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What Might Central Banks Lose or Gain in Case of Euro Adoption – A GARCH-Analysis of Money Market Rates for Sweden, Denmark and the UK

Abstract

This study deals with the question whether the central banks of Sweden, Denmark and the UK can really influence short-term money markets and thus, would lose this influence in case of Euro adoption. We use a GARCH-M-GED model with daily money market rates. The model reveals the co-movement between the Euribor and the short-term interest rates in these three countries. A high degree of co-movement might be seen as an argument for a weak impact of the central bank on its money markets. But this argument might only hold for tranquil times. Our approach reveals, in addition, whether there is a specific reaction of the money markets in turbulent times. Our finding is that the policy of the European Central Bank (ECB) has indeed a significant impact on the three money market rates, and there is no specific benefit for these countries to stay outside the Euro area. However, the GARCH-M-GED model further reveals risk divergence and unstable volatilities of risk in the case of adverse monetary shocks to the economy for Sweden and Denmark, compared to the Euro area. We conclude that the danger of adverse monetary developments cannot be addressed by a common monetary policy for these both countries, and this can be seen as an argument to stay outside the Euro area.[1]

Keywords: Euro adoption, EMS, money markets, interest rates, GARCH-M-GED models, international financial markets

JEL Classification: E42, E43, F36, G01, G15

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Was gewinnen oder verlieren Zentralbanken bei einer Euro-Einführung – Eine GARCH-Untersuchung der Geldmarktsätze in Schweden, Dänemark und im Vereinigten Königreich

Zusammenfassung

Der Beitrag befasst sich mit der Frage, ob die Zentralbanken Schwedens, Dänemarks und des Verinigten Königreichs kurzfristig ihre jeweiligen Geldmarktsätze beeinflussen können und folglich bei einer Einführung des Euro anstelle ihrer nationalen Währungen diesen Einfluss verlieren würden. Mit Hilfe eines GARCH-M-GED-Modells mit täglichen Zinsdaten wird dies für den Zeitraum von 1992 bis 2011 überprüft. Als Referenzzins dient hierbei der Euribor. Die Ergebnisse zeigen eine gleichgerichtete Entwicklung zwischen dem Euribor und den nationalen Drei-Monats-Geldmarktsätzen in den untersuchten Ländern an. Diese gleichgerichtete Bewegung kann in dem Sinne interpretiert werden, dass die jeweiligen Zentralbanken nur einen geringen Einfluss auf die Entwicklung der Geldmarktzinsen in ihren Ländern haben. Es ist nicht auszuschließen, dass dieses Argument jedoch nur für „ruhige Zeiten“ an den Finanzmärkten gilt. Deshalb liegt ein Augenmerk der Untersuchung auf Zeiten mit beträchtlichen Turbulenzen in den Märkten. Die Ergebnisse zeigen, dass die Politik der Europäischen Zentralbank (EZB) einen beträchtlichen Einfluss auf die Entwicklung der drei Geldmarktsätze ausübt. Zusätzlich zeigen die Ergebnisse des GARCH-M-GED Modells eine im Vergleich zum Euroraum unterschiedliche Risikoentwicklung und instabile Volatilitäten des Risikos, wenn Schweden und Dänemark negativen monetären Schocks gegenüberstehen. Der Beitrag endet mit der Schlussfolgerung, dass sich diese beide Staaten gegenüber negativen monetären Schocks nicht durch eine gemeinsame Geldpolitik schützen können und es somit aus Sicht der skandinavischen Länder rational sein kann, der Eurozone nicht beizutreten.

Schlagwörter: Euro-Einführung, EWS, Eurosystem, Geldmärkte, Geldmarktzinsen, GARCH-M-GED-Modelle, internationale Finanzmärkte

JEL-Klassifikation: E42, E43, F36, G01, G15

1 The research question

Sweden, the UK (and Denmark) are 'old' EU members still outside the monetary union. While the UK and Denmark made use of an opt-out clause, Sweden is obliged to adopt the euro after fulfilling the convergence criteria. But the authorities managed not to fulfill the convergence criteria – violating the inflation criterion.[2] Lacking political support in the population was and is a main factor behind euro abstinence. Recently, reservations against EU political and economic integration even seem to have risen among the European public. The entire EU might slide into a severe crisis, in which the monetary union already is. But, public sentiments are volatile. Iceland, for instance, is eager to join the EU and the monetary union not at least to slip under the umbrella of financial assistance after the disastrous banking and government crisis. It seems there is still some room for economic reasoning. The aim of our study is to expand the economic literature into one new direction: instead of using methods to capture possible long-run gains in terms of growth, employment and welfare, this study applies a GARCH-M-GED approach to model short-term money market shocks the central banks are faced with. This method helps to identify the degree of monetary integration in the presence of (crisis) shocks and, in addition, it provides insights into monetary market risks of the countries considered compared to those in the monetary union. Sweden and the UK constitute the core of the study because a floating exchange rate is coupled with inflation targeting by the central bank; these are the institutional requirements for any impact of monetary policy on money markets.[3] Denmark with her nominal peg to the Euro is different: policy rate changes are preserved to situations of severe monetary shocks. Under normal conditions, Danish policy rates follow the ECB rates. Short-term market rates follow the central bank's intervention on the FX markets, hence, these differences would disappear in case of euro adoption. We include Denmark into our sample to compare the Danish money market developments under a more or less fixed exchange rate against the Euro with the two other countries with flexible exchange rate.

