Interest and exchange rate volatility in Belgium

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Introduction

The fixed exchange rate objective pursued by the Belgian authorities is not aimed only at providing an anchor for the operational conduct of monetary policy. The link between the Belgian franc and the Deutsche Mark also serves as a reference framework for the various financial market participants and thus extends beyond the exchange rate to cover all interest rates.

This integration of the Belgian market with the Deutsche Mark zone is obviously the clearest in the case of very short-term interest rates, as the National Bank of Belgium (NBB) coordinates its rate changes with those of the Bundesbank. There is also a very close link between the other money market rates, however. Furthermore, in order to safeguard its exchange rate objective, the NBB seeks to prevent the emergence of a negative short-term interest rate differential vis-à-vis Germany and does not hesitate to tighten market liquidity so as to ensure that all Belgian money market rates shadow increases, even those of a seasonal nature, in German money market rates.

As maturities lengthen, the authorities' direct influence on rates diminishes, with long-term rates being influenced by three factors, namely the level of real interest rates, inflation expectations and the risk premium. The integration of the financial markets and the pursuit of exchange rate stability vis-à-vis the Deutsche Mark have prevented the first two of these three factors from creating significant interest rate differentials between Belgium and Germany. On the other hand, the fixed exchange rate policy is not, in itself, sufficient to equalise the risk premium in the two countries, as this depends not only on the currency of investment but also on the rating of the government sector in the two countries, the liquidity of secondary markets and the tax arrangements. While these factors are liable to change in the medium term, they show a certain inertia in the shorter term, which means that, under normal circumstances, changes in long-term rates in Belgium are a reasonably faithful reflection of those in the corresponding German rates.

To date, the link between Belgium and Germany on the foreign exchange markets, the money market and the capital market has chiefly been studied in terms of levels. This paper aims to extend the examination of this link to include volatility. More specifically, has the progressive alignment of the conditions prevailing on the Belgian and German markets been accompanied by a parallel development in volatilities or has it, on the contrary, been achieved only at the cost of greater volatility in Belgium? If the latter is the case, is this difference in volatility a constant phenomenon or is it confined to certain periods?

From a practical point of view, the most direct measure of volatility is based on the dispersion of changes in the price of a given asset during a period; it is evaluated using the standard deviation of daily changes expressed as a percentage. This measure reflects what is commonly called the unconditional volatility of the price of the asset under consideration, since it is produced without attempting to isolate that part of volatility which could have been expected on the basis of available information. Forecasts of future, or conditional, volatility can be made by means of econometric models, mostly GARCH models, in which past volatility in particular is included among the explanatory variables in the form of combinations of past residuals. These models reveal the persistence of a high level of volatility following an unexpected shock.

1 The authors wish to thank Raf Wouters for his assistance in producing the econometric estimates for this study.

This paper focuses on a short-term approach to volatility, based on daily data. The first section is devoted to historical or unconditional volatility and attempts to assess how it is influenced by domestic policy decisions and external shocks respectively. The second section uses a GARCH model to compare the respective impacts on interest rates in Belgium of conditional volatility and other variables relating to both the Belgian and German financial markets.

1. Recent developments in the historical or unconditional volatility of interest rates and the exchange rate in Belgium

1.1 Main factors likely to have affected the volatility of the Belgian financial markets

Per se, some volatility in financial asset prices is a normal consequence of the efficient functioning of the markets on which these prices are set. Thus any modification in the equilibrium conditions of the markets following changes in the fundamentals that are likely to affect the supply of or demand for these assets must be reflected in changes in the level of prices and their volatility. It is only when this volatility cannot be explained by the development of fundamentals that it may be regarded as excessive.

In this context, it would seem essential to take stock of the various factors likely to affect volatility. These have been particularly numerous over the last few years: Belgium has not been spared, any more than most other industrialised countries, from a series of structural developments which may have affected both financial asset price volatility and its distribution mechanism. Successive deregulation measures, financial innovations and the introduction of new IT and telecommunications techniques have contributed to a progressive globalisation of the financial markets. This may have resulted in some increase in volatility and, above all, an acceleration in its transmission process, not just between markets in the same financial centre but also between markets in different financial centres. As regards Belgium, these factors are likely in themselves to produce a certain alignment of volatilities with those observed in the main foreign markets and in the German market in particular.

In addition to these structural changes in the macro-financial environment, a number of more isolated events have, in the recent past, influenced the volatility of Belgium's financial and foreign exchange markets. Some of them were of external or international origin and therefore also prompted a bout of volatility in foreign markets. Others, conversely, are specific to Belgium and should, in principle, only have affected the domestic markets. The following main events can be noted, in chronological order:

- the reduction in the rate of withholding tax on interest income in Belgium from 25 to 10% on 1st March 1990;
- the abolition of the two-tier foreign exchange market system in Belgium on 5th March 1990;
- the pegging of the franc to the most stable currencies in the European Monetary System (EMS) - in this instance the Deutsche Mark - on 16th June 1990;
- the change in the implementation of monetary policy in Belgium on 29th January 1991;
- the withdrawal of the Italian lira and sterling from the EMS exchange rate mechanism (ERM) on 17th September 1992;
- the widening of the ERM fluctuation bands (from 2.25 to 15%) on 2nd August 1993;
- the general fall in bond prices in 1994, which started in the United States in October 1993 and spread to Europe following the rate increase by the US Federal Reserve on 4th February 1994.

In the remainder of this section, we shall attempt to evaluate the influence of these events on the historical volatilities of the Belgian markets relative to the German markets. On the foreign exchange markets, the analysis focuses directly on the volatility of the Belgian franc/Deutsche Mark exchange rate. On the money and capital markets, we compare the volatility of the interest rate on three-month Euro-franc and Euro-DM deposits and ten-year benchmark bonds in the same currencies.

Volatility is measured using the standard deviation of daily percentage changes observed over the thirty preceding working days. The period under consideration runs from 5th June 1989 to 30th August 1995.[2]

The differing behaviour of the volatility on the three markets considered is immediately obvious. The foreign exchange market shows the lowest volatility, including periods of foreign exchange crisis. Average volatility was less than 0.1% over the period as a whole and rose to only 0.16% between July 1993 and August 1995. The average volatility of the long-term interest rate (0.6%) is considerably higher than that of the exchange rate, but the tension between the volatility peaks and troughs is less marked (with a ratio of 4.5 for the long-term interest rate and 20 for the exchange rate).[3] Furthermore, there is hardly any significant difference between the volatility of the Belgian and German capital markets, either in terms of level or of tension. Finally, the three-month interest rate on the Belgian money market is characterised by both a high average volatility and a wide dispersion between the volatility extremes. Average volatility amounts to 1.3% and is substantially higher than in Germany (0.7%), while the tension indicator used in the above instance reveals a ratio of 16.7 in Belgium and 3.5 in Germany.

