# Extreme Coexceedances in New EU Member States' Stock Markets*

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**Abstract:** We analyze the financial integration of the new European Union (EU) member states' stock markets using the negative (positive) coexceedance variable that counts the number of large negative (large positive) returns on a given day across the countries. A similar analysis is performed for the old EU countries. We use a multinomial logit model to investigate how persistence, asset classes, and volatility are related to the coexceedance variables. We find that the effects differ (a) between negative and positive coexceedance variables (b) between old and new EU member states, and (c) before and after the EU enlargement in 2004, suggesting a closer connection of new EU stock markets to those in Western Europe.

**Keywords:** Financial market integration; Comovement; Emerging markets; EU enlargement; EU member states; Extreme returns; New EU Member States; Stock markets

**JEL Classifications:** C25; F36; G15

# 1 Introduction

The European Union (EU) enlargement in 2004 might be considered a natural experiment to observe the effects of institutional changes in the financial markets. This study attempts to illustrate whether and to what extent comovements across national stock markets change after the EU enlargement. This is an important issue related to the Optimal Currency Area (OCA) literature. In his seminal work, Mundell (1961) points out the main trade-off for adopting a common currency. On the one hand, a common currency represents a reduction of transaction costs.[1] On the other hand, it implies the loss of the natural "shock absorbers" represented by flexible exchange rates and independent monetary policies. The literature has analyzed the complexity of these mechanisms in deeper details. Integration within an enlarged monetary union could lead to greater synchronization of fluctuations because of greater trade and similar policy shocks, see Frankel and Rose (1998). However, it can also turn into a lower synchronization because country-specific risks would be diversified better and countries could specialize more in specific productions, see e.g. Krugman (1993); Kalemli-Ozcan, Sørensen and Yosha (2001). The tension between these opposite forces is also relevant for stock market comovements. Does integration lead to stronger comovements among established stock markets and among recent EU members?

This paper is also somewhat related to the contagion literature. In times of financial crisis, investors and policy makers have a very strong interest in whether and how the crisis propagates to other countries; this is known as contagion effects. The way international markets react to recent events such as 9/11 and more recent episodes suggests that contagion is increasingly a global phenomenon. In this paper, we investigate the interaction effects in the emerging and developed European stock markets. As we are not looking at crisis periods we are not investigating contagion effects as such. Our analysis provides valuable information about the typical market conditions and dynamics leading to joint extreme price falls or rises in European countries.

We propose to measure financial market integration by how often extreme returns on different markets occur simultaneously. This can easily be analyzed empirically by using the method applied by Bae, Karolyi and Stulz (2003) to investigate contagion. Extreme returns in one country, or exceedances, are large positive and large negative returns only in that country. Coexceedances are the joint occurrences of extreme returns in different countries. Bae et al. (2003)

[1] Mundell (1973) also considers how exchange rate uncertainty will interfere with the economy.

count the number of coexceedances (positive and negative separately) in different emerging stock markets in the same region. In this way, their definition of contagion is implicitly similar to that of correlation, yet it overcomes some relevant limitations: (1) The conflicting definitions of contagion in the literature, (2) the bias due to conditional heteroskedasticity, and (3) that the correlation coefficient is a linear measure which is inappropriate to analyze nonlinear phenomena such as financial market integration or contagion.[2][3] Bae et al. (2003) use the multinomial logit model to explain the number of coexistences of extreme returns in Asia and Latin America. They find that contagion depends on interest rates, exchange rate changes and conditional stock return volatility. In this paper, we apply a similar method to investigate the factors that explain the comovement between the stock markets in the new EU member states from the previous Communist states of Central and Eastern Europe. In particular, an increase of coexceedances would partially counterbalance some favorable effects related to economic and monetary integration. Among a variety of factors, entrant countries should also take into account the adverse effects of stronger cross-country shocks propagation.[4]

Measuring integration in terms of coexceedance has some limitations. In particular, there is always the chance that a common shock causing observed coexceedances does not have its origin within the EU or is not captured by the sets of variables considered in this study. To address these caveats, we take into account the stock market movements outside Europe.

Other papers use related methods to investigate integration and contagion effects. Cumperayot, Keijzer and Kouwenberg (2006) use a bivariate probit model for the extreme currency event and the extreme stock event as the explanatory variables. The model is estimated separately for 26 countries. Extreme stock market events are found to increase the likelihood of extreme currency events. Fazio (forthcoming) looks at bivariate probit models for crisis variables for a pair of countries. Contagion emerges if the error terms are correlated. The crisis variable is a measure of speculative pressure depending on the exchange rate and level of international reserves. Hartmann, Straetmans and de Vries (2004) use extreme value theory to model the expected number of market crashes given that at least one market has already crashed. Their empirical analysis covers the

[2] In the literature, there is yet little convergence of definitions and terminology of contagion. A number of authors call for discrimination between the terms "pure contagion", "interdependence", "shock propagation", "transmission effects", "spillovers" and so on (see, e.g., Forbes and Rigobon (2002)).

[3] For a more detailed analysis about this bias, see Boyer, Gibson and Loretan (1999), Forbes and Rigobon (2002), Baur and Schulze (2005), and Longin and Solnik (2001).

[4] For a more exhaustive treatment of these issues, see Frankel and Rose (1998); Alesina, Barro and Tenreyro (2002); Kalemli-Ozcan et al. (2001); and Imbs (2004).

five largest industrialized countries. Chan-Lau, Methieson and Yao (2004) also apply extreme value theory to analyze contagion in Latin America and Asia.

In general, the new EU member states' asset markets are becoming more integrated with the old EU member states' asset markets. Cappiello, Gérard, Kadareja and Manganelli (2006) consider the integration of seven new EU countries' stock markets, using quantile regressions to make so-called comovement plots. They find that the integration within the new EU countries and with the old EU countries increases over time, and that it is mainly due to the three largest markets (the Czech Republic, Hungary, and Poland). Moore and Wang (2007) consider the volatility of five new EU member states' stock markets. They show that the stock volatility decreases when the state enters the EU, i.e. the stock markets tend to be in the low volatility states. They use a regime switching model so that they do not have to use the exact entry date to investigate the effect of EU entry. Dovak and Podpiera (2006) investigate the stock returns in the new EU member states after the announcement of the enlargement of the EU. They use firm-specific data to calculate betas. They find that part of the stock price increase is connected to differences between local and world betas. Dovak (2007) shows that the new EU member states' bond yields (government and corporate) have moved towards the levels in the old EU countries.

We investigate the integration between the stock markets in the ten new EU member states from the former Communist countries in Eastern and Central Europe as well as the integration between the 14 old EU member states. The negative coexceedance variable for the new EU countries counts the number of extreme returns (below the 5% percentile) across the new EU countries on a given day. The positive coexceedance variable for the new EU counts the number of large positive returns (above the 95% percentile) across the new EU countries on a given day. The negative and positive coexceedance variables for the old EU are constructed analogously. Using the multivariate logit model, we investigate which factors are associated with the coexceedance variables. We distinguish between five hypotheses, namely persistence effects, asset class effects, volatility effects, asymmetry effects, and EU enlargement effects. Persistence refers to the likelihood of observing autocorrelation in the coexceedances. The asset class hypothesis refers to the relation between extreme stock returns and three asset classes, namely interest rates, stock returns, and currency returns. Volatility effects point to the link between coexceedances and volatility in the stock, interest rate, and currency markets. Finally, the EU enlargement hypothesis refers to the fact that we expect significant changes in the persistence,

asset class, and volatility effects after the new EU member states joined the EU. The effects from the explanatory variables are of the expected signs. We find strong persistency effects. The new EU markets are more closely connected with the old EU countries after the EU enlargement in May 2004. Overall, negative coexceedances in the new EU stock markets are significantly related to lagged negative coexceedance for new EU, negative coexceedance for old EU, US stock return, old EU stock return, old EU stock volatility, and interest rate volatility. Moreover, the factors explaining the coexceedance variables differ for the old and new EU stock markets. More specifically, we find that coexceedances among old EU states appear more connected to the US stock market and to price movements of other asset classes. Finally, the comovement factors also differ for the positive and negative coexceedance variables.

The structure of the remaining part of the paper is as follows: In Section 2 we present the data, and in Section 3 we explain the empirical set-up. Section 4 contains the empirical results, and Section 5 concludes.