The road map of this study is as follows: The second chapter provides a brief discussion of the literature. The third chapter describes the institutional framework and stylized facts. The fourth section includes the data and the model set up. Estimation results are presented and discussed in section five. The sixth section concludes with some political considerations.

2 In addition, the Riksbank is not an independent central bank, and therefore, Sweden does not meet one of the institutional criteria for becoming a member of EMU.

3 Euro adoption would also lead to the elimination of differences in inflation targeting between the countries (see *Kuttner*, 2004: 99) and the European Central Bank; but this issue belongs to further research questions.

2 A Review of the Debate

Whether Sweden, the UK (and Denmark) should join the EMU is a topic of economic research since the early 1990s. Most studies of researchers or scientific committees deal with a broad understanding of welfare gains and losses, including those of growth, employment and inflation. These are typical scenarios of long-run results, mostly gains from a common currency. But the literature contains also considerations about short-term benefits from preserving an own currency. In the UK, two reports of the finance ministry of 1997 and 2003 (HM Treasury, 1997 and 2003) argued that the weak synchronization of business cycles between UK and the then monetary union candidates and the weak flexibility of the economy would speak against the abandoning of the pound. Denmark seems to preserve the option to play the card of an independent monetary policy in case of heavy shocks (Holden, 2009; Volz, 2004), and to accept some foregone gains of participating in the monetary union. In Sweden, the Calmfors commission (Calmfors et al., 1996) concluded that Sweden (in 1996) was not yet ready to adopt the Euro. The Commission argued that monetary union would lead to only small (long-run) efficiency gains due to reduced transaction costs and less exchange rate uncertainty and increased competition. However, these gains have to be weighed against the adverse effects of large (short-run) country-specific disturbances that could have severe consequences if they were not counteracted by country-specific monetary policy and exchange insurance against such extreme events. The literature on the subject that followed the verdicts in the UK and Sweden did not end with clear conclusions. Some studies (Moser et al, 2004; Economidou and Kool, 2007; Giannone et al., 2009) found increasing signs of business cycle synchronization between the two countries (plus Denmark) and the EMU and hence, improving (long-run) conditions for adopting the euro. But Mazier and Saglio (2008) using an international macroeconomic model, found severe (long-run) structural asymmetries among EU countries – even 10 years after the Euro was introduces in 11 countries, so that in case of an initial negative shock Sweden, the UK and Denmark could offset the effects thanks to their greater flexibility, although this flexibility is somewhat weaker in case of Denmark. Söderströhm (2008) reconsidered the conclusions of the Calmfors commission 10 years later and achieved conflicting results when applying different models.

Relevant for the issue in our study, Söderströhm found that (short-run) country-specific disturbances have been more important for fluctuations in the Swedish economy since 1993 than for the EMU area, implying that Euro adoption could be costly in case of a commonly spread crisis. Söderströhm also referred to a political argument: The Calmfors commission argued that a possible loss of political influence in the EU could be detrimental for Sweden when staying outside of the EMU. But ‘available evidence suggests that there are no strong political disadvantages for Sweden remaining outside EMU’ (Söderströhm, 2008: 20/21 with reference to various studies on this issue). Moser et al. (2004) argued that the bilateral exchange rates with the Euro are subject to economic policy coordination in the EU for they are regarded as of common interest (see

Article 124.2 of the EU Treaty). From this perspective, a loss of influence is rather implausible, since EU and EMU countries are interested to avoid competitive devaluations. With respect to UK, Holden (2009) concluded from the strong upward deviation of the UK money market rates from the Euribor that a common monetary policy would have been costly in terms of growth and employment in case of Euro adoption. However, de Grauwe (2007: 104) argued that the comparably high weight of the British economy in the calculation of the common inflation rate would the ECB policy rate set closer to an interest rate in the UK's interest.