These results, relating to the entire period of observation, permit a comparison of the degrees of volatility of the three prices considered in this study. They obviously need to be supplemented by a more systematic analysis, since they do not take account of the different characteristics of the three markets and do not reflect the changes they underwent during the period.

1.2 Belgian franc/Deutsche Mark exchange rate volatility

In the development of the Belgian franc/Deutsche Mark exchange rate volatility, two sub-periods are clearly visible. The point of transition was in August 1993, when the ERM fluctuation bands were widened.

From January 1989 to the end of July 1993, the Belgian franc/Deutsche Mark exchange rate volatility was very limited; its average level was less than 0.05%.

This low volatility is all the more remarkable in that the franc appreciated strongly against the Deutsche Mark during the first few months of 1990. However, this appreciation was reflected in only a fairly small increase in volatility. This dichotomy highlights the distinction which should be drawn between the trend of a variable and its volatility. A regular trend, such as that observed in the progressive appreciation of the Belgian franc during the first half of 1990, does not imply a significant increase in volatility.

It should be noted that the abolition of the two-tier foreign exchange market on 5th March 1990 did not interrupt the gradual strengthening of the franc. This measure did not put any pressure on the exchange rate, which, on the contrary, continued to appreciate against the Deutsche Mark. At that time, moreover, the differential between rates on the regulated and free markets had

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2 The starting date for this period was chosen for reasons of data availability: it is only from that date that Belgian ten-year benchmark bond yields are available.

3 This ratio is calculated on the basis of the distribution of daily volatilities by comparing the lower and upper limits of the bands including at least 5% of the highest or lowest values observed. For example, for the foreign exchange market, 5% of the highest values showed a volatility greater than 0.4%, while 5% of the lowest values showed a volatility of less than 0.02%; the tension indicator is thus 0.4/0.02 = 20.

Table 1

Unconditional exchange and interest rate volatility

(in percentages)

Deutsche Mark/Belgian franc rate

	5.6.89-28.1.91	29.1.91-11.9.92	14.9.92-19.7.93	20.7.93-30.8.95	Entire period
Maximum	0.12	0.07	0.09	0.80	0.80
Highest 5%	0.11	0.06	0.09	0.61	0.40
Average	0.06	0.03	0.05	0.16	0.09
Lowest 5%	0.02	0.01	0.03	0.03	0.02
Minimum	0.01	0.01	0.02	0.02	0.01
Tension coefficient*	5.5	4.5	3.0	24.4	20.0

Short-term (three-month) Belgian franc interest rate

Maximum	1.07	0.77	2.47	0.95	9.95
Highest 5%	1.00	0.73	2.45	9.10	5.00
Average	0.52	0.45	1.38	2.40	1.28
Lowest 5%	0.28	0.25	0.60	0.60	0.30
Minimum	0.25	0.17	0.56	0.43	0.17
Tension coefficient*	3.6	2.9	4.1	15.2	16.7
Correlation coefficient between B.fr. and DM rates	64.8	73.7	4.5	18.8	13.0

Short-term (three-month) Deutsche Mark interest rate

Maximum	1.36	1.35	2.37	1.12	2.37
Highest 5%	1.28	0.86	2.30	1.00	1.23
Average	0.81	0.47	1.03	0.71	0.71
Lowest 5%	0.50	0.29	0.65	0.43	0.35
Minimum	0.36	0.23	0.56	0.31	0.23
Tension coefficient*	2.6	3.0	3.5	2.4	3.5

Long-term (10-year) Belgian franc yield

Maximum	0.93	0.67	0.98	1.60	1.60
Highest 5%	0.85	0.64	0.95	1.38	1.13
Average	0.46	0.37	0.63	0.79	0.58
Lowest 5%	0.18	0.25	0.38	0.50	0.25
Minimum	0.11	0.21	0.32	0.37	0.11
Tension coefficient*	4.9	2.6	2.5	2.8	4.5
Correlation coefficient between B.fr. and DM rates	57.4	89.6	7.4	72.2	75.6