## 2 Data Description

We consider the following ten new EU member states: Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia. Notice that we focus on the new EU member states from the former Communist Central and Eastern European countries, i.e. we exclude two new EU member states, Cyprus and Malta, which are small population-wise and Mediterranean. Bulgaria and Romania joined the EU on January 1, 2007, the other countries on May 1, 2004.[5] We consider the joining countries as one group irrespective of whether they joined the EU in 2004 or in 2007. However, the results are robust to leaving out the latecomers Bulgaria and Romania (results not tabulated).

The group of old EU countries consists of the following 14 countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden, and the UK.

We apply daily data for the stock markets for various European countries. When available we use the DataStream stock index. In a few cases, we use the relevant index from the local stock market instead because the DataStream index is not available. This applies to Estonia, Latvia, Lithuania, Slovakia, and Slovenia.

[5] We excluded Luxemburg for obvious reasons of data availability (e.g. no stock market index exists).

We use daily log returns from the total return indexes for the stock markets measured in local currency.[6] The data cover the period from October 2, 2000 to April 20, 2007, which gives us a total of 1710 observations. This can be viewed as a representative sample period including both bull and bear phases, high and low volatility environments and different market conditions.[7][8]

## 2.1 Coexceedance Variables

It is from the log returns that we define the extreme returns. We follow Bae et al. (2003) and use the 5% and 95% percentiles to define the negative and positive extreme returns, respectively.[9] We treat large positive and negative returns separately.[10]

We construct a variable that counts the number of extreme negative returns for the new EU countries on a given day. The variable can take on integer values between 0 and 10. We collect observations of 2 and above into one group, so the variable is truncated to take on values between 0 and 2. We denote this variable the negative coexceedance variable for the new EU countries. So, we distinguish between the following situations for a given day: no extreme return, only one country with an extreme return, and several countries with an extreme return. The more likely the last situation is, the more comovement between the new EU stock markets there is. A similar negative coexceedance variable is constructed for the old EU countries. The positive coexceedance variable for the new EU countries is constructed by counting the number of positive extreme returns on the new EU stock markets on a given day. Finally, we construct the positive coexceedance variable for the old EU countries. We use the following notation for the coexceedance variables.

- $XN_t^{new}$: negative coexceedance for new EU countries on day $t$
- $XP_t^{new}$: positive coexceedance for new EU countries on day $t$
- $XN_t^{old}$: negative coexceedance for old EU countries on day $t$

[6] Local currency returns are equivalent to currency hedged returns. Using common currency returns would bias the results and confound the genuine stock performance with that of the exchange rates.

[7] October 2, 2000 is the earliest date with daily stock market data for all the countries under investigation.

[8] We do the same analysis using a shorter sample period, namely beginning in August 2002. We performed this additional analysis in order to compare two well-defined bull periods, i.e. from August 2002 to April 2004 and after May 2004. This allows us to see whether the bull markets may bias our results. The results are very similar.

[9] The 5% and 95% percentiles are supposed to be the best compromise to capture the farthest portions of the distribution tails and to get representative samples of extreme returns.

[10] As a robustness test, we also combine positive and negative coexceedances, more on this in Section 4.4.

- $XP_t^{old}$: positive coexceedance for old EU countries on day $t$

Below, we also make a little use of the pooled coexceedance variable for the new EU that counts both positive and negative extreme returns; we denote this $X_t^{new}$. Again, we truncate this variable to take on values 0, 1, and 2. Similarly, we define the pooled coexceedance variable for the old EU that counts both positive and negative extreme returns in the old EU, $X_t^{old}$.

Summary statistics for the coexceedance variables are given in Table 1. Most of the days, there are no instances of extreme returns: 66% and 77% of the days there are no extreme negative returns in the new EU countries and the old EU countries, respectively. The figures are slightly lower for extreme positive returns. For negative extreme returns, 12% (13%) of the days have several extreme returns in the new EU (old EU). There are slightly fewer days with more than one extreme positive return in both the new and old EU countries.

Figures 1-4 show the time series plot of the four coexceedance variables. We see that the instances of several coexceedances are spread out during the sample period and are not confined to a limited period of time.

## 2.2 Explanatory Variables

In the empirical analysis, we also make use of these additional explanatory variables in various logit models. We have a sample of daily observations for which the sample period matches that for the coexceedance variables.

- $S_t^{US}$ : Concurrent return from the US stock market (DataStream index)
- $S_t^{old}$ : Concurrent return for European stock market (DataStream index for Western Europe)
- $S_t^{new}$: Concurrent return for new EU stock market (log-returns from equally weighted index constructed for the Czech Republic, Hungary, and Poland)
- $\sigma_t^{old}$: Concurrent volatility for old European stock return (see below)
- $C_t$: Concurrent currency log return (exchange rate of DEM or EUR per USD)
- $\sigma_t^C$: Concurrent volatility for currency return (see below)
- $R_t$: Concurrent interest rate (first differences of 1-month EURIBOR (Euro Interbank Offered Rate), first differences because unit root cannot be rejected)[11]

[11] It does not matter whether we use a US or a European interest rate.

- $\sigma_t^R$: Concurrent interest rate volatility (see below)

The old EU stock volatility ($\sigma_t^{old}$) is the square root of the conditional variance stemming from estimating the AR(1)-GARCH(1,1) model for the old EU stock return ($S_t^{old}$). We estimate the following model: $S_t^{old} = c_0 + c_1 S_{t-1}^{old} + \varepsilon_t$ where $\varepsilon_t \sim N(0, \sigma_t^2)$ where the variance follows a GARCH(1,1) process: $\sigma_t^2 = c_2 + c_3\sigma_{t-1}^2 + c_4\varepsilon_{t-1}^2$. The time series of volatilities is then $\widehat{\sigma_t}$ from the AR(1)-GARCH(1,1) estimation. The currency volatility ($\sigma_t^C$) and the interest rate volatility ($\sigma_t^R$) are calculated similarly from $C_t$ and $R_t$.

# 3 Empirical Set-Up

In the first part of this section, we present the econometric technique. The second part describes the hypotheses to be tested.

## 3.1 Multinomial Logit Model for Coexceedances

As discussed above, the Bae et al. (2003) method offers a more efficient (in econometric terms) and consistent (in economic terms) way of analyzing which factors can help explain extreme comovement between financial markets. In fact, the coexceedance measure is not biased in periods of high volatility, it is not restricted to model linear phenomena, and it has some practical advantages (e.g. it is easy to compute across time and assets).

We conduct univariate analysis and model one coexceedance variable at the time. The coexceedance variables are discrete choice variables which can be modelled using a multinomial discrete choice model, such as the logit model we apply here. By considering only three categories (0, 1, and 2 and above), we reduce the number of parameters and make the results easier to understand.

In the multinomial logit model, the probability of (say) $XN_t^{new}$ being in category $i$ where $i = 1, 2$ the distribution is given by

$$P_i = \frac{\exp\left(\boldsymbol{\beta}_i'\mathbf{x}\right)}{\sum_{j=1}^{2}\exp\left(\boldsymbol{\beta}_j'\mathbf{x}\right)}$$

where $\mathbf{x}$ is the vector of explanatory variables (including a constant) and $\boldsymbol{\beta}_i$ is the vector of coefficients for category $i$. For simplicity, below we state that the probability of being in category $i$ is given as a function of the explanatory variables: $P_i = function(\boldsymbol{\beta}_i'\mathbf{x})$ where $i = 1, 2$. There is one coefficient for each covariate for each of the categories (e.g. $\beta_{1j}$ for category 1 for $x_j$). There is no

coefficient for the category where $i = 0$ because this is the situation that the others are compared to.

When $\beta_{1j}$ is significant, then variable $j$ has a positive effect upon the probability of the occurrence of an exceedance. When $\beta_{2j}$ is significant, then variable $j$ has a significant effect upon the probability of the occurrence of a coexceedance. We use a $\chi^2$ test to access the significance of a given explanatory variable; i.e. whether both coefficients for both categories are insignificant simultaneously (i.e. $\beta_{1j} = \beta_{2j} = 0$ for explanatory variable $x_j$).

We access the goodness of fit of the various models by using a $\chi^2$ test for the significance of all the explanatory variables; i.e. where we compare the estimated model with the base line model that only has the constant term as explanatory variable. We also use the base line model to calculate a pseudo $R^2$ which is not adjusted for the number of parameters.

