DO FOREIGN EXCHANGE MARKETS MATTER FOR INDUSTRY STOCK RETURNS ?

An empirical investigation

Vincent Bodart[a], Paul Reding[b]

(April 2001)

Abstract

In this paper, we develop a bivariate two factor-two country GARCH model of stock returns in order to investigate whether exchange rate fluctuations have a significant impact on the conditional mean, variance, and correlation of industry stock returns. Weekly data for seven industries in five European countries over the 1990-1998 period are used. We document that exchange rates have a significant effect on expected industry stock returns and on their volatility. The magnitude of this effect is, however, quite small. The contribution of the exchange rate factor to the time-varying correlation coefficients between two countries' industry returns is also very modest. The paper also shows that the importance of the exchange rate spillovers is influenced by the exchange rate regime, the magnitude and the direction of exchange rate shocks.

JEL classifications : C22; F31; F33; G15.

Keywords : Industry stock returns; FX market; Volatility; International correlation

[a] IRES, Catholic University of Louvain, Louvain-la-Neuve, Belgium, bodart@ires.ucl.ac.be

[b] Department of Economics, University of Namur, Rempart de la Vierge 8, 5000 Namur, Belgium, paul.reding@fundp.ac.be , corresponding author

1. Introduction

A good understanding of the determinants which shape the first and second moments of the conditional distribution of stock returns is crucial for efficient portfolio management strategies. Among those determinants, exchange rates have received particular attention, for two reasons at least : the importance of currency management strategies in highly integrated financial markets; the implications of exchange rate fluctuations for company profits. In this paper we develop a two factor model with the aim of empirically assessing the contribution of foreign exchange markets to explaining expected returns, conditional volatilities and conditional cross-country correlations of industry stock returns.

We focus our analysis on industry stock returns. Industry indexes are, with national stock market indexes, standard benchmarks for portfolio analysis. The industry level is also a reasonable compromise between arguments pleading for less or for more disaggregation in studying the interaction between exchange rates and stock returns. To study the effects of exchange rates on expected stock returns, a firm level approach seems a priori the most appropriate. Indeed, any aggregation of stock returns within an index may underestimate the effects of exchange rate rates, as the reaction of stocks from firms with opposite exposures to exchange rates may cancel out. On the other hand, the lower the level of aggregation, the more difficult it becomes to correctly define the exchange rate index which appropriately measures the induced changes in competitiveness. Also, some level of aggregation is necessary if one wants to study in a meaningful way the impact of exchange rates on conditional cross country correlations between stock returns. We selected Datastream’s level 4 degree of aggregation, in which firms are aggregated into 39 industries. Out of these, we selected a set of seven industries comprising traded and non-traded sectors, in which exposure to exchange rate shocks is expected to be different.

The analysis is performed for five European countries over the 1990-1998 period. This period provides for sufficient variety, across countries and time, of exchange rate regimes and variability, outside or inside the Exchange Rate Mechanism of the European Monetary System (EMS). Stock returns are defined as weekly local currency returns. For the exchange rate, we use nominal trade-weighted indices.

Our two factor - two country model enables us to simultaneously estimate exchange rate effects on the conditional means, variances and covariance of the returns. Our approach has the four following characteristics:

1. We postulate that the dynamics of industry returns can be adequately captured by two orthogonalized factors : the change in the nominal effective exchange rate and the domestic market return; the latter represents all the factors, other than the exchange rate, which influence industry returns. We thus abstract from the possibility that industry returns might be directly influenced by world market shocks, independently of the market return. This assumption should however not bias the estimation of the total contribution of exchange rates to industry return dynamics. Indeed, available evidence strongly suggests that national market indexes are "good instruments" (Drummen and Zimmermann, 1992, p.25) for the different international factors which contribute to a stock's systematic risk.

2. We estimate two separate effects of exchange rates : an impact on the expected part of industry stock returns; a volatility spillover. We thus depart from a common CAPM-type specification, in which stock returns are regressed on contemporaneous market returns and exchange rate changes (see Roll, 1992, Bodnar and Gentry, 1993, Griffin and Stulz, 1997, Dominguez and Tesar, 2001). We adapt a framework developed by Longin and Solnik (1995) and Bekaert and Harvey (1997) and widely used to study volatility spillovers between stock

markets (see e.g. Ng, 2000)[1] . In our two country model, past changes in the exchange rate determine, together with past changes in the market return, the conditional means of both countries' stock returns for a given industry, whereas the conditional variances and covariance of these returns are shaped by innovations in the two factors.