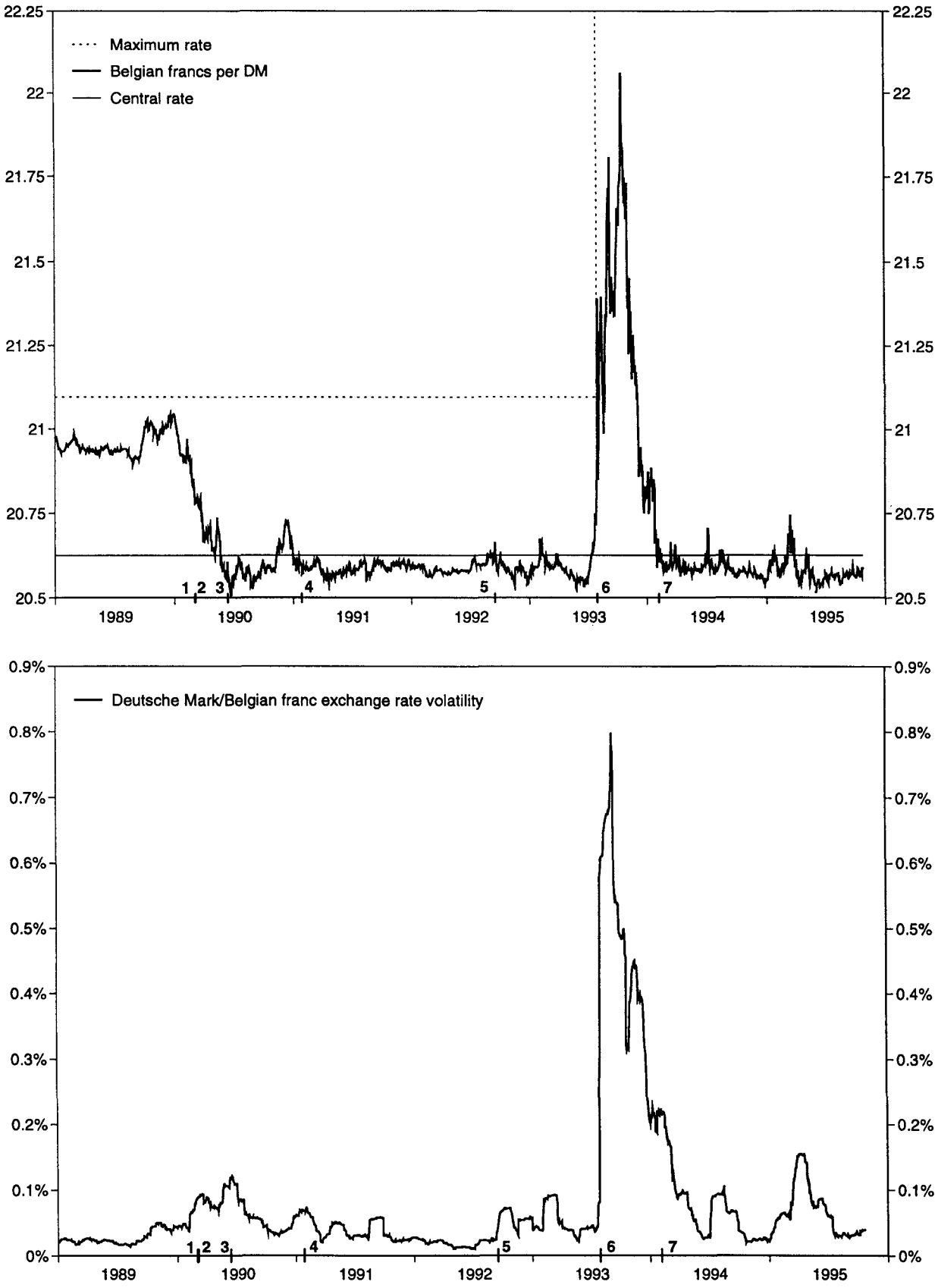
Long-term (10-year) Deutsche Mark yield

Maximum	0.92	0.61	0.67	1.57	1.57
Highest 5%	0.83	0.60	0.67	1.40	1.10
Average	0.48	0.34	0.45	0.72	0.52
Lowest 5%	0.25	0.23	0.29	0.35	0.25
Minimum	0.22	0.20	0.21	0.28	0.20
Tension coefficient*	3.3	2.7	2.3	4.0	4.4

* The ratio of the upper and lower limits of the bands including at least 5% of the highest or lowest values.

Graph 1

Deutsche Mark/Belgian franc exchange rate



Notes: 1. Reduction of withholding tax from 25 to 10% (1.3.90). 2. Abolition of the two-tier foreign exchange market (5.3.90). 3. Pegging of the Belgian franc to the Deutsche Mark (16.6.90). 4. Change in the implementation of monetary policy (29.1.91). 5. Withdrawal of the Italian lira and sterling from the ERM (17.9.92). 6. Widening of the ERM fluctuation bands from 2.25 to 15% (2.8.93). 7. General fall in bond prices in Europe (4.2.94).

virtually disappeared. It should, however, be borne in mind that the existence of this particular system had made it possible to remove all obstacles to the movement of capital between Belgium and the rest of the world from 1955.

It is true that the abolition of the two-tier foreign exchange market was coupled with the reduction of the withholding tax on new fixed income financial assets from 25 to 10% on 1st March 1990. This reduced the scale of foreign investment by Belgian private individuals aimed at avoiding this tax. It was also reflected in a reversal of the outflows on long-term capital account.

The strengthening of the Belgian franc within the ERM should also be seen in relation to the temporary weakening of the Deutsche Mark due to uncertainties raised by German reunification. The Belgian monetary authorities sought to consolidate this strengthening by undertaking, on 16th June 1990, to link the franc closely to the anchor currencies of the EMS. This policy implies not only that the franc's central rate vis-à-vis the Deutsche Mark is maintained in the event of a general EMS realignment, but also that, in day-to-day practice on the foreign exchange market, the franc shadows the Deutsche Mark around its central rate.

This pegging of the Belgian franc to the Deutsche Mark was well understood and accepted by financial market operators. It thus allowed the Belgian authorities to implement a major reform of money market operating techniques and of monetary policy instruments without giving rise to significant variations in exchange rate volatility.

On the contrary, the period between the monetary policy reform and the crisis of August 1993 saw the Deutsche Mark/Belgian franc exchange rate at its most stable. On average, daily exchange rate volatility was only 0.04% and only 5% of the volatility values observed were higher than 0.08%. By way of comparison, during the preceding period (June 1989 to January 1991), average volatility was 0.06%, while 5% of the volatility values were higher than 0.11%.

There was, admittedly, a certain increase in volatility at the end of 1992 and the beginning of 1993. This should be seen in relation to the withdrawal of sterling and the Italian lira from the ERM in September 1992, followed at the beginning of 1993 by the emergence of a generally more uncertain climate, underlined by the Belgian Government's tendering of its resignation in March. These episodes were, however, well absorbed by the foreign exchange market, whose volatility was constantly below 0.1%.

It was not possible to maintain this stability during the foreign exchange crisis of summer 1993. Speculative pressures intensified and spread to affect the majority of EMS currencies. In view of their magnitude, it was decided on 1st August 1993 to widen the ERM fluctuation bands from 2.25 to 15%. The temporary weakening of the Belgian franc exchange rate which followed was obviously reflected in its volatility, which increased sharply, reaching a peak of 0.8% at the beginning of September.

While the gradual return of the franc towards its central rate vis-à-vis the Deutsche Mark was, fairly naturally, accompanied by a reduction in volatility, the events of July 1993 seem, nonetheless, to have marked a certain break. Volatility generally remained at a higher level than during the preceding period and appeared to show a fairly high degree of persistence.

Thus, while the franc had returned to its central rate by the end of January 1994, exchange market volatility remained at a high level until the beginning of April. After that date, moreover, it proved to be more sensitive than before, as is illustrated by the two upsurges observed around mid-1994 and again during the second quarter of 1995. These volatility peaks, furthermore, were not systematically linked to any weakening of the Belgian franc exchange rate. To some extent, they were also the result of a temporary sharp appreciation, as was the case at the beginning of June, when the exchange rate briefly dipped below B.fr. 20.5 to the Deutsche Mark. Such developments indicate that the widening of the ERM fluctuation bands, while reducing the risks of a crisis within the system, also entails greater precision in the conduct of monetary policy in those countries seeking to achieve a precisely targeted exchange rate objective.