The multinomial logit model is estimated using PCGive in OxMetrics. We apply a 5% level of significance.

## 3.2 Testable Hypotheses

We investigate three main hypotheses (H1-H3) relating market conditions to the likelihood of the coexceedance variables. The hypotheses refer to persistence, asset class, and volatility effects. For the sake of presentation, we use a separate logit model for each hypothesis. The results from an encompassing model including all three hypotheses are presented at the end.

The fourth hypothesis (H4) relates to asymmetry effects between positive and negative extreme returns. In each case, we also investigate whether the relevance of these variables has changed for the new EU states after the first group of the former Eastern Block countries joined the EU in May 2004 (H5). The hypotheses that we investigate are described in detail below.

### 3.2.1 H1: Persistence Effects

The mechanism of how coexceedances materialize is uncertain. On the one hand, the overreaction hypothesis in behavioral finance (DeBond and Thaler (1985)) suggests that extreme movements in stock prices are followed by movements in the opposite direction to correct the initial overreaction, and that the greater the magnitude of initial price change, the more extreme the offsetting reaction. On the other hand, there may be momentum effects, and coexceedances of the same sign may cluster across time. Here, we test whether coexceedances follow reversal (i.e. opposite directions of successive returns) or continuation

patterns (i.e. same direction of consecutive returns). We also test whether coexceedances within new EU countries are more likely to occur at the same time as coexceedances in old EU member states, and whether this link has changed after the EU enlargement.

### 3.2.2 H2: Asset Class Effects

One important reason behind financial crisis transmission across asset classes is an abrupt portfolio re-allocation in times of flight-to-quality (e.g. Caballero and Krishnamurthy (forthcoming)), and these effects can be reinforced by liquidity spirals (Brunnermeier and Pedersen (forthcoming)). These arguments suggest a substitution effect between equities and safer assets such as bonds or money market instruments. Extreme price interdependence between short-term bonds, equities, and currencies can arise at unanticipated news announcements and monetary policy decisions. Other sources of transmission especially relevant for emerging markets are currency attacks (Morris and Shin (1998) and Obstfeld (1986)) and unwinding carry trade (Bank for International Settlements (1999)). According to these arguments, we expect that coexceedances in equity markets be connected with large price movements in bond and currency markets.

Additionally, the EU membership may have (1) decreased the currency risk premium and (2) increased the degree of equity return correlation within new member states and between them and old member states. As pointed out by Adjaouté and Danthine (2003), these effects may be intensified by a higher integration of capital markets and a reduction of "home bias".

### 3.2.3 H3: Volatility Effects

Shock propagation is more likely in a highly volatile environment overriding all asset classes. Unhedged or leveraged international allocations may also increase contagion. Schinasi and Smith (2001) show that even in an efficient and frictionless setting, spillover effects can emerge on the basis of optimal portfolio decisions taken by leveraged investors as a simple rebalancing response. The hypothesis to test is whether coexceedances are more likely to occur when volatility is pervasively high in all financial markets.

Increased trade is one of the few undisputed gains from a currency union. Among other factors, joining a monetary union should eliminate exchange rate volatility, reduce the transaction costs of trade and synchronize more regional economies.[12] On the other hand, more specialized productions due to capital

[12] There are four main aspects in the Maastricht Convergence Criteria: inflation, fiscal, interest rates, and exchange rates. The inflation and interest rate criteria state that the

market integration can reduce correlation across regions. If the former (latter) factor prevails, we expect that coexceedances in new EU member states are more (less) connected with equity market volatility in the old EU member states after formal EU membership.

#### 3.2.4 H4: Asymmetry Effects

Abundant empirical evidence shows that correlation between assets is different in upward and downward markets. Bertero and Mayer (1990) and King and Wadhwani (1990) find evidence of an increase in the correlation of stock returns at the time of the 1987 crash. Also, Calvo, Leiderman and Reinhart (1996) report correlation shifts during the Mexican crisis. Baig and Goldfajn (1999) find significant increases in correlation for several East Asian markets and currencies during the East Asian crisis. Samitas, Kenourgios and Paltalidis (2007) show that during periods of large negative returns, equity market volatilities share stronger linkages. It is also a stylized fact that stock markets react asymmetrically to good and bad news, see e.g. Boyd, Hu and Jagannathan (2005). In the same line of reasoning, we expect that there is asymmetry between positive and negative coexceedances.

The literature also proposes some theoretical arguments that imply asymmetry between positive and negative returns. Although these factors have typically been outlined for a single (stock) market, they can also be seen as factors driving cross-market comovements. Among the main factors, there are liquidity and institutional reasons. The former are studied by Morris and Shin (2004) and Brunnermeier and Pedersen (forthcoming). Morris and Shin (2004) propose a theoretical model for "liquidity black holes" where there are two types of traders: risk-averse long horizon traders and short horizon traders who privately know the loss limits. In this setting, when the price gets close to the loss limits, a mutually reinforcing mechanism of incentives to sell materializes (similar to a bank run). Brunnermeier and Pedersen (forthcoming) propose a model that links market and funding liquidity. Under certain conditions, market and funding liquidity are mutually reinforcing, leading to liquidity spirals. Initial losses trigger funding problems. By reducing their position, speculators make prices move away from fundamental values and, in turn, this implies higher margins and larger losses on existing positions. Both models can explain why, in downward markets, liquidity can suddenly dry up, why "flight-to-quality" can happen, as well as how stronger comovements across securities can arise. An additional

macroeconomic variables of a country should remain within a given range defined by "the three best performing states". Adjaouté and Danthine (2004) provide empirical evidence on increased synchronization of macroeconomic activities across the euro area.

rationale is the so-called peso problem, see Veronesi (2004); i.e. the existence of a small probability that a catastrophic event can happen in an economy implies asymmetric market reactions to positive and negative shocks even in a rational expectations model. Among the institutional factors, initial margins (Hardouvelis and Theodossiou (2002)), short sale constraints (e.g. Jones and Lamont (2002)) along with "leverage effects" can take part in asymmetric responses in downward and upward markets. All the above arguments suggest to test the three hypotheses H1-H3 separately for positive and negative coexceedances.

#### 3.2.5 H5: Changes after Joining the EU

For each hypothesis, we test whether the effects for the new EU coexceedance variables have changed after May 1, 2004, the time of the first round of the recent EU enlargement. It is worth noting that although the common currency is important, it is just one element in the integration process. Thus, the date of the EU enlargement should not be seen as the exact commencement of the integration effects.[13]

# 4 Empirical Findings

## 4.1 H1: Persistence Effects

We test whether the coexceedances are related to the coexceedances of the same type in the other European markets and whether the coexceedances are autoregressive. For the negative coexceedance variable for the new EU member states ($XN_t^{new}$), the explanatory variables are $XN_t^{old}$ and $XN_{t-1}^{new}$. For $XN_t^{new}$, the probability of having $i$ negative coexceedances is:
$P_i = function\left(\beta_{i0} + \beta_{i1} XN_{t-1}^{new} + \beta_{i2} XN_t^{old}\right)$ where $i = 1, 2$.

The results are given in Table 2. The left-most part of the table concerns the situation where the negative coexceedance variable for the new EU is the explained variable, in the second part the positive coexceedance variable for the new EU is the explained variable, and in the third and fourth parts the negative and positive coexceedances for old EU are the explained variables. The first two columns show the parameter estimates and their standard deviations in parentheses. In the third column, */**/*** indicate the significance of the individual parameter ($\beta_{ij}$) at a 10%/5%/1% level of significance. In the fourth column, it is marked by &/&&/&&& when the explanatory variable $x_j$ is overall

[13] McKinnon (2004) analyzes the role of the credibility of the euro as a stable currency. A credible anchoring mechanism is a necessary condition for a successful common monetary standard.

significant at the 10%/5%/1% level of significance ($\beta_{1j} = \beta_{2j} = 0$). We investigate whether the coexceedance variables for the new EU member states have changed after May 2004. We include an intercept dummy as well as interaction dummies for both variables into the model, where the dummy variable equals unity after May 1, 2004 and zero before. The estimates are not tabulated, but the joint significance level (10%/5%/1%) of the dummy variables is indicated by #/##/### in the right-most column in the first two parts of the table, i.e. in the regressions concerning the new EU.[14]

For all four models, both explanatory variables are significant and the relations are positive. So, the more extreme negative returns we have on the old EU markets, the more likely it is to have many extreme negative returns on the new EU markets. Moreover, the number of extreme negative returns today is positively related to the number of extreme negative returns yesterday supporting the "continuation" rather than the "reversal" hypothesis. A similar interpretation applies to the other markets.

