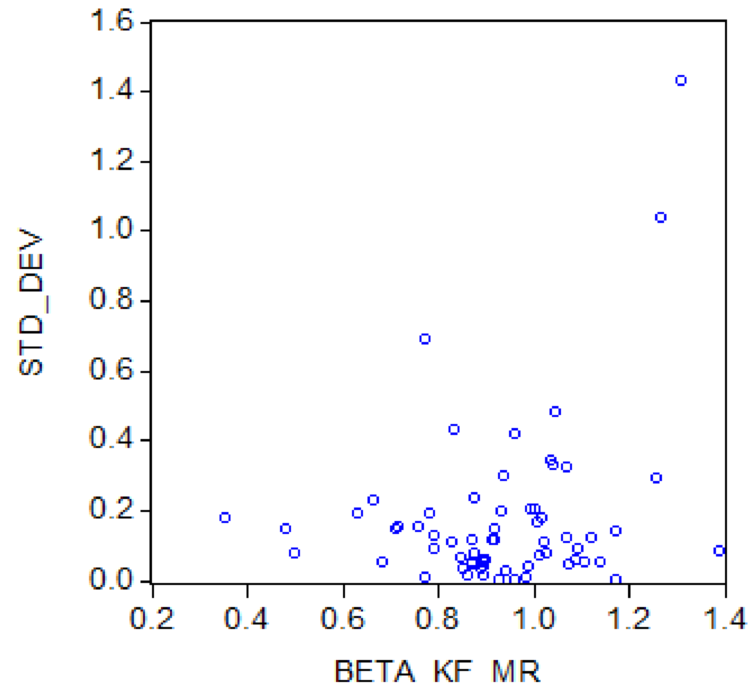
KALMAN FILTER BASED APPROACHES

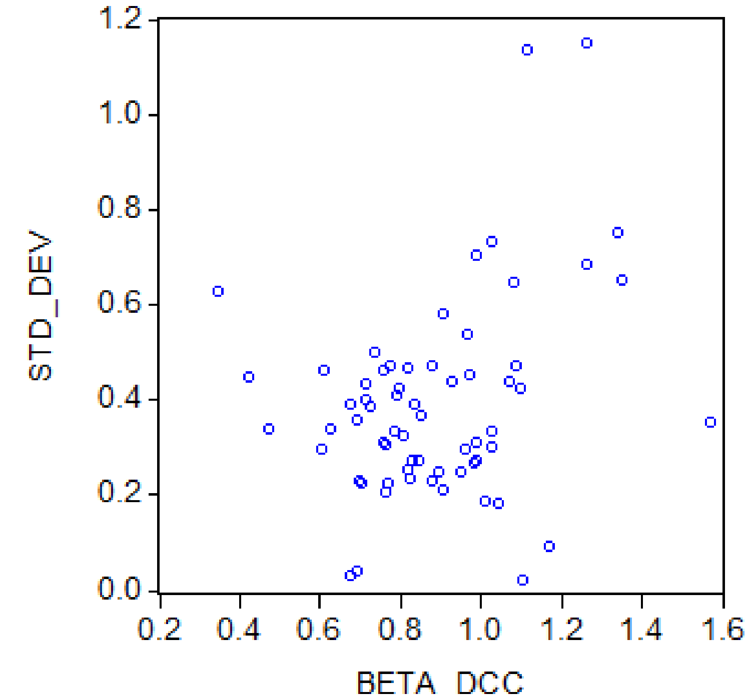
- Even though the mean-reverting model requires the estimation of two additional parameters, the AIC is generally smaller than for the simpler random walk specification
- So, for most of the stocks the second Kalman Filter specification is preferred