3. We assume that these two critical FOREX "spillover coefficients", in mean and in volatility, are not constant, but are conditioned on "information variables" which characterize the environment in which the exchange rate innovations occur. We first control for the exchange rate regime. In our earlier work, we have found evidence of systematic differences in volatilities and correlations of stock returns across "fixed" and "more flexible" exchange rate regimes, within the context of the EMS [2]. This observation may not only reflect the pure effect of changes in exchange rate volatility, but also the nature of the regime : interventions rules in a fixed exchange rate regime may, for example, determine how market expectations react to observed exchange rate innovations, which in turn may impinge on observed movements in stock prices (see Roll, 1992, p. 28). The two other information variables which condition the two FOREX spillover coefficients are the sign and the magnitude of the lagged foreign exchange innovations, both of which Longin and Solnik (1995) have shown to be potential determinants of the second moments of the distribution of stock returns.

4. In line with standard practice, we complement the two factor volatility model for industry stock returns with a bivariate, constant correlation coefficient, GARCH(1,1) model on the idiosyncratic part of each of the two countries' industry stock return. We also account for leptokurtosis in financial returns and assume in our estimation procedure that all return innovations follow a Student distribution.

---

1 The approach developped by Karolyi and Stulz (1996) is also in the same spirit.

2 See Bodart and Reding (1999). Bartov, Bodnar and Kaul (1996) also note a significant increase in the volatility of stock returns of US multinationals when the switch from fixed to flexible exchange rates occurred in 1973.

For the four countries (Belgium, France, Italy and the UK), each paired with Germany, we estimate this bivariate two factor GARCH(1,1) for the seven industries. For each country pair, we also estimate the link between exchange rates and stock returns at the aggregate market level, using a GARCH(1,1) model of similar structure.

Our main finding is that exchange rates exert in slightly more than half the cases a significant effect on expected industry stock returns and on their volatility, but that the magnitude of this effect is, in general, quite small. We also show that industries from traded sectors are usually more sensitive to exchange rates than non-traded sectors, both in mean and volatility. These results are not at variance with the conclusions of other studies, which use different methodologies, level of aggregation and which in general do not distinguish between exchange rate spillovers in conditional mean and in conditional variance. Bodnar and Gentry (1993) regress the monthly stock returns, in local currency, of a set of three countries' industries on the domestic market return and on changes in the effective exchange rate; they find that the latter is significant in about 30 % of cases and that its coefficient can be explained by industry characteristics, including a traded-non-traded dummy variable. Heston and Rouwenhorst (1994) conclude that monthly firm returns, expressed in local currencies and after control for industry effects, are approximately uncorrelated with exchange rate movements. Drummen and Zimmerman (1992) show that currency factors only account for a tiny fraction of the variance of local currency daily stock returns of European firms. The results of Griffin and Stulz (1997) for a large set of industry-country pairs go in the same direction : exchange rate shocks have, even when significant, only trivial economic importance on weekly stock returns in local currency. Studying weekly returns of more than 300 firms in eight countries, Dominguez and Tesar (2001) present evidence of significant exchange rate exposure in a large number of cases (20 to 30 % at firm level, 20 to 65 % percent at industry level), but do not report the economic magnitude of these effects. Bartov, Bodnar and Kaul (1996) note that monthly stock returns of US multinationals reacted significantly negatively to the appreciation of the currency during the fixed exchange rate period (pre-1973); this relationship disappeared however in the floating rate period. They also show that there is an independent link between second moments : exchange rate volatility contributed to increase the stock price volatility of the multinational firms in the floating rate period. Karolyi and Stulz (1996), who distinguish between effects in conditional mean and covariance, find no foreign exchange rate effects on the conditional mean of daily dollar returns for a matched set of Japanese and US firms and only weak evidence of an effect in the conditional correlation.

Beyond this general result of a weak, albeit often significant, effect of changes in exchange rates on industry returns, our framework of analysis allows us to obtain additional results. First, we conclude that the domestic market return is not, as sometimes argued (e.g. Drummen and Zimmermann, 1992), the only channel of influence of the exchange rate on industry returns. Indeed, significant exchange rate effects frequently occur, in mean or in volatility, for a country's industry returns even when no influence of the exchange rate on the market return can be detected. A single factor model is thus inappropriate for the purpose of studying exchange rate spillovers for industry or firm level stock returns. Second, we show that the influence of exchange rates on the conditional first moment can occur independently of its impact on second moments : the two spillover coefficients, of lagged changes in exchange rates on mean returns on the one hand and of contemporaneous exchange rate innovations on the unexpected part of the returns on the other hand, are not necessarily significant simultaneously ; they also react differently to the same three information variables which enter their specification. Third, we find that these three information variables do matter for explaining the impact of the exchange rate. Within the EMS, the transition to a regime with greater exchange rate flexibility tends to decrease the generally positive (negative) effect a currency depreciation (appreciation) has on industry mean returns; it also matters, in a limited number of cases, for volatility spillovers. We also find that, in about one third of cases, the spillover in mean is influenced by the absolute magnitude of the exchange rate shock observed in the preceding period : positive spillovers of a currency depreciation are amplified, negative spillovers attenuated. Large shocks also tend to decrease the volatility spillover coefficient, but this evidence is much weaker. As for the asymmetric effects of FX shocks, it only seldom occurs in a significant way. Fourth, the conditional correlation between two countries' effective exchange rates contributes positively, although in a modest way, to the conditional correlation coefficients between their industry returns .