For the negative coexceedance variable for the new EU, the connection to the old EU has become stronger after May 2004. For the positive coexceedance variable for the new EU, only the level decreased after May 2004.

We also considered other possible combinations such as adding positive coexceedances for the old EU markets ($XP_t^{old}$) to the equation for $XN_t^{new}$. This opposite market movements would be reasonable in the light of flight to quality effects when investors flee emerging markets for safer and more liquid markets in times of stress. The results do not support this idea in that $XP_t^{old}$ is insignificant whereas $XN_t^{old}$ remains significant.

## 4.2 H2: Asset Class Effects

Now we ask whether coexceedances are related to different asset type returns. The explanatory variables for the new EU coexceedance variables are currency return ($C_t$), interest rate ($R_t$), US stock return ($S_t^{US}$), and the old European stock return ($S_t^{old}$).[15] For $XN_t^{new}$, the probability of having $i$ negative coexceedances is:

$P_i = function\left(\beta_{i0} + \beta_{i1}C_t + \beta_{i2}R_t + \beta_{i3}S_t^{US} + \beta_{i4}S_t^{old}\right)$ where $i = 1, 2$.

For the old EU coexceedance variables, the new EU stock return ($S_t^{new}$) is

[14] We are aware that some new EU members have relatively developed bond markets, e.g. Poland and Czech Republic. However, the limited number of these countries and their short lifetime do not allow a comprehensive analysis.

[15] The results are robust to using the yield to maturity of the German 10-year government bond index in place of the EURIBOR interest rates (results not tabulated). So apparently the results do not depend on whether we use a short term interest rate or a long term interest rate.

applied as an explanatory variable in place of $S_t^{old}$. The results are given in Table 3, which has the same structure as Table 2.

For the negative coexceedance variable for the new EU member states only the stock market has significant effects. In particular, the likelihood of observing negative exceedances is negatively related to stock returns in old EU countries and in the US. The likelihood of observing coexceedances is related to old EU returns but not to US returns. For the positive coexceedance variable for the new EU member states, both the currency return and the old EU stock return have significant and positive effects upon the likelihood of observing coexceedances. In neither case is the interest rate of importance for the new EU.

For the old EU member states, the likelihood of observing negative coexceedances is mainly related to stock returns, both US and new EU. For the positive coexceedance variable for the old EU, we observe a positive link with the two stock returns and, to a lesser extent, a negative link with interest rates. The signs of the interest rate coefficients are in line with the discounted value approach; that is, an equity asset value decreases as its discounted factor increases.

Old EU stock markets appear more highly connected with US markets. This can be explained by the stronger marked attitude towards international business of firms in developed markets or, conversely, some market segmentation and local focus of companies in new EU member states.

For the negative coexceedance variable for the new EU, currency returns become more relevant after May 2004 (more negative). Also, for both positive and negative coexceedance variables for the new EU, the level decreased after May 2004.

The fact that the level of the new EU coexceedance variables decreased after 2004 could be interpreted as an effect of the inclusion in the EU (at least for negative coexceedances). If the euro appreciates in response to a tighter monetary policy, this would increase the likelihood of equity price falls in new EU member states after 2004 since they are all simultaneously affected by the euro's fortune. This reaction would be even more intense because of the Balassa-Samuelson effect, where inflation risk is higher for new EU states. However, it is worth emphasizing that in the euro-zone, there were two distinct monetary policy phases before and after 2004. The former (latter) period was characterized by an expansionary (restrictive) stance. In that sense, it is more likely to observe equity price drops as the euro appreciates after 2004.

### 4.3 H3: Volatility Effects

We investigate whether volatility factors are related to the simultaneous occurrence of very large or very small returns. We apply both currency, interest rate, and stock market volatility as explanatory variables: $\sigma_t^C$, $\sigma_t^R$, and $\sigma_t^{old}$. For $XN_t^{new}$, the probability of having $i$ negative coexceedances is:[16]
$P_i = function\left(\beta_{i0} + \beta_{i1}\sigma_t^C + \beta_{i2}\sigma_t^R + \beta_{i3}\sigma_t^{old}\right)$ where $i = 1, 2$.

The results are given in Table 4. For the coexceedance variables for the new EU member states, we find that the stock and currency volatility acts as expected; i.e. the likelihood of observing an coexceedance increases in highly volatile environments, whereas the interest rate volatility is insignificant.

For the old EU member states, the volatility in all three asset classes is relevant for the likelihood of observing a coexceedance. Consistent with the second hypothesis discussed above, stock markets in old EU countries appear more affected by spillover effects across asset classes.

For the negative coexceedance variable for the new EU, the probabilities have changed after May 2004. The level has declined such that negative coexceedances have become less likely. However, the link between stock volatility in old EU markets and coexceedances in new EU markets has increased after May 2004. A possible explanation is that the new EU countries' equity markets have become more connected with old EU equity markets. The results are similar for the positive coexceedance variable for the new EU.

### 4.4 H4: Asymmetry Effects

The separate analysis of joint price drops and price jumps suggests that there are significant differences between negative and positive coexceedances. In general, negative coexceedances appear to be more related to the international dynamics of stock markets. Oppositely, positive coexceedances appear to be more responsive to other asset classes, in particular with respect to the currency movements both in terms of returns and volatility. In contrast, the way positive and negative coexceedances materialize in terms of persistence and interconnection between old and new EU member states is similar.

[16] Here, we present the results based on EURIBOR rates. Using the same method, we also investigated the volatility hypothesis using the volatility from the yield from the German 10-year government index calculated. The results (not tabulated) are consistent with what we find using the EURIBOR volatility.

## 4.5 H5: Changes after Joining the EU

While discussing the results for H1-H3, we also discuss the last hypothesis that states that there were changes after the first set of countries formally joined the EU in May 2004.[17] We find that many significant changes take place after May 2004. The likelihood of coexceedances in new EU markets have decreased after May 2004. It is noteworthy that after May 2004, negative coexceedances in new EU markets are more related to stock market movements in the old EU zone.

## 4.6 Encompassing Model

Finally, we estimate an encompassing model that includes all the explanatory variables analyzed above. The main idea is to carry out a joint test for the persistence effects, asset class effects, and volatility effects. The encompassing model can be seen as a robustness check in two main respects: omitted variable bias and endogeneity. The omitted variable bias could arise because we conduct a separate analysis for the three hypotheses (H1 to H3). In other words, it is possible that in each model, we omitted one or more independent variables that are correlated with the included independent variables. The endogeneity issue stems from the temptation to regard exogenous variables as the causes of the endogenous variables (i.e. coexceedance). It is always possible that we omit the consideration of common shocks or other potential factors that originate outside the EU zone. The encompassing model is an attempt to remedy these issues. It represents a comprehensive model that considers persistence effects, market movements in the US market, as well as other concurrent variables all at once.[18]

For robustness, we estimate the encompassing model for the pooled coexceedance variable that pools positive and negative coexceedances for the new EU as well as for the old EU. The results are shown in Table 6. For the encompassing model for the pooled coexceedance variable for the new EU, fewer explanatory variables are significant compared to the separate encompassing models for the negative and positive coexceedance variables. Now, only the own lagged coexceedance variable ($X_{t-1}^{new}$), the pooled coexceedance variable for the old EU ($X_t^{old}$), and the stock volatility ($\sigma_t^{old}$) are significant. By merging positive and negative coexceedances for new EU states, we thin down the statistical significance of the estimated coefficients specifically related to negative coexceedances

[17] In the same way as for the new EU countries, we applied the dummy variables to old EU countries in order to capture if there is a significant difference before and after May 2004. The main findings show that despite a slight change in levels, all the interaction dummies are not significant.

[18] The encompassing methodology might encounter problems of multicollinearity. However, the correlation analysis among all the explanatory variables (not tabulated) suggests that this is not the case.

in the new EU, namely negative coexceedances in old EU ($XN_t^{old}$), currency return ($C_t$), and stock return on old EU ($S_t^{old}$). So by pooling positive and negative extreme returns we lose information.