Reade and Volz (2010) contributed to the debate with a new argument. They simply asked why Sweden should preserve an own currency when money market rates follow the Euribor, and policy rates simply mimic the ECB's rates. Applying VAR techniques on daily money market data, they found that short-term rates in Sweden are co-integrated with the Euribor. The authors conclude that Sweden would not lose something she never had – influence on money markets – after joining EMU, but would gain more political influence over the common monetary policy of the ECB. The authors obtained their results by an extensive use of dummy variables for days of high instability in the data. However, when two time series might co-move during tranquil times, they might nevertheless significantly deviate in their developments in turbulent times. If turbulent periods last for some time, co-integration analysis may fail to give an appropriate advice to policy decision makers how to deal with these short-term disturbances. With the elimination of outliers in a test for co-integration, one of the major arguments the Calmfors commission (1996) raised against a premature membership in EMU would be circumvented, namely the appearance of adverse country-specific disturbances.

ARCH/GARCH techniques and their recent extensions are an appropriate methodology for the identification of both the co-movement of two monetary time series and of elevated risks in turbulent times – hence, they are an alternative option to VAR and/or co-integration approaches. Distinct to linear regression models, a GARCH-M-GED model accounts for a non-constant, time varying variance in the error term by modeling the error term as a GARCH(p, q) process and by adding the GARCH term in a suitable manner as an additional regressor in the so-called mean equation (Engle et al., 2008, 2010). This estimation process is non-linear. The non-linearity reflects the impact of news ('shocks') on the behavior of the variable and reveals its specific risk structure, which cannot be modeled by other econometric techniques.

The GARCH-in-Mean (GARCH-M) approach we apply considers the conditional covariance terms. The appealing idea behind this methodology is to investigate the in-mean GARCH variances. These variances might be unstable and even increasing, and deviate from the benchmark variable – in our case: the Euribor - thus require particular attention by monetary policy makers. A slight extension of the GARCH-M model is the GARCH-M-GED approach. The GARCH-M-GED approach addresses the problems of leptokurtic distributions of many monetary variables as well. Therefore, GARCH-M-GED models provide an appropriate technique to deal with non-linearity and fat tails in

monetary policy key variables simultaneously. A leptokurtic distribution means that risks (measured by the volatility) are suppressed in tranquil times (signaling a co-movement, say, with the Euribor), but extremely elevated ('fat tail risks') in turbulent market times.

Multivariate GARCH-M models were recently applied to Euro candidate countries of Central-Eastern Europe by Kočenda/Poghosyan (2007) in their study on foreign exchange risks and Gabrisch/Orlowski (2010) on financial market risks, among them short-term interest rate risks. These studies detect important differences across the countries due to underlying systemic differences between them. Gabrisch and Orlowski (2010) argue that different risk premiums increase the probability of potentially destabilizing nominal shocks even in case of a co-movement of short-term interest rates. For the country group considered, Gabrisch and Orlowski (2010) found actually no co-movement between the countries interbank rates and the Euribor, and the prevalence of extreme risks in the conditional volatility series of interbank rates. We believe that the application of a GARCH model is innovative for the identification of the conditions for giving up an own currency.

3 Stylized Facts

A central bank should be able to manage at least the short-term money market rates by open market policy, setting policy rates, and other instruments of its tool kit. Therefore, it might be reasonable to assume that the ECB can influence the Euribor. The question that matters is how strong is the influence of the Euribor on the money market rates of Sweden, UK, and Denmark? We use daily data of the Frankfurt money market rate since 1992, the three-month money market rates of Sweden (Sibor), the UK (Libor) and Denmark (Cibor). The Frankfurt money market (FF_GM) rate is our long-run proxy for the Euribor. The latter is reported since 1999 only, while the former is historical and goes back to at least 1975. Correlation coefficients in Table 1 reveal an almost 100 % and highly significant identity between the FF_GM and Euribor since 1998, so that we feel safe to use the former and longer time series of the Frankfurt money market rate for longer time spans. We observe an almost complete correlation between FF_GM/Euribor and the Cibor of Denmark as well, which supports the hypothesis that monetary policy might be integrated in case of a fixed exchange rate with respect to the Euro. There remain interesting differences between the Sibor (Sweden) and the Libor (UK). The correlation between Euribor and Libor is relatively weak, and reflects the strong integration of British financial markets with the rest of the world.

Table 1:
Correlation of FF_GM rate with the four money market rates between 12/02/1992 and 6/03/2010 (4568 observations)

	Euribor (since 1999)	Sibor (Sweden)	Libor (UK)	Cibor (Denmark)
FF_GM against...	0.999***	0.838***	0.628***	0.931***
Euribor against...		0.836***	0.625***	0.930***

*** Significance at the 1 per cent level.

Source: Datastream, data taken from: Deutsche Bundesbank (FF_GM), the Bank of Sweden (Sibor), National bank of Denmark (Cibor), Bank of England (Libor), and FBE&ACI: Europäischer Bankenverband und Handelsorganisation ACI (Euribor); own compilation.