The paper is organized as follows. The next section describes the data. In section 3, we describe the methodology and present the structure of our two factor-two country model for industry stock returns. Results about the foreign exchange rate effects on conditional mean, variance and cross-country correlations of industry stock returns are discussed in sections 4, 5 and 6 respectively. Section 7 concludes.

2. Data

Industry data are selected from level 4 Datastream stock indices[3]. Seven representative industries were selected : banks (BAN), insurance (INS), retail and food (FED), support services (SUP), chemical industry (CHM), electronic equipment (ELT) and engineering (ENG). The industry group provides for a cross-section of industries with different degrees of exposure to foreign competition and, presumably, to exchange rate fluctuations. The first four industries (BAN, INS, FED, SUP) are mainly service industries whose activity is largely oriented towards the domestic market and faces little foreign competition. Conversely, CHM, ELT, and ENG are manufacturing industries and are directly exposed to strong foreign competition.

Our empirical work uses stock data for five European countries over the last decade. The countries selected are Belgium (BE), France (FR), Germany (GE), the United Kingdom (UK), and Italy (IT). The countries can be divided into two groups with different exchange rate experiences since 1990 : on the one hand, Belgium, France, and Germany, which maintained a fixed bilateral exchange rate over the whole sample period within the ERM; on the other hand, Italy and the UK, which abandoned the peg with the DEM in 1992 for a prolonged period[4].

Our data set is weekly and covers the period from January 5, 1990 to November 12, 1998 [5]. Weekly stock returns are computed as the change in the logarithm of stock indexes between two consecutive Fridays (expressed in %). All stock returns are measured in local currency[6]. For every country, exchange rate fluctuations are measured by the weekly (logarithmic) change in their nominal effective (trade-weighted) exchange rates. All exchange rates are measured as domestic currency price of foreign currency.

Throughout the analysis, all asset returns are excess returns, obtained by subtracting a 7-day Eurocurrency interest rate from the gross asset return. Asset returns are expressed as percent per week.

Table 1 reports data on the market capitalization, the unconditional mean, standard deviation and international correlations of the selected industry stock returns. Most of the selected industries have a small market capitalization. For 27 out of the 34 industry stocks returns, the market

---

3 Datastream classifies stock indices into one of six levels, using FTA definitions of industries and sectors. Level 1 is the market index, which is then broken down into industries or sectors on a number of levels, each level offering an increasingly detailed breakdown. Level 4 corresponds to intermediate disaggregation.

4 Italy returned to the (wide band) ERM in November 1996.

5 All data are obtained from Datastream.

6 Expressing all returns in a common currency would automatically have introduced a direct link between exchange rates and stock returns and would possibly have introduced a bias in favor of a direct influence of exchange rates on means, volatilities and correlations of stock returns. Longin and Solnik (1995, p.8 and footnote 7) also note that local currency excess returns are “currency hedged excess returns from any nationality viewpoint” and are thus numeraire invariant.

capitalization does not exceed 10 percent. It is less than 5 percent in 24 cases. This feature guarantees sufficient exogeneity to the market return in our two factor model of industry stock returns. The volatility of the selected industry stock returns varies between 2.39 and 5.19. Volatilities are however rather uniform. In 18 cases out of 34, the volatility is lower than 3.0. It is also less than 3.5 for 27 returns out of 34. International correlations, computed as the contemporaneous correlation between stocks returns of a given industry in a particular country and in Germany, are less uniform. Correlations are comprised between 0.08 and 0.63. Of the 27 correlations, 19 are larger than 0.3, 15 are larger than 0.4 and 5 are larger than 0.5.

It also appears from Table 1 that the volatility of the exchange rate return, as measured by the standard deviation of the weekly percentage change in the nominal effective exchange rate, is twice larger in the UK and in Italy than it is in Belgium, France, and Germany. We also note that exchange rate volatility increases for each country with the ERM regime change, from the OLD to the NEW EMS. For Belgium, France and Germany, the "New EMS" period starts on August 2, 1993 when ERM bands for exchange rate fluctuations were enlarged from 2.25 to 15 % around parity, while for Italy and the UK, it starts on September 15, 1992 when both countries decided to abandon the ERM. The ratios of standard deviations of weekly changes in effective exchange rates between the NEW and OLD EMS periods are 1.08 for France, 1.09 for Germany, 1.17 for Belgium, 1.48 for the UK and 4.05 for Italy.