1.3 Short-term interest rate volatility

The main event to affect the Belgian money market in the past few years was the change in the implementation of monetary policy in January 1991.

Prior to this reform, the NBB influenced money market rates by using a very particular technique which differed greatly from that used by the other central banks, viz. the discretionary fixing of the interest rate on Treasury certificates: the NBB, in consultation with the Minister of Finance, fixed the rate on short-term Belgian franc securities (essentially those at one, two and three months) issued by the Belgian Treasury. In addition, these securities were issued on tap and were reserved for Belgian and Luxembourg credit institutions. This meant that the latter could, in view of the considerable stock of securities in circulation and the spread of maturities, adjust their liquidity daily by adapting their portfolios without the need for recourse to a secondary market. In this context, any change in the interest rate on these securities was directly reflected in all money market rates.

The adoption in 1991 of techniques fulfilling the conditions for participation in economic and monetary union (EMU) and making direct use of market mechanisms meant that the NBB now acts on much shorter maturities. Periodic credit tenders designed to show the general direction of rates usually have a term limited to one week, while daily interventions on the market more often than not have even shorter maturities (two to three days), and end-of-day credits and deposits with the central bank must be renewed on a daily basis.

This change might have been expected a priori to lead to an increase in the volatility of three-month rates, which from then on were controlled only indirectly by the monetary authorities.

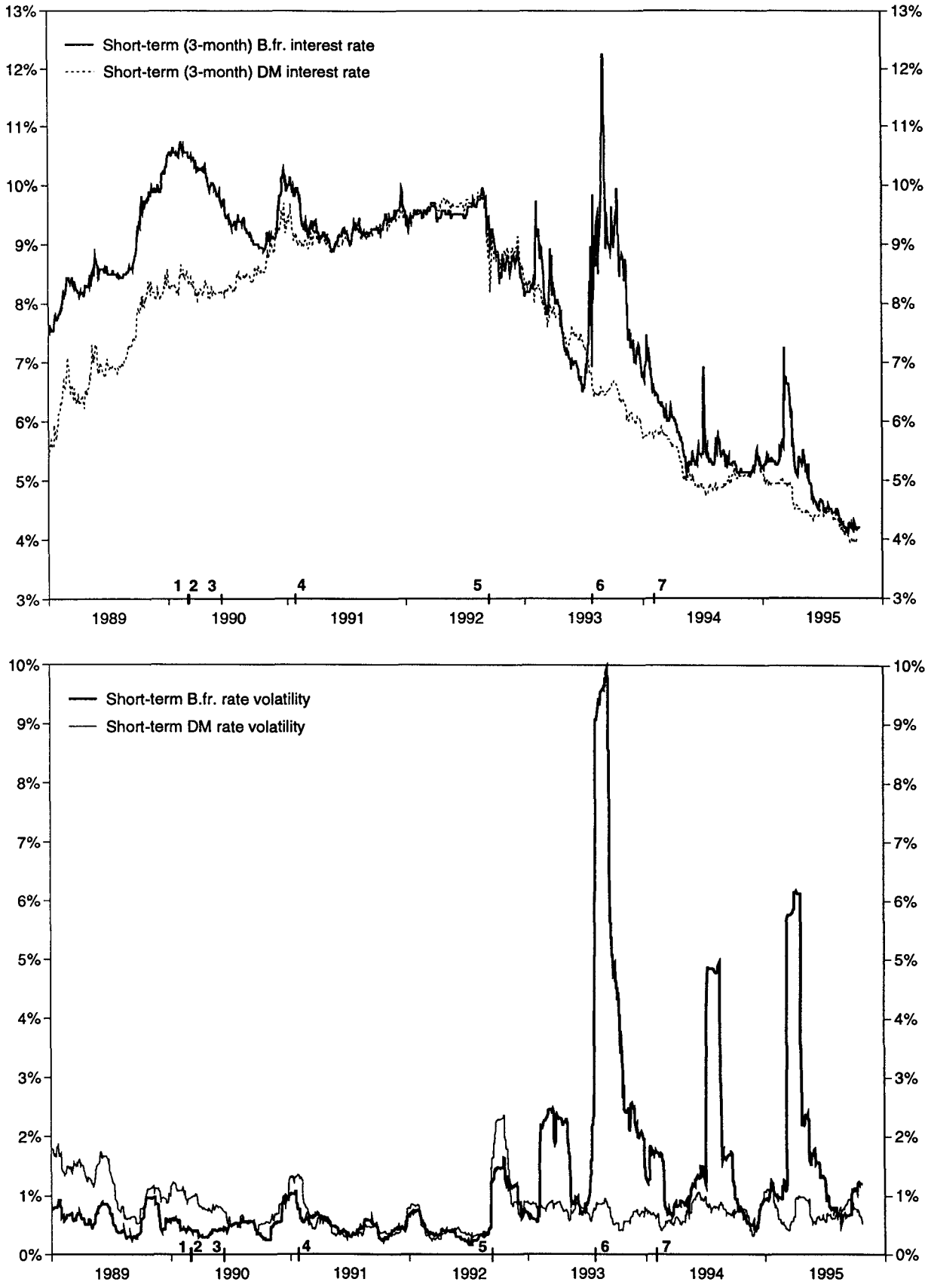
However, this was not the case. The volatility of three-month Belgian franc interest rates remained very low and was no different during the periods immediately preceding and following the reform of monetary policy instruments. There are doubtless various factors which help explain the lack of impact of the reform on the volatility of short-term rates:

- under the old system, the authorities at times had to make very frequent changes to the rate on three-month certificates, which was in itself a cause of volatility. These frequent changes obviously resulted in greater interference between the conduct of monetary policy and the management of the public debt, which was, moreover, one of the advantages of changing the monetary policy instruments;
- although, prior to the reform, changes in the rate on three-month certificates had an almost immediate effect on the three-month Euro-deposit rates used here to measure volatility, the link was nevertheless not absolute. In fact, whenever money market operators expected even a minimal rate change by the central bank, they had a tendency to anticipate this decision in the positions they took. This was reflected in a temporary widening of the differential between Treasury certificate and Euro-deposit rates. In the new environment, this volatility directly induced by the lower anticipation of a change in the direction of monetary policy has a more noticeable effect on the shortest maturities and a lesser one on longer maturities;
- finally, the low volatility of Belgian franc three-month rates during the initial phase of application of the new monetary policy instruments can be partly explained by the international environment. Whereas in 1989 and 1990 short-term rates had undergone sharp variations in both Belgium and Germany, they remained very stable during 1991 and the first few months of 1992. Such a situation is, per se, conducive to low volatility. In addition, it may be noted that the volatility of Belgian and German short-term rates was closely correlated during this period.