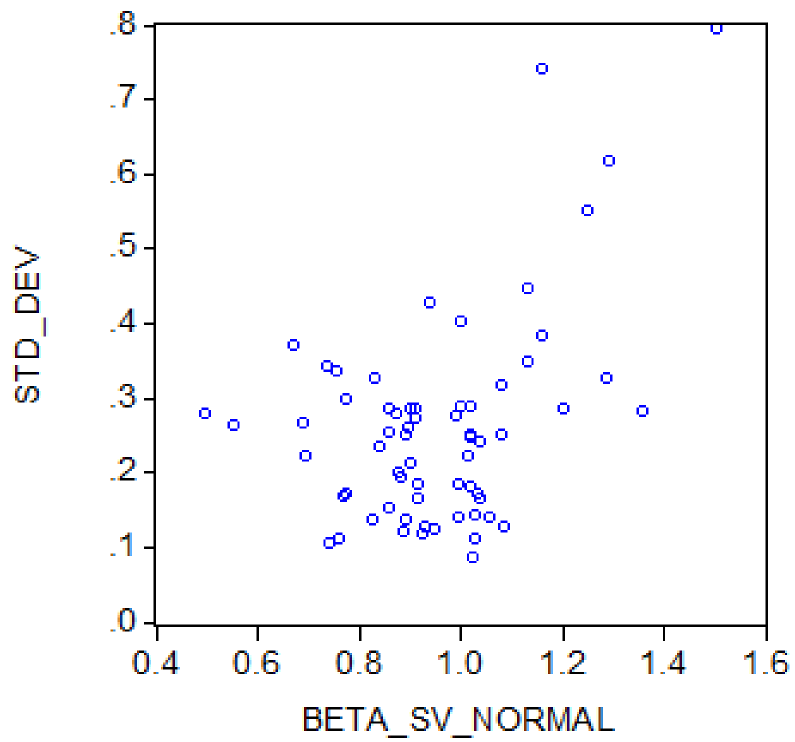
RESULTS - TIME-VARYING BETA

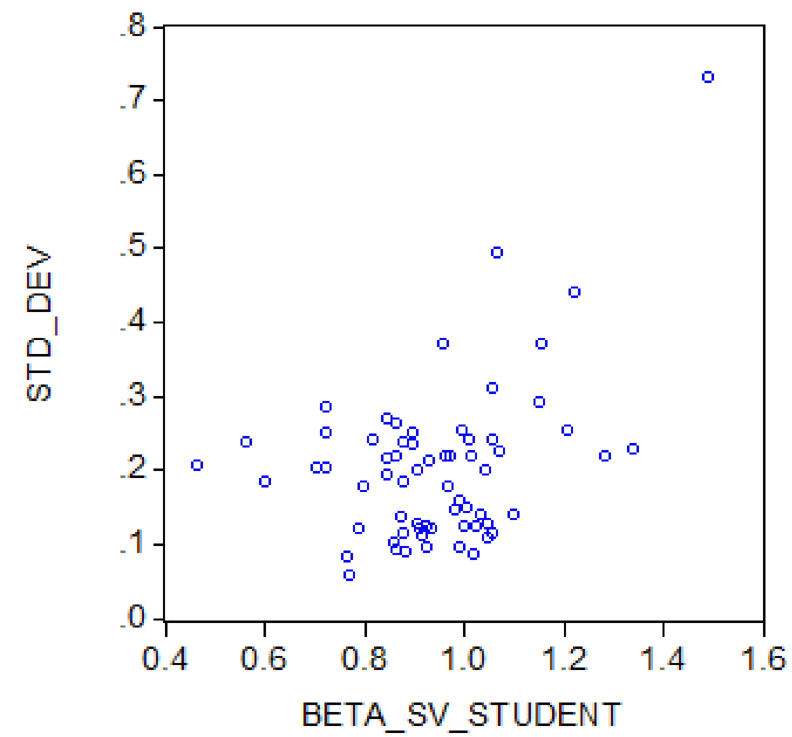
STOCHASTIC VOLATILITY CONDITIONAL BETAS











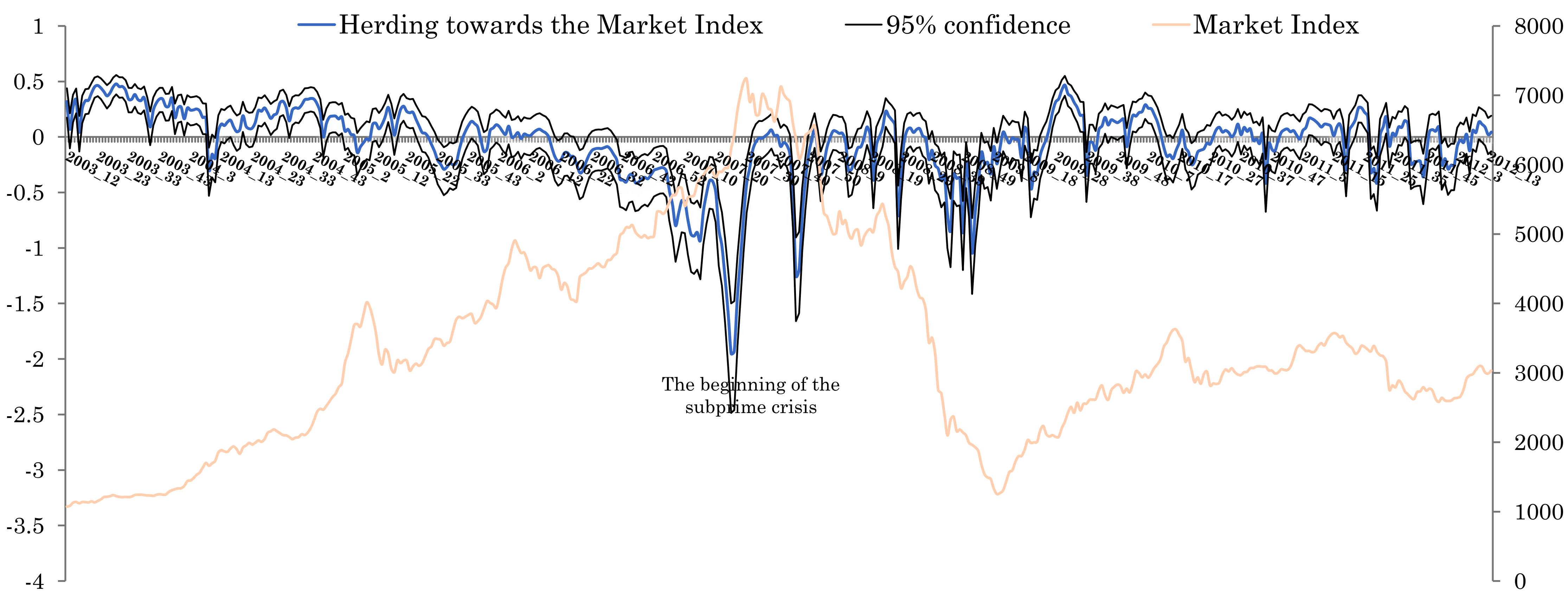
RESULTS - TIME-VARYING BETA

COMPARISON OF CONDITIONAL BETA ESTIMATES

- The different techniques are ranked based on their in-sample performance
- Having forecast r_{it} using each of the conditional beta series (the series of market return is assumed to be known in advance), the root mean squared error (***RMSE***) is determined:

Symbol	KF RW	KF MR	DCC GARCH	SV normal distribution	SV t-student distribution	Symbol	KF RW	KF MR	DCC GARCH	SV normal distribution	SV t-student distribution	Symbol	KF RW	KF MR	DCC GARCH	SV normal distribution	SV t-student distribution
ALR		**0.035**	0.0523		0.0481	*COMI*		**0.054**	0.067		0.0628	*RMAH*		**0.063**	0.1121		0.1022
ALT		0.053	0.0525		**0.0476**	*COTR*		0.076	0.079		**0.0746**	*ROCE*		**0.048**	0.0532		0.0496
ALU	**0.039**		0.0536		0.0478	*DAFR*		**0.039**	0.057		0.0512	*RPH*		0.087	**0.084**		0.0845
AMO	0.073		0.0748		**0.0687**	*ECT*		**0.054**	0.057		0.0543	*RRC*		**0.043**	0.0486		0.0445
APC		0.053	0.0548		**0.0527**	*EFO*	0.065		0.066		**0.0638**	*RTRA*		0.046	0.0461		**0.0454**
ARS	0.049		0.0501		**0.048**	*ELGS*	0.113		0.115		**0.112**	*SCD*		**0.035**	0.0391		0.0359
ARTE	0.066		0.0681		**0.0633**	*ELMA*		0.069	0.071		**0.0683**	*SNO*		0.048	0.0499		**0.0468**