Table 1. Market capitalization, mean, standard deviation and correlation of stock returns

	Belgium	France	Germany	UK	Italy
Market capitalization (% of market total)					
Banks	21.1	4.8	11.9	15.8	25.6
Insurance	12.5	7.1	16.3	3.0	12.0
Food &Retail	2.1	6.4	0.1	2.6	0.2
Support services	0.2	1.3	0.03	2.2	n.a.
Chemical	4.8	2.0	8.6	1.1	0.3
Electronic	1.5	3.4	4.3	1.4	0.2
Engineering	0.7	0.7	3.1	1.6	0.3
Mean (%)					
Market	0.0372	-0.0013	0.0250	0.0137	-0.0301
Banks	0.1509	-0.1282	-0.0047	0.1850	-0.0296
Insurance	0.0762	-0.0693	0.1068	-0.0980	-0.0772
Food &Retail	0.1387	0.2164	-0.0421	0.0167	0.0811
Support services	0.3804	0.0371	0.6560	0.1003	n.a.
Chemical	0.1111	0.0706	0.0473	-0.1343	-0.2027
Electronic	n.a.	-0.0233	-0.0477	-0.0364	-0.1436
Engineering	-0.2259	-0.1950	-0.0248	-0.0581	-0.1506
Mean of FX return (%)	-0.1331	-0.1481	-0.1252	-0.1666	-0.1282
Standard deviation					
Market	1.8731	2.2709	2.2395	1.8584	3.0230
Banks	2.5789	3.5717	2.61	3.1943	3.1499
Insurance	2.9674	3.2943	3.00	3.3004	3.3055
Food &Retail	2.6642	2.6361	2.98	2.7919	4.4726
Support services	4.4944	3.4309	5.19	2.3923	n.a.
Chemical	2.6945	2.7381	2.67	2.4103	3.9314
Electronic	n.a.	3.2865	2.75	2.7351	3.7138
Engineering	2.9854	2.7460	2.75	2.4829	3.1991
Standard deviation of FX return	0.3538	0.3905	0.4656	0.9373	0.8674
Correlation					
Market	0.6999	0.6993	1.0000	0.5052	0.6059
Banks	0.4775	0.6361	1.0000	0.4989	0.4451
Insurance	0.5267	0.5311	1.0000	0.4101	0.3585
Food &Retail	0.1224	0.0883	1.0000	0.0848	0.1095
Support services	0.2044	0.3904	1.0000	0.2825	n.a.
Chemical	0.4907	0.4255	1.0000	0.4151	0.3617
Electronic	n.a.	0.5525	1.0000	0.2372	0.3507
Engineering	0.4592	0.5224	1.0000	0.4185	0.4402
Correlation of FX return	0.6786	0.5438	1.0000	-0.3766	-0.4796

Note : Market capitalization of industry stock returns is reported for end 1998. Descriptive statistics are computed over the period from January 5, 1990 to November 12, 1998. International correlations are computed with Germany. All returns are defined as the weekly change in the logarithm of the underlying asset price (expressed in %).

3. A factor model of industry stock returns

In this section, we describe the approach that we use to investigate how developments in foreign exchange markets affect the conditional means, variances and international correlations of industry stock returns.

3.1. Modeling the industry stock return

Our methodology rests on the assumption that industry stock returns are governed by two factors : the return on the domestic stock market and the return on the foreign exchange market. The two factors enter both as determinants of the anticipated and unanticipated parts of the industry stock return.

To model conditional means, volatilities and correlations within this two-factor framework, we use a bivariate GARCH(1,1) model. For each industry return, the model is specified for two countries : country *k (k = BE, FR, UK, IT)* and Germany, the reference country.

The industry model is specified in equations (1a) to (1g). For country *k*, R_j^k denotes the return of the stock index of industry *j* in local currency, R_M^k denotes the return on the domestic stock market in local currency, and R_{EF}^k is the nominal effective exchange rate return. Similar notations are used for returns in Germany, with the superscript *k* being replaced by the superscript *G*.