This almost perfect synchronism in the volatilities of Belgian franc and Deutsche Mark rates was halted in September 1992. Beginning in June, new tensions had arisen on the European foreign exchange markets as a result of the uncertainty related to the known or expected results of

Graph 2

Interest rates for three-month Euro-Belgian franc and Euro-Deutsche Mark deposits



Note: For an explanation of the events marked, see Graph 1.

referendums held in some member states on the ratification of the Maastricht Treaty on European Union. These tensions culminated in September in the withdrawal of the Italian lira and sterling from the ERM. Although these events, as noted above, had only a limited effect on the volatility of the Belgian franc/Deutsche Mark exchange rate relationship, this stability was, however, maintained at the cost of pressure on short-term interest rates, which underwent a sharp increase in volatility.

The factors of uncertainty which prevailed in all European markets during this period seem, moreover, to have triggered a general increase in the volatility of short-term interest rates. Thus during the last few months of 1992 the volatility of German rates also increased, even reaching higher levels than the volatility of Belgian rates.

From the beginning of 1993, the Belgian money market was subject to periodic surges in volatility which did not reflect the variations in German volatility. This development must evidently be seen in relation to the conduct of monetary policy. The traditional arbitrage between variations in levels of the short-term interest rate and the exchange rate also had an effect on volatility. At times of tension, the volatility of the exchange rate can only be held within narrow limits at the cost of a sharp increase in interest rate volatility.

In the four periods of tension observed between the beginning of 1993 and the end of August 1995, this kind of arbitrage was undertaken in three instances. The only exception was during the summer of 1993. Owing to the magnitude of the crisis which occurred within the ERM, a substantial rise in interest rates did not suffice to prevent a temporary depreciation of the Belgian franc exchange rate.

1.4 Long-term interest rate volatility

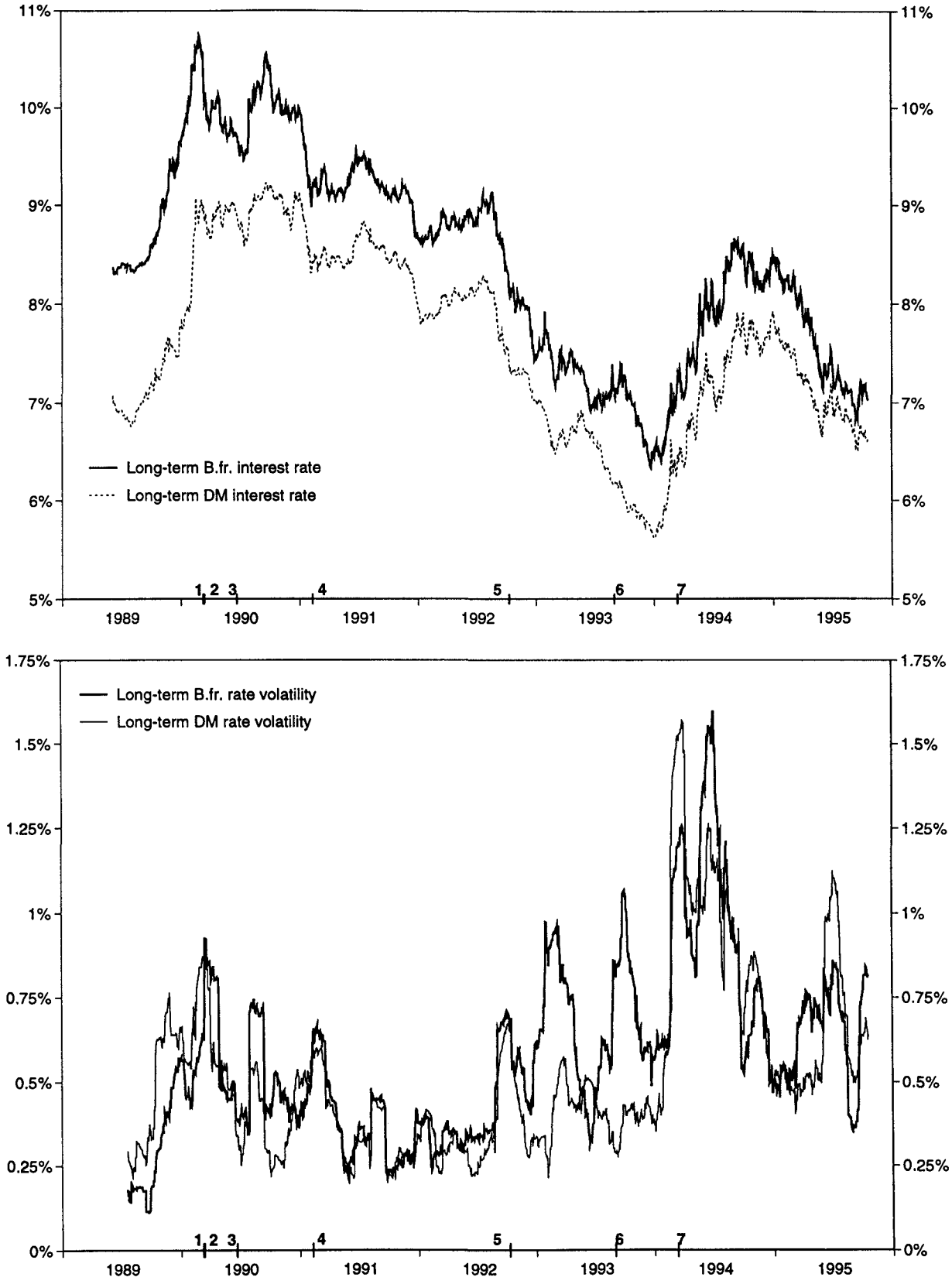
The major economic and monetary policy measures taken by the authorities in 1990 and 1991 do not appear to have exerted a dominant influence on the volatility of the long-term Belgian franc interest rate. Thus the reduction in the withholding tax (March 1990), while contributing to reducing the differential between Belgian franc and Deutsche Mark rates, plainly had no impact on the volatility of the Belgian capital market. Nor does the latter appear to have been any more affected by the official announcement of the foreign exchange policy aimed at tying the Belgian franc exchange rate closely to that of the Deutsche Mark, even though this decision was likely to lower economic agents' inflation expectations. The apparent lack of influence of the change in the implementation of monetary policy on long-term interest rate volatility seems more logical, to the extent that this reform in no way altered the objective of price stability assigned to monetary policy. Any impact of this reform on long-term rates would, therefore, only have made itself felt indirectly via a change in short-term rate volatility, which, as we have seen, did not occur.