Figure 1:
Time distribution of Euribor and three-month market rates of Sweden, UK, and Denmark

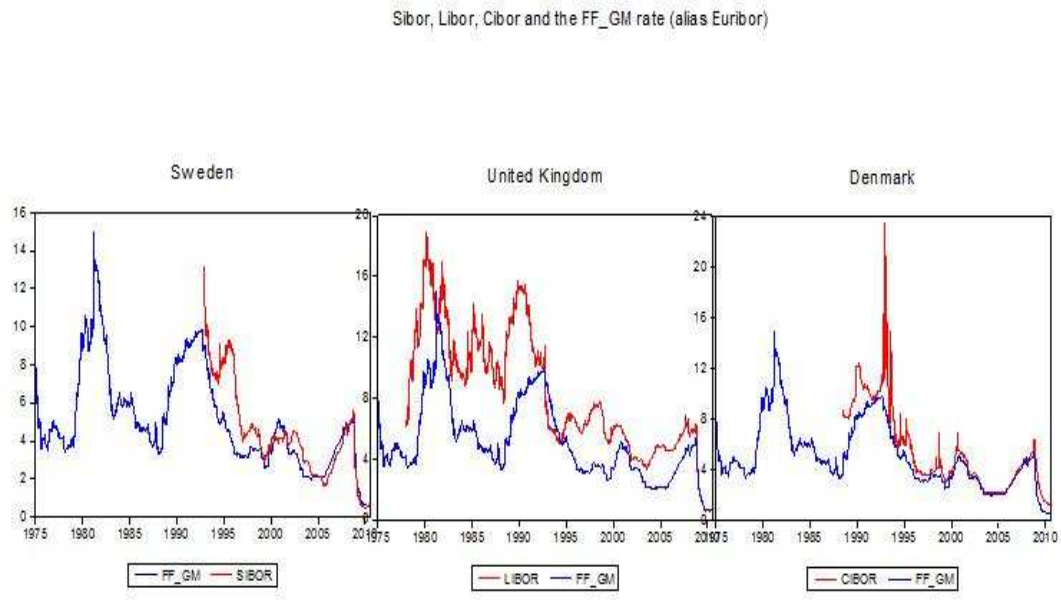


Figure 1 illustrates how the three-month 'Euribor' and the three-month money market rates of Sweden (Sibor), the UK (Libor), and Denmark (Cibor) performed over time. We observe a strong dissimilarity between the 'Euribor' and the Libor (confirming the weak correlation and the specific 'competitive' situation between financial market places of Frankfurt and London), and an increasing co-movement of the Euribor and the Sibor since around 2004. A similar picture shows the Danish Cibor, although there were more explicit deviations at the beginning of the previous decade and in the recent financial crisis than in the Swedish case. The central bank of Denmark did not only use policy rates to stabilize the money market in the early 2000s, but did so also ahead and dur-

ing the recent financial crisis (compare Figures 1 and 2). In October 2008, the main rate was raised to the highest levels since more than 8 years in order to prevent a massive outflow of FX reserves. Afterwards the rate was cut to record levels, and FX interventions served to defend the peg.

Table 2 presents the descriptive statistics of the series including data available for all countries for the period 12/03/1992 – 06/18/2010. The data show a weak skewness (left and right), and remarkable leptokurtosis for the Euribor, the Libor and the Cibor (< 3), but an almost normal distribution for the Sibor (3.1). Using the shorter periods, all interest rates show remarkably lower values of the kurtosis, hence, the emerging leptokurtic distribution since 1992 could reflects emerging disturbances around this time (the Nordic Banking crisis and the EMS crisis), but some effects of the approaching EMU as well.[4] To put it differently: since the pre-euro period, extreme interest rate gains emerge with a higher probability than one should expect under a normal distribution (Jacobi, 2005: 4). Judged by standard deviation measures (common sample), Sibor is the most volatile variable, while Euribor is least volatile. Euribor, Sibor, and Cibor are right-skewed, sharing a prevalence of positive over negative shocks; Libor is left-skewed.