$$R_{j\,t}^{k} = a_{0\,j}^{\ k} + a_{1\,j}^{\ k} R_{j\,t-1}^{k} + g_j^{k} R_{M\,t-1}^{k} + d_{j\,t-1}^{k} R_{EF\,t-1}^{k} + e_{j\,t}^{k} \qquad (1a)$$

$$R_{j\,t}^{G} = a_{0\,j}^{\ G} + a_{1\,j}^{\ G} R_{j\,t-1}^{G} + g_j^{G} R_{M\,t-1}^{G} + d_{j\,t-1}^{G} R_{EF\,t-1}^{G} + e_{j\,t}^{G} \qquad (1b)$$

$$e_{j\,t}^{k} = e_{j\,t}^{k} + f_j^{k} e_{M\,t}^{k} + y_{j\,t-1}^{\ k} e_{EF\,t}^{k} \qquad (1c)$$

$$e_{j\,t}^{G} = e_{j\,t}^{G} + f_j^{G} e_{M\,t}^{G} + y_{j\,t-1}^{\ G} e_{EF\,t}^{G} \qquad (1d)$$

$$h_{j\,t}^{k} = c_{0\,j}^{\;k} + c_{1\,j}^{\;k} \, (e_{j\,t-1}^{k})^{2} + c_{2\,j}^{\;k} \, h_{j\,t-1}^{k} \tag{1e}$$

$$h_{j\,t}^{G} = c_{0\,j}^{\;G} + c_{1\,j}^{\;G} \, (e_{j\,t-1}^{G})^{2} + c_{2\,j}^{\;G} \, h_{j\,t-1}^{G} \tag{1f}$$

$$h_{j\;t}^{k,G} = r_{j}^{\;k,G} \; [\, h_{j\,t}^{k} \; h_{j\,t}^{G} \,]^{\,0.5} \tag{1g}$$

Industry stock returns are driven by two factors: the return on the domestic stock market return, $R_M^{\,k}$, and the foreign exchange return, $R_{EF}^{\,k}$. Expected stock returns - the risk premium component - depend on past returns in the domestic stock market and in the foreign exchange market. The unanticipated part of industry stock returns ($e_{j\,t}^{k}$, $e_{j\,t}^{G}$) are determined by innovations in the domestic stock market ($e_{M\,t}^{\,k}$, $e_{M\,t}^{\,G}$), by innovations in the foreign exchange market ($e_{EF\,t}^{\,k}$, $e_{EF\,t}^{\,G}$) and by pure idiosyncratic shocks ($e_{j\,t}^{k}$, $e_{j\,t}^{G}$). Idiosyncratic shocks have time-varying conditional variances, respectively $h_{j\,t}^{k}$ and $h_{j\,t}^{G}$ [7]. Following Bollerslev (1990), it is assumed that the conditional correlations between $e_{j\,t}^{k}$ and $e_{j\,t}^{G}$ is constant. As explained below in section 3.2, innovations $e_{j\,t}^{k}$, $e_{M\,t}^{\,k}$ and $e_{EF\,t}^{\,k}$ are orthogonal by construction. The same holds for $e_{j\,t}^{G}$, $e_{M\,t}^{\,G}$ and $e_{EF\,t}^{\,G}$.

As we wish to focus on the FX effects on stock returns, our specification assumes that coefficients of spillover in mean and in volatility are constant for the domestic stock market factor, but time dependent for the FX factor. In line with the methodology of Bekaert and Harvey (1995) and Ng (2000a, 2000b) we consider in section 3.3 various information variables as potential determinants of these FX spillover coefficients.

3.2. Modeling the FX and domestic stock market innovations

7 As standard in the literature, our specification of the conditional variance also includes asymmetric effects : the variable [$e_{j\,t-1}^{k}$*min(0, $e_{j\,t-1}^{k}$)] is included as an additional explanatory variable in equations (1e) and (1f). We did not find much evidence of such effects in our sample and do therefore not discuss this issue further in the text.

To implement and estimate the above industry model, it is necessary to identify, for each country, innovations in the domestic stock and foreign exchange markets. To this purpose, we develop two auxiliary models. The models are specified in a hierarchical way so as to guarantee orthogonality for estimated innovations. Moreover, the bivariate framework introduced for the industry returns is maintained.

3.2.1. Foreign exchange innovations

We estimate for every country k (k = *BE, FR, UK, IT*) the following bivariate GARCH(1,1) model :

$$R_{EF}{}^{k}{}_{t} = a_{0\,EF}{}^{k} + S_{i=1}{}^{4}\, a_{i\,EF}{}^{k}\, R_{EF}{}^{k}{}_{t-i} + e_{EF}{}^{k}{}_{t} \qquad (2a)$$

$$R_{EF}{}^{G}{}_{t} = a_{0\,EF}{}^{G} + S_{i=1}{}^{4}\, a_{i\,EF}{}^{G}\, R_{EF}{}^{G}{}_{t-1} + e_{EF}{}^{G}{}_{t} \qquad (2b)$$