In a capital market with a large degree of international integration, the volatility of long-term Belgian franc rates appears to have reacted more to external macro-financial factors than to changes, even major ones, at national level. Moreover, it is striking that the fairly clear break in the volatility trend in the third quarter of 1992 marks the end of a period of low volatility, despite numerous measures implemented by the Belgian authorities, followed by a period of much more pronounced volatility brought on by international developments.

A comparison of the sensitivity of the Belgian and German markets reveals great similarity. Daily volatility was of the same magnitude on both markets, not just in average terms (0.58% for the Belgian franc and 0.52% for the Deutsche Mark), but also in terms of dispersion. Thus the floor under the highest 5% of values was 1.13% for the Belgian franc and 1.1% for the Deutsche Mark. Furthermore, the path of the two volatilities was very similar, even though the closeness of the relationship varied markedly during the period under observation. From a maximum of 89.6%, which reflected a close correlation between the volatility of Belgian and German rates between February 1991 and September 1992, the correlation coefficient between the daily volatilities of Belgian and German long-term rates fell to 7.4% during the period following the ERM crisis of September 1992.

Graph 3

Long-term Belgian franc and Deutsche Mark interest rates*



Note: For an explanation of the events marked, see Graph 1.

* Yield on benchmark loans with a residual maturity of 10 years.

From July 1993, the correlation between the two volatilities recovered strongly to 72.2%, notwithstanding an unfavourable context of tensions within the ERM during summer 1993 and a substantial rise in volatility on the capital markets in most countries in 1994. This recovery in the correlation between Belgium and Germany was, however, not observed for short-term interest rates, whose volatility was more affected by monetary policy interference.

The temporary volatility differentials which sometimes opened up between Belgian and German long-term rates do not appear to be attributable to specific events, with the exception of the foreign exchange crisis of July 1993. The sharp increase in volatility which occurred in Belgium at that time on both the money market and the foreign exchange market also spread to the capital market.

On the other hand, autonomous variations in the volatility of Belgian long-term rates were sometimes provoked by "news", as advice by certain foreign analysts or operators to withdraw from the Belgian franc capital market at times had an appreciable, albeit transient, impact on the volatility of Belgian long-term rates. Thus increases in volatility were observed between November 1992 and March 1993, when the market had viewed the Belgian franc/French franc long-term interest rate differential as insufficient, resulting in advice to arbitrage between positions in Belgian linear bonds (OLOs) and French Treasury bonds (OATs).

2. Analysis of the conditional volatility of Belgian interest rates

2.1 Why the GARCH model was chosen

While the degree of ex post volatility of financial asset prices or yields can be estimated from the variance or standard deviation of the series considered, this traditional measure of volatility does not capture volatility as expected ex ante by economic agents. But it is primarily this factor which influences financial decisions.

In principle, this expected volatility may be inferred from options prices. In practice, however, the Belgian franc interest rate options or currency options market is still too narrow to provide reliable series of expected volatility.

An alternative measure often used is that of conditional volatility. The idea on which it is based is that actual volatility, as captured by variance or standard deviation, is in fact a combination of, on the one hand, changes in the environment not anticipated by economic agents and, on the other, conditional volatility. The latter may be anticipated on the basis of the information available to agents on the past behaviour of volatility.

This anticipatory exercise, which is intended to extract conditional volatility from past asset variability, is meaningless, however, unless the volatility tends to persist over time. If this is the case, the conditional component of the volatility is a function of the levels of variance observed in the past. By using this function, agents can anticipate future conditional volatility, which constitutes an assessment of the riskiness of the assets in question.

With the ARCH and GARCH models (ARCH = Auto Regressive Conditional Heteroscedasticity; GARCH (Generalised ARCH) refers to the ARCH models generalised by Bollerslev (1982)), it is possible to estimate these functions where they exist. This study is based on a GARCH model (1,1) in which the present conditional variance depends on a combination of residuals, namely past forecasting errors. Thus the GARCH model is able to isolate that component of volatility which can be anticipated by economic agents and which, for that reason, guides their financial behaviour. Similarly, the GARCH-M version of the model ("GARCH in mean") makes it possible to capture the arbitrage relationship between this risk indicator and the return on the investments in question.

Two GARCH-M models were estimated. The first relates to ten-year interest rates, while the second is concerned with three-month Belgian Euro-market rates. In accordance with the main

purpose of this paper, the Belgian variables are systematically compared with the corresponding German variables using the specified GARCH-M models, which are estimated over the period June 1989 to August 1995 on the basis of daily data.

2.2 Conditional volatility of long-term rates

The GARCH-M model used to analyse long-term interest rate volatility is based on a conditional variance relationship and a relationship combining the variation in the rate on ten-year Belgian OLOs (linear bonds) with other variables which serve as a proxy for the behaviour of present and past German rates, past Belgian rates and the Deutsche Mark exchange rate in Brussels.