Table 2:
Descriptive statistics

	Euribor		**Sibor**		**Libor**		**Cibor**	
	1992-2010	1999-2010	1992-2010	1999-2010	1992-2010	1999-2010	1992-2010	1999-2010
Mean	3.592	3.070	4.360	3.113	5.146	4.480	4.357	3.456
Median	3.404	3.083	4.102	3.306	5.455	4.800	3.876	3.435
Maximum	9.080	5.393	12.218	5.600	7.800	6.850	23.500	6.908
Minimum	0.634	0.634	0.473	0.473	0.530	0.530	1.195	1.195
Std. Dev.	1.521	1.218	2.325	1.261	1.600	1.541	2.429	1.248
Skewness	0.707	-0.117	0.723	-0.504	-1.190	-1.236	2.756	0.260
Kurtosis	4.218	2.211	3.0653	2.396	4.470	3.921	14.794	2.035
Jarque-Bera	662.71	83.92	398.64	171.26	1488.63	864.07	32242.9	149.17
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observation	4566	2980	4566	2980	4566	2980	4566	2980

Sources: see Table 1.

4 Descriptive statistics for the period since 1999 (EMU) show a decline of leptokurtosis.

4 Set Up of the GARCH-M-GED Model

A basic assumption of long-run risk co-movement between the Euribor and the local money market interest rates is a decreasing in-mean GARCH variance in the time series, i.e. a diminishing risk. Hence, information about the stability and risks cannot be just linearly extrapolated from historical data. It is adequately captured by the dynamics of the in-mean variance in the conditional mean equation with generalized error distribution specification (GARCH-M-GED). The GARCH estimator grasps the aggregate effects of all the institutional and structural asymmetries, regardless whether real or nominal convergence is actually observed in the long-period time-series. One of these institutional asymmetries might stem from the different role, integration and regional orientation of financial markets in the countries considered ('London-Frankfurt'). The sign of the in-mean GARCH variance coefficient reflects positive or negative risk premium for investors. Considering these advantages, we have chosen to apply this method to the short-term market interest-rate, which are assumed to be affected by the policy rates of the central bank.

For empirical testing, we develop the following model examining co-movement between domestic $i_t^{j,3m}$ three-month money market rate (Sibor, Libor, and Cibor) of country j

(j = Sweden, Denmark, UK) and common currency market rate, i_t^{*3m} (FF_GM alias Euribor). As additional explanatory variable we insert the (log of the) exchange rate e of the domestic currency in terms of Euro in order to capture the impact of the exchange rate volatility on money market risks. The inclusion of the Euribor and the exchange rate explains the room for an independent monetary policy pursuit of the central bank. Augmented Dickey-Fuller tests for stationarity (ADF tests) reveal unit roots for all interest and exchange rates at their (log) levels except for the SIBOR. First differences, however, are stationary, so that we use first differences in our regressions. The basic linear model of interest rate yield co-movement is linear

$$\Delta i_t^{j,3m} = \beta_0 + \beta_1 \Delta i_t^{*3m} + \beta_2 \Delta \log e_t^j + \xi_t \qquad (1)$$

with ξ as the error term. Further, it is a well-known fact that linear regressions should be applied only when the error is assumed to have a zero mean and a constant standard deviation σ. In finance and monetary economics, however, this is frequently not the case. In ARCH/GARCH models we focus on the error process and assume the conditional mean to be zero. The term 'conditionality' stands for the forecast for the variable i_t^{3m} conditional on the information I_{t1} known at time t_1. Based on the information available at earlier times one can define the conditional means and the conditional variances

of these earlier periods (Engle et al., 2008). Hence, conditional volatility dynamics of changes in the considered countries' short-term interest rates as a function of the Euribor are examined on the basis of the GARCH(p,q)-equation system with ARCH(p) and GARCH(q) lags. The conditional mean equation in first differences is given by

$$\Delta i_t^{j,3m} = \beta_0 + \beta_1 \Delta i_t^{*3m} + \beta_2 \Delta \log e_t^j + \beta_3 \sigma_{t-1}^2 + \xi_t^{'}, \tag{2}$$

with ξ' as the error term with a zero conditional mean. The inclusion of the GARCH variance σ_{t-1}^2 in the mean equation allows for ascertaining the overall risk premium on short-term interest rates. The estimated value of the β_1 coefficient is expected to be close to or higher than one if a given change in the Euribor drives completely the short-term market rates in the countries into the same direction. ß$_2$ is expected have a negative sign in this specification; if interest rates parity holds: devaluation (appreciation) of the home currency against the euro leads to a positive (negative)value of the $\Delta \log e^j_t$ variable and should lead to a decrease (increase) of the money market rate. A risk discount for domestic short-term money instruments compared to Euribor instruments is detected when $\beta_3 < 0$, a risk charge when $\beta_3 > 0$. The corresponding conditional variance equation is specified as

$$\sigma_t^2 = h_0 + h_1 \xi_{t-1}^{'2} + ... + h_p \xi_{t-p}^{'2} + g_1 \sigma_{t-1}^2 + ... + g_q \sigma_{t-q}^2 \tag{3}$$