$$h_{EF}{}^{k}{}_{t} = c_{0\,EF}{}^{k} + c_{1\,EF}{}^{k}\,(e_{EF}{}^{k}{}_{t-1})^{2} + c_{2\,EF}{}^{k}\, h_{EF}{}^{k}{}_{t-1} \qquad (2c)$$

$$h_{EF}{}^{G}{}_{t} = c_{0\,EF}{}^{G} + c_{1\,EF}{}^{G}\,(e_{EF}{}^{G}{}_{t-1})^{2} + c_{2EF}{}^{G}\, h_{EF}{}^{G}{}_{t-1} \qquad (2d)$$

$$h_{EF}{}^{k,G}{}_{t} = r_{EF}{}^{k,G}\, [\, h_{EF}{}^{k}{}_{t}\;\; h_{EF}{}^{G}{}_{t}\,]^{0.5} \qquad (2e)$$

In equations (2a) and (2b), the weekly effective exchange rate return of country k and Germany, respectively, is modeled as an AR(4) process. Equations (2c) and (2d) describe the time dependent conditional variances of the idiosyncratic component $e_{EF}{}^{k}$ and $e_{EF}{}^{G}$. The conditional variance of exchange rate innovations is modeled as a GARCH(1,1) process. The conditional covariance between exchange rate innovations in country k and in Germany is given by equation (2e), with the conditional correlation being assumed constant.

3.2.2. Domestic stock market innovations

A specification broadly similar to the above specification for industry returns is posited for the joint process governing the returns on the domestic aggregate stock market return in country *k* ($k = BE, FR, UK, IT$), R_M^k , and in Germany, R_M^G. The model is specified as follows :

$$R_{M\,t}^{k} = a_{0\,M}^{k} + a_{1\,M}^{k}\, R_{M\,t-1}^{k} + a_{2M}^{k}\, R_{M\,t-1}^{G} + d_{M\,t-1}^{k}\, R_{EF\,t-1}^{k} + e_{M\,t}^{k} \quad (3a)$$

$$R_{M\,t}^{G} = a_{0\,M}^{G} + a_{1\,M}^{G}\, R_{M\,t-1}^{k} + a_{2\,M}^{G}\, R_{M\,t-1}^{G} + d_{M\,t-1}^{G}\, R_{EF\,t-1}^{G} + e_{M\,t}^{G} \quad (3b)$$

$$e_{M\,t}^{k} = e_{M\,t}^{k} + y_{\,M\,t-1}^{k}\, e_{EF\,t}^{k} \quad (3c)$$

$$e_{M\,t}^{G} = e_{M\,t}^{G} + y_{\,M\,t-1}^{G}\, e_{EF\,t}^{G} \quad (3d)$$

$$h_{M\,t}^{k} = c_{0\,M}^{k} + c_{1\,M}^{k}\, (e_{M\,t-1}^{k})^{2} + c_{2\,M}^{k}\, h_{M\,t-1}^{k} \quad (3e)$$

$$h_{M\,t}^{G} = c_{0\,M}^{G} + c_{1\,M}^{G}\, (e_{M\,t-1}^{G})^{2} + c_{2\,M}^{G}\, h_{M\,t-1}^{G} \quad (3f)$$

$$h_{M\,t}^{k,G} = r_{M}^{k,G}\, [\, h_{M\,t}^{k}\, h_{M\,t}^{G}\,]^{0.5} \quad (3g)$$

Equations (3a) and (3b) indicate that the conditional mean of the return on the domestic stock market is explained by the first lag of the returns on the domestic aggregate stock market, the foreign aggregate stock market and the foreign exchange market. The unexpected portion of the return ($e_{M\,t}^{k}$ for country *k* and $e_{M\,t}^{G}$ for Germany) is driven in part by foreign exchange innovations ($e_{EF\,t}^{k}$ and $e_{EF\,t}^{G}$) and by a pure idiosyncratic shock ($e_{M\,t}^{k}$ and $e_{M\,t}^{G}$) whose conditional variance is given by equations (3e) for country *k* and (3f) for Germany.