Table 2

Garch-M modelling of long-term interest rates*
(maximum likelihood method)

Conditional variance relationship

June 1989 to August 1995			June 1989 to September 1992		September 1992 to August 1995	
Independent variables	**Coefficients**	**Student t**	**Coefficients**	**Student t**	**Coefficients**	**Student t**
Const.	0.00004	5.90	0.00002	4.21	0.00034	4.50
u^2-1	0.12150	10.69	0.08050	6.18	0.20140	5.52
h^2-1	0.85510	78.25	0.90220	64.90	0.57930	8.32

Relationship of the variation in the return on ten-year bonds

June 1989 to August 1995			June 1989 to September 1992		September 1992 to August 1995	
Independent variables	**Coefficients**	**Student t**	**Coefficients**	**Student t**	**Coefficients**	**Student t**
Const.	0.0051	- 0.67	0.0372	2.07	- 0.0063	- 0.32
Δdemlt	0.8385	53.02	0.7955	34.52	0.8982	34.37
Δbeflt-1	0.1069	4.18	0.1875	5.16	0.0644	1.38
Δdemlt-1	- 0.0630	- 2.37	- 0.0906	- 2.49	- 0.0566	- 1.18
Δh	0.5439	2.45	0.7005	1.78	0.3555	0.99
beflt-1	- 0.0069	- 2.44	- 0.0299	- 4.55	- 0.0250	- 2.78
demlt-1	0.0082	2.42	0.0285	3.66	0.0280	2.82
PIV	0.0259	5.08	0.0714	3.93	0.0186	2.53

With: U = residual of relationship b; u^2 is the square of the residual.
h = conditional standard variation; h^2 is the conditional variance.
demlt = level of the rate on ten-year Bunds.
beflt = level of the rate on ten-year OLOs.
PIV = level of the Deutsche Mark in Brussels, less the B.fr./DM bilateral central rate.

* Based on the daily variation in the return on ten-year OLOs.

The coefficients defining the GARCH process reveal a marked persistence of the conditional variance since the sum of the coefficients is close to unity, which suggests that a variance shock is reflected in a lasting drift of conditional volatility.

There is a strong correlation between the daily variation in the ten-year OLO yield and the corresponding German variable. Over the reference period an average of 84% of an increase in German ten-year rates is transmitted to Belgian rates. Other results of the estimation corroborate this first indication of a close association between the Belgian and German situations. Thus the sign associated with the *level* variable of the Belgian rate is negative, whereas it is positive for the *level* variable of the German rate. This tends to suggest that the variation in Belgian rates adjusts to the differential between Belgian and German rates, reflecting the existence of an equilibrium relationship linking the two rates. In other words, the differential between these rates cannot persistently deviate from a certain limit, as the OLO rate tends to counteract any divergent movements.

The differential between the Deutsche Mark rate in Brussels and the bilateral central rate also influences the course of Belgian rates, as a deviation from the central rate appears to be accompanied by a movement in the same direction in the yield on Belgian rates, which reflects a tendency for Belgian rates to be increased when the franc weakens against the Deutsche Mark on the foreign exchange markets.

Lastly, conditional volatility also seems to have an upward influence on OLO yields, probably because the increased volatility encourages risk-averse bond purchasers to demand an additional return by way of a risk premium.

The GARCH-M model was estimated for two sub-periods separated by the trend break referred to in Section 1.4, which was caused by tensions arising within the EMS in September 1992. The results are very similar for the two sub-periods, although two differences deserve to be emphasised. Firstly, the GARCH process seems less persistent during the sub-period September 1992 to August 1995, while at the same time manifesting an increased sensitivity to very short-term shocks. The result perhaps reflects heightened market nervousness during the period after September 1992. Secondly, the conditional variance coefficient no longer plays a significant part in the estimated equation. Conceivably, the erratic nature of the volatility fluctuations, which is particularly pronounced as from September 1992, to some extent explains why the rate differential with Germany is not sensitive to conditional volatility.

2.3 Conditional volatility of short-term rates

As the monetary authorities' direct influence on short-term rates sometimes contributes towards blurring conditional volatility, it seems preferable to capture the volatility of three-month rates by grafting a term structure model onto the GARCH-M process. This approach provides the estimation with a theoretical anchor and above all makes it easier to interpret the link between short rates and conditional volatility. As in most empirical analyses which apply the ARCH process to the short-term interest rate, the volatility calculated in the context of this study is obtained by observing excess returns.

These are assessed on the basis of three-month rates three months forward, which are calculated implicitly by comparing contemporary three and six-month rates. Excess returns in fact express the extra yield obtained by an arbitrageur who, over a six-month time horizon, grants a six-month loan, while at the same time borrowing twice in succession on the three-month rate segment.

The excess return consists of at least three elements. Forecasting error by agents is a first source of excess return. This may be illustrated in a relatively simple manner by the following example. Annualised six and three-month interest rates of 8 and 6% respectively on a market without risk premia and arbitrage costs indicate that market participants foresee an annualised three-month rate

of 9.85% in three months' time.[4] If, because of an unexpected monetary easing, for instance, the actual three-month rate in three months' time is 9%, the excess return relative to a six-month time horizon, which is an ex post concept, is 85 basis points.

A second component of the excess return, which is linked to the idea of conditional volatility, is a time-varying risk premium. In an environment characterised by a high degree of uncertainty, a six-month investment tends to involve a greater risk than a three-month investment which, if need be, can be renewed on the basis of the new effective three-month rate three months after the contract was concluded. This term risk is normally covered by a premium, which increases according to the degree of uncertainty in the markets. The term risk premium is probably dependent on the conditional variance, which attempts specifically to capture this phenomenon of uncertainty. The unconditional variance is a priori a less effective determinant of the risk premium, as it incorporates unexpected shocks which therefore do not influence current investor behaviour, whereas investors' future decisions are revised only insofar as these shocks give rise to a reappraisal of conditional volatility.

The third component of the excess return on longer-term investments is associated with segmentation of the three and six-month markets, or also with a preferred habitat premium. In this context, liquidity preference reveals an inclination to invest for a term of three months.

In an admittedly imperfect manner, the specification of the model used endeavours to integrate the three components of excess return described above. In doing so, it reveals the influence of conditional volatility on rates, which may be reflected in the existence of a term risk premium. Incidentally, other lessons are gleaned which, although less directly related to the purpose of this study, are nonetheless useful.

The GARCH-M model used consists of two relationships. The first associates the daily excess return with four independent variables: the German excess return; the conditional standard deviation, which serves as a proxy for the term risk premium; a dummy variable associated with the foreign exchange crisis episode; and a term premium. The last of these variables is supposed to incorporate contemporary information relating to the rate structure. It is equal to the implicit three-month rate three months forward. If agents' expectations are rational and the markets are efficient, this information variable is not correlated with the excess return; an opposite result would indicate that agents' expectations are systematically skewed, which contradicts the pure expectations hypothesis. The residual lagged by one day is also integrated into the estimated excess return relationship, in order to remedy an autocorrelation problem.