The ARCH terms $h_i \xi_{t-i}^{'2}$, i = 1,..,p, represent the impact of common 'news' or shocks to volatility from p-periods before, while the GARCH terms gkσ2t-k , k = 1, 2,..,q, reflect persistency in volatility carried from q-periods before. In particular, we are focusing on the sum of ARCH and GARCH coefficients; if its value is less than unity, the GARCH (p,q) process is a special case of a homoskedastic error process; it implies a compression of interest rate volatility, hence risk convergence with the Euro area. In hindsight, risk convergence is detected if the sum of ARCH and GARCH terms is less than one, while risk divergence matters when the sum is larger than one. In this case, the ARCH process loses its white noise properties. The impact of past shocks on the conditional variance is persistent. Some authors underline a strict non-negativity requirement for ARCH and GARCH residuals at each lag (Bollerslev et al., 1994: 2969; Jacobi, 2005: 8), while others (Nelson and Cao, 1992: 230) reduce this requirement to the sum of the residuals. We prefer the latter approach to receive the best estimation fit. The orders of p for the ARCH terms for each interest rate series have been chosen on the basis of the minimum of the Schwartz information criterion (SIC) and maximum log-likelihood value, respectively. For the GARCH term, we decide for one lag only (q = 1). Such a reduced model has proved efficient in many empirical studies (Jacobi, 2005: 20). Further, a change in the sign in subsequent ARCH coefficients might point at strong speculation.

Our data generating process assumptions include the generalized error distribution (GED) parameterization to account for possible 'tail risks' or a fat-tailed data distribution (leptokurtosis according to Table 2). The GED parameter was fixed through an optimisation process aiming at a positive coefficient of determination, the R squared. The overview below Table 3 provides a scheme for a comprehensive evaluation of the results. We assess a scenario as the best case when the GARCH variance term in the conditional mean equation is smaller than 0 and the sum of ARCH and GARCH terms in the conditional variance equation is smaller than 1 (but, of course, larger than 0). If this holds, a crisis common to the Euro market and one of the national money markets puts no specific challenge to the central bank in one of the three countries considered. The worst case scenario is a strong argument to maintain an own currency and own monetary policy instruments. The other two cases are inconclusive.

Table 3:
An evaluation scheme

		Conditional mean equation	
		Variance terms < 0	Variance term >0
Conditional variance equation	Sum of ARCH and GARCH terms < 1	***Best case scenario***	inconclusive
	Sum of ARCH and GARCH terms > 1	inconclusive	***Worst case scenario***

Note: shadowed fields: conclusive cases.

5 Estimation Results

Regressions include the whole period (from early 1992 to mid 2010) and the period since the euro introduction (from early 1999). The results of the GARCH(p,1) tests based on eqs.(2) and (3) for each country's interest rate and for the two periods are shown in Table 4. The conditional mean equation shows that there is co-movement between the Euribor and the three-month money markets rates of all three countries. Not surprisingly, the co-movement with the Danish Cibor is the strongest, given the fixed exchange rate. Somewhat surprisingly, the co-movement between the Libor and Euribor turns out to be high, too. In the case of Sweden, this co-movement has a causality running from the Euribor to the Sibor, since we cannot expect that the small Sweden drives the large Euro area. In the case of the Libor, the same is not easily to repeat, for the financial markets in UK are larger than in the case of Sweden; and UK financial markets compete with Frankfurt money markets. The exchange rate variable obtained the correct (negative) sign in all model specifications, hence, interest parity holds. There is a rising and now strong impact of exchange rate variations on the money markets since the es-

tablishing of the common currency. Independent financial flows have even a larger impact on short-term market rates than the Euribor since euro introduction.