The choice of a similar specification for industry and domestic stock market returns makes it possible to compare FX effects between aggregate and industry levels. To this end, we also assume that the FX spillover coefficients in the domestic aggregate market specification ($d_{M\,t-1}^{k}$,

$\delta_{M\ t-1}^{G}$, $\psi_{M\ t-1}^{k}$, $\psi_{M\ t-1}^{G}$) are determined by the same information variables as those introduced for the FX spillover coefficients in the industry model (see section 3.3)

3.3. Assessing Foreign Exchange market effects

We hereafter relate the FX spillover coefficients in mean ($\delta_{j\ t-1}^{k}$, $\delta_{j\ t-1}^{G}$) and in volatility ($\psi_{j\ t-1}^{k}$, $\psi_{j\ t-1}^{G}$) to three information variables designed to capture specific features of exchange rate shocks:

$$\delta_{j\ t-1}^{k} = \delta_{0j}^{k} + \delta_{1j}^{k}\, EMS_{t-1}^{k} + \delta_{2j}^{k}\, LGFX_{t-1}^{k} + \delta_{3j}^{k}\, ASYM_{t-1}^{k} \quad (4a)$$

$$\delta_{j\ t-1}^{G} = \delta_{0j}^{G} + \delta_{1j}^{G}\, EMS_{t-1}^{G} + \delta_{2j}^{G}\, LGFX_{t-1}^{G} + \delta_{3j}^{G}\, ASYM_{t-1}^{G} \quad (4b)$$

$$\psi_{j\ t-1}^{k} = \psi_{0j}^{k} + \psi_{1j}^{k}\, EMS_{t-1}^{k} + \psi_{2j}^{k}\, LGFX_{t-1}^{k} + \psi_{3j}^{k}\, ASYM_{t-1}^{k} \quad (4c)$$

$$\psi_{j\ t-1}^{G} = \psi_{0j}^{G} + \psi_{1j}^{G}\, EMS_{t-1}^{G} + \psi_{2j}^{G}\, LGFX_{t-1}^{G} + \psi_{3j}^{G}\, ASYM_{t-1}^{G} \quad (4d)$$

where *EMS*, *LGFX*, and *ASYM* are three dummy variables.

EMS is an *exchange rate regime* dummy which equals 1 during what we refer to as the "New EMS" period and 0 otherwise ("Old EMS")[8]. *LGFX* refers to the *size* of exchange rate shocks; it is set equal to 1 whenever the absolute value of exchange rate innovations is among the 10 % largest ones in the sample, and to zero otherwise. *ASYM* is designed to capture *asymmetry* in exchange rate effects; it is equal to 1 when exchange rate innovations are negative, that is when the effective exchange rate unexpectedly appreciates, and to 0 otherwise.

---

8 Italy returned to the ERM in November 1996. As the wide bands were already in place, we do not consider this as a significant regime change and did therefore not include an additional dummy variable.

As far a market returns are concerned, we adopt for the corresponding FX spillover coefficients $d^{k}_{M\,t-1}$, $d^{G}_{M\,t-1}$, $y^{k}_{M\,t-1}$ and $y^{G}_{M\,t-1}$ in equations (3a) to (3d) a specification similar to that used in equations (4a) to (4d) for industry returns.

Our framework also enables us to assess the relative contribution of the FX factor in shaping the conditional mean, volatility and international correlation of industry stock returns. *Mean* spillovers occur when past FX returns enter significantly in the anticipated part of the industry stock return. *Volatility* spillovers occur when FX innovations have a significant effect on the unanticipated component of the industry stock return. Moreover, whenever (effective) exchange rate innovations influence the unanticipated component of industry returns, they also contribute to their international correlations, insofar as FX innovations in countries *k* and *G* are themselves correlated. For a given industry stock return $R^{k}_{j\,t}$, the implied time varying conditional variance $s^{2\,k}_{j\,t}$ and the bilateral conditional correlation with Germany $w^{k,G}_{j\,t}$ are the following [9] :

$$s^{2\,k}_{j\,t} = h^{k}_{j\,t} + (f^{k}_{j})^{2}\, h^{k}_{M\,t} + (y^{k}_{j\,t-1})^{2}\, h^{k}_{EF\,t} \qquad (5a)$$

$$w^{k,G}_{j\,t} = \lambda^{k}_{j\,t-1}\, r^{k,G}_{j} + \lambda^{k}_{jM\,t-1}\, r^{k,G}_{M} + \lambda^{k}_{jEF\,t-1}\, r^{k,G}_{EF} \qquad (5b)$$

where :

$$\lambda^{k}_{j\,t-1} = [h^{k}_{j\,t}\, h^{G}_{j\,t} \,/ s^{2\,k}_{j\,t}\, s^{2\,G}_{j\,t}\;]^{1/2}$$

$$\lambda^{k}_{jM\,t-1} = f^{k}_{j}\; f^{G}_{j}\;\; [h^{k}_{M\,t}\, h^{G}_{M\,t} \,/ s^{2\,k}_{j\,t}\, s^{2\,G}_{j\,t}\;]^{1/2}$$

$$\lambda^{k}_{jEF\,t-1} = y^{k}_{j\,t-1}\, y^{G}_{j\,t-1}\;\; [h^{k}_{EF\,t}\, h^{G}_{EF\,t} \,/ s^{2\,k}_{j\,t}\, s^{2\,G}_{j\,t}\;]^{1/2}$$

9 The decomposition of the conditional correlation coefficient is made under the plausible hypothesis that stock market innovations in country k (in Germany) and FX innovations in Germany (in country k) are uncorrelated. Notice also that all the coefficients premultiplying the conditional variances and correlation coefficients in (5a) and (5b) are based on information available up to time t-1.