For the pooled coexceedance variable for the old EU, overall the results are similar to those from the separate models for positive and negative coexceedances. One exception is that the new EU stock return has a negative effect on the pooled coexceedance variable. This is similar to the findings for the negative coexceedance variable and opposite the findings for the positive coexceedance variable. This implies that the effects from the negative coexceedances are stronger than the effects from the positive coexceedances.

# 5 Conclusion

We use the coexceedance methodology of Bae et al. (2003) to investigate integration between the stock markets in the ten new EU member states from the former Communist countries in Eastern and Central Europe. The negative coexceedance variable for the new EU counts the number of extreme returns (below 5% percentile) across the new EU countries on a given day. The positive coexceedance variable for the new EU (above 95% percentile) and the negative and positive coexceedance variables for the new EU are constructed analogously. Using the multivariate logit model, we investigate which factors are related to the coexceedance variables by means of five main hypotheses: persistence, asset classes, volatility effects, asymmetry effects, and changes after the EU enlargement.

For the new EU member states, we find strong persistency effects, and that there are significant global linkages with stock markets in old EU countries in terms of returns, volatility, and coexceedances. The new EU countries show asymmetry effects between negative and positive coexceedance variables. The relevance of many of the factors changed after the EU enlargement in May 2004, suggesting that new EU markets have become more integrated with old EU markets and more related to the euro.

The factors associated with the coexceedance variables differ for the old and new EU stock markets. For the old EU member states, we find that there is a stronger interdependence across asset classes and world regions, which might indicate that the capital markets in the old EU are more integrated than in the new EU.

The empirical evidence that the stock markets of entrant countries in the EU area are more exposed to adverse comovements, volatility as well as persistence

after their adhesion should draw the attention of policy makers. This result suggests that the flip side of the financial market integration is stronger cross-country shock propagation.

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# Appendix: Correlation Matrix

The appendix shows the correlations between the returns from the ten individual new EU stock markets, the 14 individual old EU stock markets, the index for the old EU, the index for the new EU, and the US.

| | Bulgaria | Czech Repub | Estonia | Hungary | Latvia | Lithuania | Poland | Romania | Slovakia | Slovenia | Austria | Belgium | Denmark | Finland | France | Germany | Greece | Ireland | Italy | Netherlands | Portugal | Spain | Sweden | UK | Old EU | New EU | USA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bulgaria** | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Czech Repub** | 0.01 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Estonia** | 0.01 | 0.15 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | |
| **Hungary** | -0.02 | 0.50 | 0.12 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| **Latvia** | 0.01 | 0.06 | 0.58 | 0.02 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| **Lithuania** | 0.01 | 0.11 | 0.41 | 0.10 | 0.05 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| **Poland** | 0.02 | 0.45 | 0.12 | 0.50 | 0.04 | 0.10 | 1.00 | | | | | | | | | | | | | | | | | | | | |
| **Romania** | 0.02 | 0.09 | 0.05 | 0.06 | 0.04 | 0.04 | 0.05 | 1.00 | | | | | | | | | | | | | | | | | | | |
| **Slovakia** | 0.01 | 0.02 | 0.02 | 0.02 | 0.00 | -0.02 | 0.03 | -0.01 | 1.00 | | | | | | | | | | | | | | | | | | |
| **Slovenia** | 0.04 | 0.07 | 0.07 | 0.07 | 0.01 | 0.02 | 0.05 | 0.06 | 0.04 | 1.00 | | | | | | | | | | | | | | | | | |
| **Austria** | -0.02 | 0.37 | 0.11 | 0.39 | 0.03 | 0.10 | 0.35 | 0.09 | 0.00 | 0.07 | 1.00 | | | | | | | | | | | | | | | | |
| **Belgium** | 0.01 | 0.30 | 0.14 | 0.33 | 0.01 | 0.08 | 0.30 | 0.08 | 0.05 | 0.09 | 0.42 | 1.00 | | | | | | | | | | | | | | | |
| **Denmark** | -0.02 | 0.38 | 0.16 | 0.38 | 0.03 | 0.11 | 0.35 | 0.07 | 0.04 | 0.08 | 0.42 | 0.53 | 1.00 | | | | | | | | | | | | | | |
| **Finland** | -0.02 | 0.39 | 0.12 | 0.40 | 0.02 | 0.04 | 0.37 | 0.05 | 0.07 | -0.02 | 0.35 | 0.51 | 0.46 | 1.00 | | | | | | | | | | | | | |
| **France** | 0.01 | 0.38 | 0.15 | 0.42 | 0.01 | 0.08 | 0.39 | 0.04 | 0.05 | 0.04 | 0.44 | 0.81 | 0.55 | 0.70 | 1.00 | | | | | | | | | | | | |
| **Germany** | 0.00 | 0.31 | 0.12 | 0.35 | 0.00 | 0.05 | 0.34 | 0.04 | 0.04 | 0.03 | 0.38 | 0.73 | 0.48 | 0.63 | 0.87 | 1.00 | | | | | | | | | | | |
| **Greece** | 0.03 | 0.36 | 0.12 | 0.32 | 0.04 | 0.05 | 0.33 | 0.05 | 0.08 | 0.05 | 0.36 | 0.38 | 0.43 | 0.36 | 0.41 | 0.38 | 1.00 | | | | | | | | | | |
| **Ireland** | 0.01 | 0.33 | 0.17 | 0.35 | 0.04 | 0.10 | 0.34 | 0.06 | 0.02 | 0.10 | 0.39 | 0.55 | 0.52 | 0.44 | 0.60 | 0.53 | 0.37 | 1.00 | | | | | | | | | |
| **Italy** | 0.01 | 0.31 | 0.12 | 0.36 | -0.01 | 0.07 | 0.35 | 0.06 | 0.04 | 0.04 | 0.40 | 0.74 | 0.45 | 0.62 | 0.88 | 0.83 | 0.35 | 0.53 | 1.00 | | | | | | | | |
| **Netherlands** | 0.00 | 0.34 | 0.14 | 0.37 | 0.02 | 0.06 | 0.35 | 0.06 | 0.05 | 0.04 | 0.39 | 0.83 | 0.54 | 0.64 | 0.92 | 0.83 | 0.39 | 0.58 | 0.85 | 1.00 | | | | | | | |
| **Portugal** | 0.03 | 0.30 | 0.15 | 0.33 | 0.01 | 0.11 | 0.34 | 0.04 | 0.05 | 0.04 | 0.37 | 0.51 | 0.40 | 0.50 | 0.60 | 0.54 | 0.38 | 0.43 | 0.55 | 0.55 | 1.00 | | | | | | |
| **Spain** | 0.01 | 0.35 | 0.13 | 0.37 | 0.02 | 0.07 | 0.36 | 0.06 | 0.05 | 0.04 | 0.42 | 0.71 | 0.48 | 0.65 | 0.87 | 0.79 | 0.37 | 0.53 | 0.83 | 0.81 | 0.60 | 1.00 | | | | | |
| **Sweden** | 0.00 | 0.40 | 0.13 | 0.41 | 0.02 | 0.07 | 0.38 | 0.03 | 0.04 | 0.04 | 0.45 | 0.68 | 0.56 | 0.70 | 0.81 | 0.76 | 0.39 | 0.56 | 0.74 | 0.77 | 0.55 | 0.75 | 1.00 | | | | |
| **UK** | 0.02 | 0.37 | 0.14 | 0.39 | 0.03 | 0.07 | 0.36 | 0.07 | 0.06 | 0.06 | 0.44 | 0.77 | 0.55 | 0.62 | 0.87 | 0.77 | 0.40 | 0.63 | 0.80 | 0.86 | 0.55 | 0.78 | 0.79 | 1.00 | | | |
| **Old EU** | 0.02 | 0.36 | 0.12 | 0.38 | 0.04 | 0.07 | 0.37 | 0.07 | 0.05 | 0.05 | 0.47 | 0.72 | 0.55 | 0.60 | 0.82 | 0.76 | 0.44 | 0.57 | 0.78 | 0.78 | 0.55 | 0.76 | 0.74 | 0.82 | 1.00 | | |
| **New EU** | -0.01 | 0.64 | 0.14 | 0.98 | 0.03 | 0.11 | 0.59 | 0.07 | 0.03 | 0.07 | 0.42 | 0.36 | 0.42 | 0.44 | 0.45 | 0.38 | 0.37 | 0.39 | 0.39 | 0.41 | 0.36 | 0.41 | 0.46 | 0.43 | 0.42 | 1.00 | |
| **USA** | -0.03 | 0.20 | 0.08 | 0.25 | 0.02 | 0.00 | 0.23 | 0.05 | 0.08 | 0.04 | 0.22 | 0.43 | 0.27 | 0.39 | 0.50 | 0.59 | 0.24 | 0.31 | 0.50 | 0.47 | 0.32 | 0.47 | 0.46 | 0.45 | 0.47 | 0.27 | 1.00 |