Table 3:
GARCH estimation results

First differences of…	logSibor		logCibor		logLibor	
Period	Whole [a]	Euro [b]	Whole[a]	Euro[b]	Whole[a]	Euro[b]
Variables	Conditional mean equation					
Constant	-0.017***	-0.005***	-0.004***	0.002***	0.002***	-0.038**
ΔlogEuribor	0.668***	0.609***	0.708***	0.809***	0.231***	0.518***
ΔlogER	-0.528***	-1.750***	-0.329***	-1.54***	-0.214***	-0.546***
Log(GARCH*1000)	-1.711***	-0.510***	-0.325***	0.225***	--[c]	-4.651**
	Conditional variance equation					
Constant	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
$[ARCH(-1)]^2$	0.302***	1.253***	0.497***	0.843***	0.240***	0.007***
$[ARCH(-2)]^2$	-0.157***	-0.696***	-0.166**	0.341***	-0.060***	0.033**
$[ARCH(-3)]^2$	-0.112***	0.112***		-0.721***	-0.081***	0.076***
$[ARCH(-4)]^2$	0.128***			-0.047***	-0.032***	0.007***
$[ARCH(-5)]^2$	0.181***			0.170***	-0.038***	-0.014***
$[ARCH(-6)]^2$	-0.200***			0.079***	0.019***	
GARCH(-1)	0.913***	0.721***	0.822***	0.780***	0.937***	0.356***
Sum of ARCH & GARCH residuals	1.072	1.390	1.153	1.445	0.985	0.465
GED parameter	2.0	2.0	1.5	2.0	1.5	1.475***
Diagnostic Statistics						
logLikelihood	10232.24	7395.72	11665.73	8742.81	10459.00	7051.50
DW-Stat	1.892	1.959	2.658	1.887	2.020	1.906
Observations	4566	2980	4483	2980	4566	2980

[a] 12/3/1992 – 6/03/2010; [b] 1/1/1999 – 6/03/2010; [c] none.

Significance levels: *** 1 %, ** 5 %, * 10 %.

For all three countries it holds that the GARCH-variable $ß_3 < 0$, showing a significant risk premium discount as compared to the Euribor for the entire period. This discount seems to erode since the Euro area was established; in case of Denmark, a risk surcharge on the Cibor replaced an earlier discount. The conditional variance variable is significant for the Libor only since the Euro exists.

In the conditional variance equation, ARCH/GARCH coefficients are highly significant; the non-negativity requirement is fulfilled since the sum of coefficients is positive Note, that the coefficients describe the deviation of volatility from Euribor volatility; hence, it can be interpreted as a sign of the prevalence of country-specific disturbances. In the case of the Libor only, the sum of ARCH and GARCH residuals turned out to be less than one, indicating declining volatility and risk convergence. And this convergence gained momentum since the euro exists. This is surprising since UK would enter the 'best case scenario' in our evaluation scheme. Hence, having adopted the Euro, a crisis common to the Euro would not put a specific challenge to the Bank of England.

This is different for the other two other countries and in part, surprisingly for Denmark. The sum of ARCH/GARCH terms is remarkably larger than one and the volatility gap to the Euribor increased in the Euro era. This means that in turbulent market periods in Sweden and Denmark, the reaction of the risk premium tends to be higher than in the euro area. In case of the Cibor, this is likely due to disturbances on the foreign exchange market (and could be healed by adopting the Euro). For all money market rates, we get many higher orders of ARCH-type shocks to volatility, suggesting an unstable path of adjustment. The alteration of signs of the residuals reveals high speculation in the Swedish and Danish market.

With respect to Denmark one may argue that the exchange rate vis-a-vis the Euro is more or less fixed and will thus not contribute much to the explanation of the Danish money market rate. But rerunning the regressions without the exchange rate variable for Denmark leads to very similar results compared with the ones reported in Table 1.

In most cases, the GED parameter was set in accordance with the results of Table 2 (descriptive statistics). In the case of Denmark and Sweden, any leptokurtosis in the money market rates disappeared in the euro period, and we set the parameter at 2. The model estimated the GED parameter for the Libor in the euro period only. Finally, the GARCH (1) coefficients are high in most cases, but declining. In case of Sweden, the coefficient reports that almost the whole volatility from the previous period is carried over to the current period, so it is highly persistent – the same holds for Denmark at a lower degree.
In sum: the Sibor moved probably from the best case scenario in the pre-Euro period to the inconclusive part of our evaluation scheme (Table 5). Even worse, the Cibor moved from inconclusive to to the worst case area, and a common monetary shock would affect at least the Danish economy more than the Euro area.

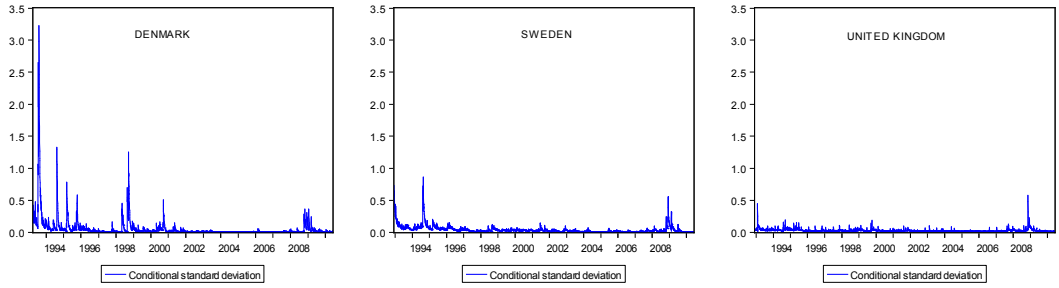
Table 5:
Evaluation results

		Conditional mean equation	
		Variance terms < 0	Variance term >0
Conditional variance equation	Sum of ARCH and GARCH terms < 1	*Sibor* / *Libor*	
	Sum of ARCH and GARCH terms > 1	*Cibor* / *Sibor*	*Cibor*