The second relationship incorporated in the model is simply the expression of the GARCH model (1,1). It defines the conditional variance, which is estimated on the basis of the conditional variance and the square of the residual observed one day later. The whole model is estimated by iteration according to the maximum likelihood method.

The results of the estimation of the conditional volatility relationship show that the process of its formation is characterised by a considerable memory capacity, which is typical of the ARCH process: the sum of the coefficients of the square of the past residual and past conditional variance is close to two-thirds, which indicates that volatility shocks tend to persist beyond the impact period. It is under such conditions that the idea of conditional volatility assumes its full significance.

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4 The implicit three-month rate three months forward is $\frac{12}{3} \times \left[\frac{0.08 \times \frac{6}{12} - 0.06 \times \frac{3}{12}}{1 + 0.06 \times \frac{3}{12}} \right] = 0.098522$ or 9.8522% on an annual basis.

Table 3

Garch-M modelling of short-term interest rates[1]

(maximum likelihood method;
estimation period June 1989 to July 1995)

Conditional variance relationship

Independent variables	Coefficients	Student t^2
Const.	0.00203	16.68
u^2-1	0.03399	23.99
h^2-1	0.63192	46.42

Relationship of the excess return on short-term rates

Independent variables	Coefficients	Student t^2
ER_{DE}	0.41366	37.93
h_t	0.16359	4.45
FORP	0.56738	97.22
DUM	- 1.90552	- 70.97
u_{-1}[3]	0.98528	88.67

With: u_{-1} = the residual, unadjusted (for first-order correlation), of the excess return relationship lagged by one period;
h_{-1}, h_t = the conditional *standard variation* for the preceding period and the current period respectively; h_2 serves as a proxy for the conditional *variance*;
ER_{DE} = the German excess return;
FORP = the term premium, which is equal to the implicit three-month rate three months forward, minus the current three-month rate;
DUM = a binary variable, which is equal to 1 between 3rd May 1993 and 20th August 1993, and to 0 for the remainder of the period.

[1] On the basis of the excess return of six-month rates compared with the three-month rate, on the Euro-market. [2] Expresses the degree of significance of the estimated coefficients. The critical values are equal to 1.96 and 2.58 for a significance threshold of 5 and 1% respectively. [3] Introducing the residual lagged by one period enables the autocorrelation of the residuals, which actually proves to be very strong, to be offset.

The model suggests that an increase in the conditional standard deviation of 1 percentage point produces a 0.16% rise in the excess return because of a higher term risk premium.[5] The German excess return is also one of the key determinants of the corresponding Belgian variable. A coefficient of 0.41, which is highly significant, testifies to this. It indicates that to a large extent Belgian and German interest rates are dependent on determinants that are common to Belgium and Germany, which is not surprising given that the Belgian franc is pegged to the Deutsche Mark.

The binary (dummy) variable, which relates to the period May 1993 to August 1993, makes it possible to work out the excess return behaviour three months later, i.e. during the foreign exchange crisis episode. It reveals a negative influence of this crisis on the excess return, which must be related to market participants' inability to anticipate the crisis. The crisis surprised holders of six-month debt instruments, who therefore had no opportunity to renew their loans three months later at a rate which had risen in the meantime because of the foreign exchange crisis.

5 Engle, Lilien and Robins (1987) obtain similar results for the United States.

Incidentally, it is interesting to note that there is a strong correlation between the excess return and the term premium,[6] which represents the contemporary information available to agents. This result, which shows that the forecasting error is not the preponderant component of the excess return, contradicts the pure expectations hypothesis. Such a finding may be based on the non-rationality of market participants' expectations behaviour or on the existence of preferred habitat premia.

Conclusion

In recent years the Belgian monetary authorities have taken a number of decisions of a structural nature, such as closely pegging the franc to the Deutsche Mark, changing the implementation of monetary policy, reducing the withholding tax on interest income or abolishing the two-tier foreign exchange market. None of these decisions seems to have had a significant impact on financial or foreign exchange market volatility in Belgium. The fact that they have not had any effect shows that the measures introduced have been both well understood and accepted by the participants in these markets. It would also tend to show that developments of a structural nature are not, in themselves, a cause of greater volatility, even if it cannot be ruled out that at times of tension such developments may affect market dynamics and accentuate price fluctuations.

These periods of tension have increased in number in recent years, with the two successive crises which rocked the EMS and the sharp fluctuations in long-term rates. These movements naturally affected the Belgian financial markets.

It is on the money market that Belgian volatility was most dissociated from German volatility. This development was of course a direct consequence of monetary policy decisions, as the authorities did not hesitate to raise short-term rates, sometimes by a substantial amount, in order to curtail foreign exchange market volatility. This arbitrage between the two markets operated correctly, except for the summer 1993 foreign exchange crisis, when the volatility of the Belgian franc/Deutsche Mark rate also suddenly surged.

On the capital market Belgian and German volatilities were generally highly correlated. Any divergences do not seem to have been related to specific shocks, except, again, for the increase in volatility following the 1993 foreign exchange crisis. On the other hand, the volatility of long-term Belgian rates appears to show a certain sensitivity to "news", which occasionally gives rise to arbitrage between the capital markets of the different countries participating in the EMS.

The use of a GARCH model to analyse conditional variance and its impact on long and short-term rates in Belgium highlighted a clear tendency towards persistent volatility. The shocks are therefore reflected in lasting drifts in conditional volatility.

Variations in long-term Belgian rates are determined above all by variations in German rates. Conditional volatility was, however, also seen to have an influence, but solely during the period from June 1989 to September 1992, i.e. when this volatility remained moderate. On the other hand, during the subsequent period, which was marked by large fluctuations in volatility, the variations in Belgian rates seem to have responded more to those in German rates and were, themselves, less directly sensitive to changes in Belgian conditional volatility.

Analysis of the conditional volatility of short-term rates is made difficult by the interference resulting from monetary policy decisions. A somewhat different approach was therefore adopted within the framework of an excess return model. This analysis confirms the phenomenon of persistent volatility. It also indicates that the excess return is sensitive to increases in conditional volatility, which lead to rises in the term risk premium.

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6 The term premium coefficient (which is to be distinguished from the term risk premium) is, moreover, the most significant one of the estimated model.

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