Table 1: Summary Statistics

| | Number of Coexceedances | | |
|---|---|---|---|
| | 0 | 1 | 2+ |
| **Negative Coexceedances in New EU** | 1130 (66%) | 369 (22%) | 211 (12%) |
| **Positive Coexceedances in New EU** | 1103 (65%) | 417 (24%) | 190 (11%) |
| **Negative Coexceedances in Old EU** | 1320 (77%) | 176 (10%) | 214 (13%) |
| **Positive Coexceedances in Old EU** | 1296 (76%) | 206 (12%) | 208 (12%) |
| **All Coexceedances in New EU** | 722 (42%) | 502 (29%) | 486 (28%) |
| **All Coexceedances in Old EU** | 966 (56%) | 294 (17%) | 450 (26%) |

Table 2: Persistence Effects

| | New EU | | | | Old EU | | | |
|---|---|---|---|---|---|---|---|---|
| | Negative Coexceedances | | Positive Coexceedances | | Negative Coexceedances | | Positive Coexceedances | |
| **Constant(1)** | -1.47 | (0.08) *** &&& # | -1.16 | (0.08) *** &&& ## | -2.38 | (0.11) *** &&& | -2.15 | (0.10) *** &&& |
| **Constant(2)** | -2.62 | (0.12) *** | -2.43 | (0.12) *** | -2.84 | (0.13) *** | -2.33 | (0.11) *** |
| **$XN^{new}_{t-1}(1)$** | 0.37 | (0.09) *** &&& | | | | | | |
| **$XN^{new}_{t-1}(2)$** | 0.67 | (0.10) *** | | | | | | |
| **$XP^{new}_{t-1}(1)$** | | | 0.23 | (0.08) *** &&& | | | | |
| **$XP^{new}_{t-1}(2)$** | | | 0.67 | (0.11) *** | | | | |
| **$XN^{old}_{t-1}(1)$** | | | | | 0.27 | (0.11) *** &&& | | |
| **$XN^{old}_{t-1}(2)$** | | | | | 0.64 | (0.10) *** | | |
| **$XP^{old}_{t-1}(1)$** | | | | | | | 0.39 | (0.10) *** &&& |
| **$XP^{old}_{t-1}(2)$** | | | | | | | 0.48 | (0.10) *** |
| **$XN^{old}_{t}(1)$** | 0.56 | (0.09) *** &&& ### | | | | | | |
| **$XN^{old}_{t}(2)$** | 1.14 | (0.10) *** | | | | | | |
| **$XP^{old}_{t}(1)$** | | | 0.23 | (0.08) *** &&& | | | | |
| **$XP^{old}_{t}(2)$** | | | 0.65 | (0.10) *** | | | | |
| **$XN^{new}_{t}(1)$** | | | | | 0.55 | (0.11) *** &&& | | |
| **$XN^{new}_{t}(2)$** | | | | | 1.09 | (0.10) *** | | |
| **$XP^{new}_{t}(1)$** | | | | | | | 0.30 | (0.10) *** &&& |
| **$XP^{new}_{t}(2)$** | | | | | | | 0.54 | (0.10) *** |
| **Pseudo $R^2$** | 7.4% | | 2.6% | | 9.0% | | 2.7% | |
| **$\chi^2$ stat** | 217.4*** | | 76.7*** | | 212.6*** | | 67.7*** | |

The table shows the parameter estimates arising from estimating the multinomial logit model for the negative coexceedance variable for the new EU (first part of the table), the positive coexceedance variable for the new EU (second part of the table), the negative coexceedances for the old EU (third part of the table), and the positive coexceedances for the old EU (fourth part of the table). Standard errors in parentheses. */**/*** indicate that the parameter is significantly different from zero at 10%/5%/1% level. &/&&/&&& indicate that the explanatory variable is significant at 10%/5%/1% level. #/##/### indicate that the parameter is significantly different after May 2004 at 10%/5%/1% level.

Table 3: Asset Class Effects

| | New EU | | | | | | Old EU | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Negative Coexceedances | | | Positive Coexceedances | | | Negative Coexceedances | | | Positive Coexceedances | | |
| **Constant(1)** | -1.12 | (0.06) *** | &&& ### | -0.98 | (0.06) *** | &&& ### | -2.02 | (0.08) *** | &&& | -1.86 | (0.08) *** | &&& |
| **Constant(2)** | -1.78 | (0.08) *** | | -1.83 | (0.08) *** | | -2.17 | (0.09) *** | | -2.13 | (0.09) *** | |
| **C(1)** | -0.10 | (0.11) | ### | 0.02 | (0.11) | &&& | 0.10 | (0.14) | | -0.05 | (0.13) | |
| **C(2)** | -0.11 | (0.14) | | 0.35 | (0.15) ** | | -0.03 | (0.14) | | 0.10 | (0.14) | |
| **R(1)** | 0.11 | (1.17) | | 0.33 | (1.11) | & | 0.00 | (1.72) | & | 2.39 | (1.31) * | && |
| **R(2)** | -1.40 | (1.43) | | -2.55 | (1.63) | | -3.56 | (1.60) ** | | -2.59 | (1.45) * | |
| **$S^{US}$(1)** | -0.17 | (0.07) ** | && | -0.07 | (0.07) | | -0.31 | (0.09) *** | &&& | 0.18 | (0.08) ** | &&& |
| **$S^{US}$(2)** | 0.02 | (0.09) | | 0.03 | (0.09) | | -0.71 | (0.08) *** | | 0.69 | (0.08) *** | |
| **$S^{old}$(1)** | -0.18 | (0.08) ** | &&& ### | 0.19 | (0.07) *** | &&& | | | | | | |
| **$S^{old}$(2)** | -0.69 | (0.09) *** | | 0.41 | (0.10) *** | | | | | | | |
| **$S^{new}$(1)** | | | | | | | -0.31 | (0.08) *** | &&& | 0.12 | (0.07) * | &&& |
| **$S^{new}$(2)** | | | | | | | -0.67 | (0.07) *** | | 0.40 | (0.07) *** | |
| **Pseudo $R^2$** | 3.1% | | | 1.2% | | | 10.1% | | | 6.1% | | |
| **$\chi^2$ stat** | 92.6*** | | | 35.9*** | | | 239.6*** | | | 151.0*** | | |

The table shows the parameter estimates arising from estimating the multinomial logit model for the negative coexceedance variable for the new EU (first part of the table), the positive coexceedance variable for the new EU (second part of the table), the negative coexceedances for the old EU (third part of the table), and the positive coexceedances for the old EU (fourth part of the table). Standard errors in parentheses. */**/*** indicate that the parameter is significantly different from zero at 10%/5%/1% level. &/&&/&&& indicate that the explanatory variable is significant at 10%/5%/1% level. #/##/### indicate that the parameter is significantly different after May 2004 at 10%/5%/1% level.