ART		**0.046**	0.0626		0.0588	*ENP*		0.045	0.05		**0.0447**	*SNP*		**0.022**	0.0282		0.0256
ATB		**0.03**	0.0357		0.0336	*EPT*		0.076	0.08		**0.0717**	*SOCP*		0.05	0.0517		**0.0492**
AZO		**0.049**	0.0783		0.0763	*EXC*		0.052	0.054		**0.052**	*SPCU*		0.078	0.0791		**0.0756**
ARM		**0.045**	0.0592		0.056	*FLA*		**0.043**	0.066		0.0624	*SRT*	0.049		0.052		**0.0485**
BIO		**0.042**	0.0473		0.0425	*IMP*	**0.061**		0.068		0.065	*STZ*		**0.064**	0.0713		0.068
BCC		**0.036**	0.049		0.0464	*MEF*		0.063	0.064		**0.0616**	*TBM*		**0.041**	0.0495		0.0456
BRD		**0.019**	0.0251		0.0221	*MJM*	0.059		0.066		**0.0582**	*TEL*		0.029	0.03		**0.0278**
BRK		0.043	0.0456		**0.0412**	*MPN*	0.058		0.059		**0.0573**	*TLV*		**0.04**	0.0439		0.0411
BRM		**0.047**	0.0538		0.0509	*OIL*		**0.047**	0.053		0.0494	*TUFE*		**0.039**	0.0432		0.0394
CBC		0.073	0.0757		**0.0726**	*OLT*		0.091	0.092		**0.0885**	*UAM*		0.066	0.0678		**0.0635**
CEON		**0.05**	0.0639		0.06	*PCL*		0.05	0.051		**0.0489**	*UZT*		0.09	0.0902		**0.0857**
CGC	**0.067**		0.069		0.0717	*PEI*	0.059		0.062		**0.0573**	*VESY*		0.06	0.0621		**0.0585**
CMF	0.059		0.0624		**0.058**	*PPL*	0.059		0.06		**0.0556**	*VNC*		**0.032**	0.0392		0.0369
CMP		**0.045**	0.0573		0.0509	*PREH*	0.089		0.092		**0.0876**	*ZIM*	0.056		0.0574		**0.0556**
COFI		**0.102**	0.1071		0.1035	*PTR*		**0.047**	0.062		0.0561						