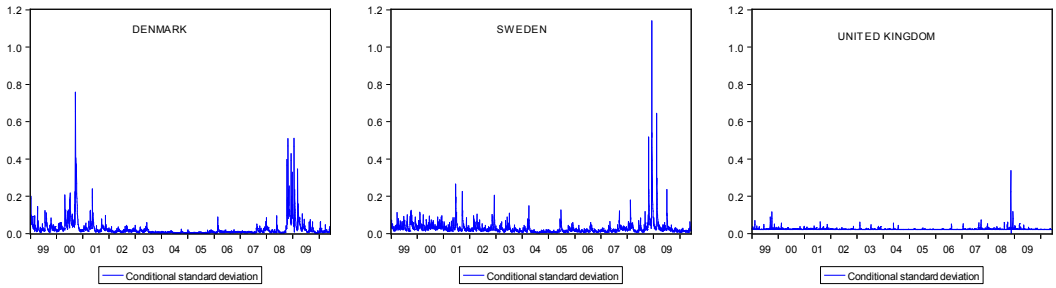
Note: left upper area of each field: entire period; right lower area: Euro area.

Figure 2:
GARCH conditional standard deviation residuals generated from estimations in Table 3

(a) Entire period



(b) Euro period



When we compare these results with those obtained by Gabrisch and Orlowski (2010) in their study on euro candidate countries from the east since the year 2000, coefficients show a rather strong co-movement of short-term interest rates, while in Poland, Hungary, the Czech Republic, Romania and Slovakia no co-movement could be identified. The persistence of shocks to volatility – GARCH (1) - seems to be weaker in the new

euro candidate countries than in Sweden or UK. Finally, 'fat tail' risks are at considerably higher levels in new euro candidate countries, where the GED parameter turned out to be less than 1.

The graphical displays (Figure 2) of the GARCH conditional standard deviation shows jumps in interest rate volatility for all three money markets relative to the FF-GM/Euribor, coinciding with the Nordic banking crisis (Sibor, Cibor) and the EMS crisis 1992-3 (UK) and since 10 October 2008, the collapse of Lehmann Brothers. In the intermediate period, volatility behaves restlessly for the UK, and a bit more in Sweden than in Denmark. To put it differently: there seems not to be any stabilizing contribution of the Euribor to the volatility of the three market rates. Looking at the shorter period since early 1999 (euro introduction), the volatility in the Sibor is pretty higher than in the Libor. All this might be interpreted in favour of Sweden's and UK's no-entry to the euro – a conclusion that seems to hold even more for Sweden.

6 Concluding Discussion

The data and our test results do not reject the argument for Sweden and Denmark that their central banks would not much loose in monetary policy when adopting the euro. If we left Denmark aside for we cannot exclude results to be biased by the fixed exchange rate, Sweden and UK become the interesting cases Sweden's Sibor – showing a high co-movement with the Euribor and a risk discount in tranquil times – is more vulnerable than the Euro in turbulent times. Even the co-movement between the Euro and UK money markets is rather high; but, we have not tested whether London should adopt the Euro or Frankfurt the British Pound – the UK financial markets are by far larger than the Swedish ones.The volatility analysis revealed a decreasing volatility compared to the Euro even in turbulent market times; hence, we conclude that a common crisis would not be a specific challenge to the Bank of England if the legal currency were the Euro. The graphical presentations display a very restless behaviour of the risk premium for Sweden and Denmark, but not for UK in the Euro period. We see this as an argument for having an own currency under a flexible exchange rate system. It is well possible for the Sibor that in tranquil times, the domestic money market rate is driven by the Euribor, and the policy rates mimic the ECB's policy. However, in turbulent times an independent monetary policy might become necessary since the domestic interest rate does no longer follow the Euribor, and is affected by country-specific factors. These turbulent times happen more frequently than plain figures show. For Sweden, there is not yet a specific gain to adopt the Euro. The Riksbank used the monetary market tools in the recent financial crisis to mitigate the possibly negative shocks on the real economy by diminishing the policy rates more than the ECB (Figure 1). This way only, the Sibor did not exceed the Euribor (Figure 2).

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