Table 4: Volatility Effects

| | New EU | | | | Old EU | | | |
|---|---|---|---|---|---|---|---|---|
| | Negative Coexceedances | | Positive Coexceedances | | Negative Coexceedances | | Positive Coexceedances | |
| Constant(1) | -2.30 | (0.34) *** &&& ### | -0.70 | (0.33) ** &&& | -4.55 | (0.48) *** &&& | -3.34 | (0.44) *** &&& |
| Constant(2) | -4.00 | (0.44) *** | -3.32 | (0.45) *** | -5.59 | (0.46) *** | -5.18 | (0.46) *** |
| $\sigma^{C}(1)$ | 1.18 | (0.57) ** &&& | -1.05 | (0.56) * && | 2.55 | (0.76) *** &&& | 1.37 | (0.71) * &&& |
| $\sigma^{C}(2)$ | 2.18 | (0.72) *** | 1.20 | (0.74) | 3.26 | (0.73) *** | 2.28 | (0.73) *** |
| $\sigma^{R}(1)$ | 2.44 | (1.20) ** | 0.61 | (1.23) | 4.32 | (1.43) *** &&& | 4.41 | (1.42) *** &&& |
| $\sigma^{R}(2)$ | 0.30 | (1.64) | 2.31 | (1.51) | 2.09 | (1.52) | 6.16 | (1.34) *** |
| $\sigma^{old}(1)$ | 0.45 | (0.18) ** &&& ### | 0.34 | (0.17) * &&& ## | 0.92 | (0.23) *** &&& | 0.60 | (0.23) *** &&& |
| $\sigma^{old}(2)$ | 1.06 | (0.19) *** | 0.80 | (0.20) *** | 1.77 | (0.19) *** | 1.75 | (0.19) *** |
| Pseudo $R^2$ | 2.0% | | 1.1% | | 7.0% | | 6.2% | |
| $\chi^2$ stat | 60.4** | | 31.7*** | | 165.3*** | | 152.8*** | |

The table shows the parameter estimates arising from estimating the multinomial logit model for the negative coexceedance variable for the new EU (first part of the table), the positive coexceedance variable for the new EU (second part of the table), the negative coexceedances for the old EU (third part of the table), and the positive coexceedances for the old EU (fourth part of the table). Standard errors in parentheses. */**/*** indicate that the parameter is significantly different from zero at 10%/5%/1% level. &/&&/&&& indicate that the explanatory variable is significant at 10%/5%/1% level. #/##/### indicate that the parameter is significantly different after May 2004 at 10%/5%/1% level.

Table 5: Encompassing Model

| | New EU | | | | | | | | Old EU | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Negative Coexceedances | | | | Positive Coexceedances | | | | Negative Coexceedances | | | | Positive Coexceedances | | | |
| **Constant(1)** | -2.08 | (0.35) *** | &&& | | -0.73 | (0.33) ** | &&& | | -4.78 | (0.49) *** | &&& | | -3.50 | (0.45) *** | &&& | |
| **Constant(2)** | -3.61 | (0.47) *** | | | -3.34 | (0.47) *** | | | -6.36 | (0.55) *** | | | -5.41 | (0.50) *** | | |
| **$XN^{new}_{t-1}(1)$** | 0.36 | (0.09) *** | &&& | # | | | | | | | | | | | | |
| **$XN^{new}_{t-1}(2)$** | 0.63 | (0.11) *** | | | | | | | | | | | | | | |
| **$XP^{new}_{t-1}(1)$** | | | | | 0.22 | (0.09) *** | &&& | | | | | | | | | |
| **$XP^{new}_{t-1}(2)$** | | | | | 0.65 | (0.11) *** | | | | | | | | | | |
| **$XN^{old}_{t-1}(1)$** | | | | | | | | | 0.10 | (0.12) | &&& | | | | | |
| **$XN^{old}_{t-1}(2)$** | | | | | | | | | 0.42 | (0.11) *** | | | | | | |
| **$XP^{old}_{t-1}(1)$** | | | | | | | | | | | | | 0.26 | (0.11) ** | && | |
| **$XP^{old}_{t-1}(2)$** | | | | | | | | | | | | | 0.12 | (0.11) | | |
| **$XN^{old}_{t}(1)$** | 0.39 | (0.11) *** | &&& | ## | | | | | | | | | | | | |
| **$XN^{old}_{t}(2)$** | 0.89 | (0.12) *** | | | | | | | | | | | | | | |
| **$XP^{old}_{t}(1)$** | | | | | 0.16 | (0.10) | &&& | | | | | | | | | |
| **$XP^{old}_{t}(2)$** | | | | | 0.37 | (0.12) *** | | | | | | | | | | |
| **$XN^{new}_{t}(1)$** | | | | | | | | | 0.40 | (0.12) *** | &&& | | | | | |
| **$XN^{new}_{t}(2)$** | | | | | | | | | 0.83 | (0.12) *** | | | | | | |
| **$XP^{new}_{t}(1)$** | | | | | | | | | | | | | 0.24 | (0.11) ** | && | |
| **$XP^{new}_{t}(2)$** | | | | | | | | | | | | | 0.19 | (0.12) | | |
| **C(1)** | -0.03 | (0.11) | | # | 0.01 | (0.11) | | | 0.06 | (0.14) | | | -0.03 | (0.13) | | |
| **C(2)** | 0.06 | (0.14) | | | 0.27 | (0.15) * | | | -0.16 | (0.15) | | | 0.11 | (0.14) | | |
| **R(1)** | 0.12 | (1.11) | | | 0.28 | (1.10) | | | -0.03 | (1.48) | | | 1.79 | (1.27) | | |
| **R(2)** | -0.78 | (1.43) | | | -1.55 | (1.39) | | | -2.90 | (1.54) * | | | -1.41 | (1.36) | | |
| **$S^{US}(1)$** | -0.15 | (0.07) ** | & | | -0.08 | (0.07) | | | -0.35 | (0.09) *** | &&& | | 0.22 | (0.08) *** | &&& | |
| **$S^{US}(2)$** | 0.03 | (0.08) | | | 0.03 | (0.09) | | | -0.67 | (0.09) *** | | | 0.57 | (0.08) *** | | |
| **$S^{old}(1)$** | -0.07 | (0.08) | && | ## | 0.16 | (0.08) ** | &&& | | | | | | | | | |
| **$S^{old}(2)$** | -0.29 | (0.10) *** | | | 0.28 | (0.10) *** | | | | | | | | | | |
| **$S^{new}(1)$** | | | | | | | | | -0.26 | (0.08) *** | &&& | | 0.10 | (0.07) | &&& | |
| **$S^{new}(2)$** | | | | | | | | | -0.49 | (0.08) *** | | | 0.36 | (0.08) *** | | |
| **$\sigma^{C}(1)$** | 0.72 | (0.59) | | | -1.11 | (0.57) ** | && | | 2.52 | (0.78) *** | &&& | | 1.39 | (0.72) * | &&& | |
| **$\sigma^{C}(2)$** | 1.22 | (0.77) | | | 0.99 | (0.78) | | | 3.10 | (0.83) *** | | | 2.28 | (0.78) *** | | |
| **$\sigma^{R}(1)$** | 2.07 | (1.23) * | | | 0.29 | (1.26) | | | 4.19 | (1.51) *** | && | | 3.93 | (1.49) *** | &&& | |
| **$\sigma^{R}(2)$** | -0.41 | (1.77) | | | 1.47 | (1.60) | | | 0.79 | (1.80) | | | 5.92 | (1.49) *** | | |
| **$\sigma^{old}(1)$** | 0.19 | (0.19) | | # | 0.25 | (0.18) | | ## | 0.97 | (0.24) *** | &&& | | 0.54 | (0.24) ** | &&& | |
| **$\sigma^{old}(2)$** | 0.42 | (0.23) * | | | 0.39 | (0.23) * | | | 1.69 | (0.23) *** | | | 1.65 | (0.23) *** | | |
| **Pseudo $R^2$** | 8.4% | | | | 3.6% | | | | 19.7% | | | | 11.9% | | | |
| **$\chi^2$ stat** | 247.2*** | | | | 106.8*** | | | | 266.0*** | | | | 292.0*** | | | |

The table shows the parameter estimates arising from estimating the multinomial logit model for the negative coexceedance variable for the new EU (first part of the table), the positive coexceedance variable for the new EU (second part of the table), the negative coexceedances for the old EU (third part of the table), and the positive coexceedances for the old EU (fourth part of the table). Standard errors in parentheses. */**/*** indicate that the parameter is significantly different from zero at 10%/5%/1% level. &/&&/&&& indicate that the explanatory variable is significant at 10%/5%/1% level. #/##/### indicate that the parameter is significantly different after May 2004 at 10%/5%/1% level.