RESULTS - BETA HERDING



- The results sustain the findings of Hwang and Salmon (2004), Wang (2008), Khan, Hassairi and Viviani (2011): periods of market crisis or stress help return markets to equilibrium, implying that efficient pricing may be helped by market stress
- There are a number of cases where herding behavior turned before the market itself turn

RESULTS
ROBUSTNESS OF THE HERDING MEASURE

Basic Model

$$\begin{cases} \log\left[Std_c\left(\beta^b_{mt}\right)\right] = \mu_m + H_{mt} + \upsilon_{mt} \\ H_{mt} = \phi_m H_{mt-1} + \eta_{mt} \end{cases}$$

Alternative Model 1

$$\begin{cases} \log\left[Std_c\left(\beta^b_{mt}\right)\right] = \mu_m + H_{mt} + c_{m1} log\sigma_{mt} + c_{m2} r_{mt} + \upsilon_{mt} \\ H_{mt} = \phi_m H_{mt-1} + \eta_{mt} \end{cases}$$

market log-volatility

market return

Alternative Model 2

$$\begin{cases} \log\left[Std_c\left(\beta^b_{mt}\right)\right] = \mu_m + H_{mt} + c_{m1} log\sigma_{mt} + c_{m2} r_{mt} + c_{m3} DR_t + c_{m4} Div_t + \upsilon_{mt} \\ H_{mt} = \phi_m H_{mt-1} + \eta_{mt} \end{cases}$$

average population deposit interest rate

average dividend ratio

RESULTS
ROBUSTNESS OF THE HERDING MEASURE

	No exogenous variables (Basic Model)	Excess market return and volatility (Alternative Model 1)	Excess market return and volatility, deposit interest rate, dividend rate (Alternative Model 2)
μ_m	-1.4461	-1.4518	-1.3669
	(0.0000)	(0.0000)	(0.0000)
Φ_m	0.9052	0.9025	0.8489
	(0.0000)	(0.0000)	(0.0000)
$\sigma_{m\upsilon}$	0.1048	0.1028	0.0986
	(0.0000)	(0.0000)	(0.0000)
$\sigma_{m\eta}$	0.1226	0.1234	0.1284
	(0.0000)	(0.0000)	(0.0000)
c_{m1}		0.0008*	-0.0001*
		(0.8715)	(0.986)
c_{m2}		-0.5734	-0.6141
		(0.0081)	(0.0052)
c_{m3}			0.2315*
			(0.8526)
c_{m4}			-1.1535
			(0.0000)

*The estimate is not significant at 5% level.

CONCLUSIONS

- Based on the in sample performance criteria, the mean reverting process, estimated by the use of the Kalman Filter and the Stochastic Volatility model with a t distribution for the excess return shocks offer the best estimation results of time-varying betas between the various techniques compared.

- Periods of market crisis or stress help return market to equilibrium, implying that efficient pricing may be helped by market stress.

- Herding towards the market shows significant movements and persistence independently from and given market conditions as expressed in return volatility and the level of the mean return.

- Macro factors do not explain the herd behavior.

Thank you for your Attention!