Table 6: Encompassing Model for Pooled Coexceedances

| | New EU Pooled Coexceedances | | | | Old EU Pooled Coexceedances | | | |
|---|---|---|---|---|---|---|---|---|
| Constant(1) | -0.83 | (0.34) ** | &&6 | # | -3.40 | (0.43) *** | &&& | |
| Constant(2) | -2.13 | (0.36) *** | | | -6.32 | (0.44) *** | | |
| $X^{new}_{t-1}(1)$ | 0.16 | (0.07) ** | &&& | | | | | |
| $X^{new}_{t-1}(2)$ | 0.59 | (0.08) *** | | | | | | |
| $X^{old}_{t-1}(1)$ | | | | | 0.21 | (0.09) ** | &&& | |
| $X^{old}_{t-1}(2)$ | | | | | 0.43 | (0.08) *** | | |
| $X^{old}_{t}(1)$ | 0.21 | (0.08) *** | &&& | | | | | |
| $X^{old}_{t}(2)$ | 0.48 | (0.08) *** | | | | | | |
| $X^{new}_{t}(1)$ | | | | | 0.27 | (0.08) *** | &&& | |
| $X^{new}_{t}(2)$ | | | | | 0.48 | (0.08) *** | | |
| C(1) | -0.05 | (0.11) | | | 0.07 | (0.12) | | |
| C(2) | 0.11 | (0.11) | | | 0.04 | (0.11) | | |
| R(1) | 0.55 | (1.18) | | # | 1.15 | (1.30) | && | |
| R(2) | -0.41 | (1.16) | | | -2.48 | (1.27) * | | |
| $S^{US}(1)$ | -0.07 | (0.07) | | | -0.09 | (0.07) | | |
| $S^{US}(2)$ | -0.04 | (0.07) | | | 0.00 | (0.07) | | |
| $S^{old}(1)$ | 0.00 | (0.08) | | | | | | |
| $S^{old}(2)$ | -0.12 | (0.08) | | | | | | |
| $S^{new}(1)$ | | | | | -0.10 | (0.06) | &&& | |
| $S^{new}(2)$ | | | | | -0.19 | (0.06) *** | | |
| $\sigma^{C}(1)$ | -0.23 | (0.58) | | | 1.08 | (0.67) | &&& | |
| $\sigma^{C}(2)$ | 0.57 | (0.60) | | | 3.56 | (0.64) *** | | |
| $\sigma^{R}(1)$ | 0.66 | (1.28) | | | 3.31 | (1.47) ** | &&& | |
| $\sigma^{R}(2)$ | 0.12 | (1.33) | | | 4.61 | (1.33) *** | | |
| $\sigma^{old}(1)$ | 0.37 | (0.21) * | && | ### | 1.34 | (0.29) *** | &&& | |
| $\sigma^{old}(2)$ | 0.55 | (0.21) *** | | | 2.66 | (0.25) *** | | |
| Pseudo $R^2$ | 5.1% | | | | 15.5% | | | |
| $\chi^2$ stat | 189.0*** | | | | 516.5*** | | | |

By pooling positive and negative coexceedance variables together, this table shows the parameter estimates arising from estimating the multinomial logit model for the pooled coexceedance variable for the new EU (first part of the table) and the pooled coexceedance variable for the old EU (second part of the table). Standard errors in parentheses. */**/*** indicate that the parameter is significantly different from zero at 10%/5%/1% level. &/&&/&&& indicate that the explanatory variable is significant at 10%/5%/1% level. #/##/### indicate that the parameter is significantly different after May 2004 at 10%/5%/1% level.

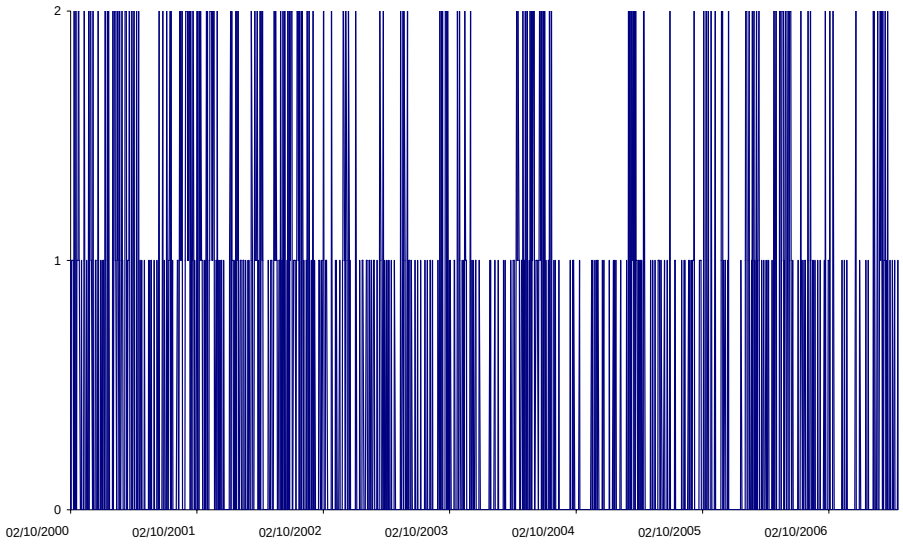


Figure 1: Time Series Plot of the Negative Coexceedance Variable for the New EU


Figure 2: Time Series Plot of the Positive Coexceedance Variable for the New EU

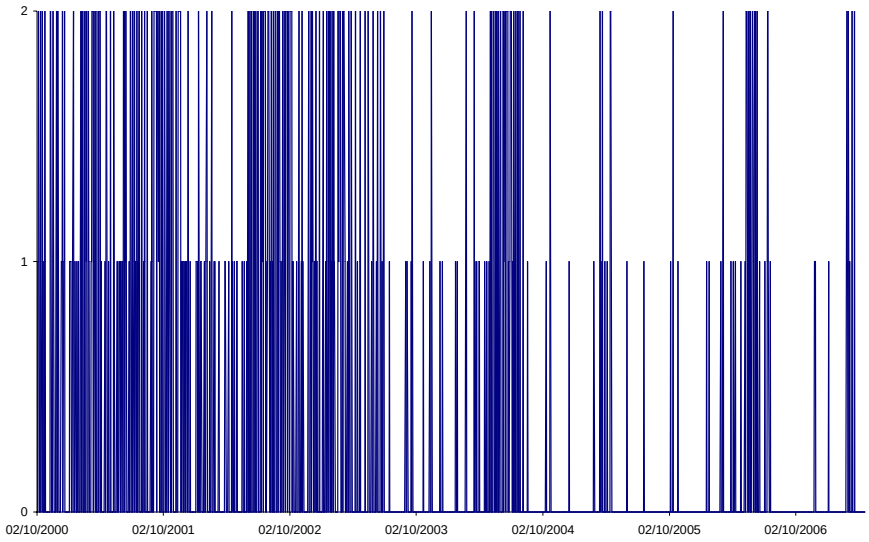


Figure 3: Time Series Plot of the Negative Coexceedance Variable for the Old EU

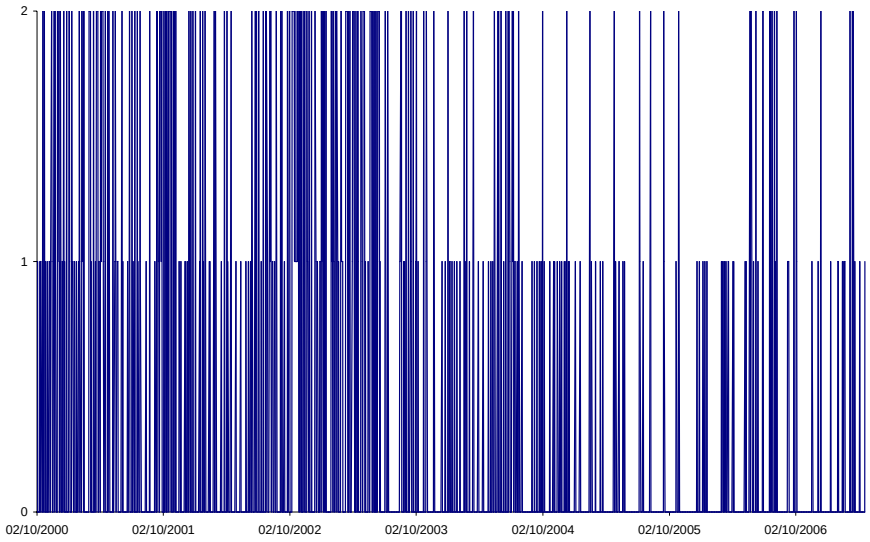


Figure 4: Time Series Plot of the Positive Coexceedance Variable for the Old EU