This linear decomposition of the conditional variance and correlation of industry returns makes it easy to empirically isolate the contribution of each of the two factors. Notice from equation (5b) that the contribution of each factor to the international correlation of industry stock returns is higher the larger the volatility of the factor[10].

While spillover effects from the domestic stock market, as measured by parameters (g^k, g^G, f_j^k and f_j^G) are assumed constant,

3.4. Estimation and diagnostics[11]

The three models are estimated using weekly data over the 1990-1998 sample period. The auxiliary FX and domestic stock market models are, successively, estimated for 4 country pairs. With orthogonal FX and domestic stock market innovations as inputs, the industry model is then estimated for 27 country-industry pairs [12]. The results for Germany are those obtained from the bivariate model with Belgium. For each model, the joint distribution of the idiosyncratic shocks is modeled by a bivariate standardized Student distribution. Estimations were also performed with a bivariate normal distribution[13]. In all cases, standard likelihood ratios show that the Student distribution provides a better fit to the data than the normal distribution[14]. In most cases, diagnostic tests do not indicate serious problems of specification, but suggest that our specification provides a good fit of the data. In particular, Ljung-Box tests performed on the

---

10 This has already been noted by King and Whadwani (1990) and King, Sentana and Whadwani (1994).

11 For reasons of brevity, we do not report the detailed estimates and diagnostic tests obtained for each model. The detailed results are however available from the authors upon request.

12 For 7 sectors and 4 countries (paired with Germany). Data are however not available for the "Support services" industry in Italy and for "Electronics" in Belgium. Each series has 458 data points.

13 For the joint likelihood of a univariate standardised Student distribution, see Bollerslev (1987); for he multivariate Student distribution, see Tong (1990). We have programmed and estimated the likelihood functions of the bivariate Student and Normal distributions with RATS 4.30, using the BHHH (Berndt, Hall, Hall and Hausman) method as maximisation algorithm.

residuals (up to 12th order) suggest that our specification captures most of the serial correlation and the heteroscedasticity in the data. To test autocorrelation, the Diebold-Lopez (Diebold and Lopez, 1995) version of the Ljung-Box test, which provides an adjustment for GARCH effects in the innovations, was used. For each model, estimates of the conditional variance parameters show a high persistence in conditional variance, a result that is in line with what is commonly observed in the literature.

4. Foreign exchange market effects on conditional means

Table 2 reports the cases (country, industry sector) when mean spillovers from the foreign exchange market to the stock market are statistically significant, as indicated by individual Student-t test on the FX coefficients in equations (4a) and (4b). It also includes (last line) the cases when the joint hypothesis of no spillover effect in mean is rejected :

$$H_{mean} : \delta_{0x}^{k} = \delta_{1x}^{k} = \delta_{2x}^{k} = \delta_{3x}^{k} = 0 \ (x = j, M, \text{ and } j=1, 7)$$

Mean spillovers from the foreign exchange market to the stock market are globally significant in slightly more than 50 percent of all cases (H_{mean} =0 is rejected in 20 out of 38 cases, at the 5 % level, in 22 cases at the 10 % level). The evidence is strongest, among countries, for the UK (6 cases out of 8) and Italy (5 cases out of 7) and, among sectors, for the "traded" sectors, Engineering in particular. At the aggregate market level, mean FX spillover is only significant for the UK. This suggests that the exchange rate may matter more for individual industries than for the stock market as a whole. It also clearly indicates that the exchange rate has an impact on

---

14 The 5 % critical value for the likelihood test ratio is always exceeded. The estimated degree of freedom parameter for the Student t-distribution has an average of 6.3 (with a minimum of 2.1 and a maximum of 10.6), indicating the importance of accommodating for fat tails in the distribution of industry stock returns.

industry returns which is transmitted independently from the market return: each individual industry has a specific exposure to the exchange rate, which may be different from that of the average industry represented by the market portfolio. This result also vindicates our choice of a two factor model for industry returns, as it points out that the exchange rate is a significant additional factor explaining industry risk premia.

Table 2. Mean spillovers from the foreign exchange market

	Market	Banks	Insurance	Food &retail	Support services	Chemical	Electronic	Engineer	**Total**
Constant d_{0x}^{k}		GER(-)	IT(+)		FR(+) UK(-)	FR(+) IT(+) UK*(-)	IT(+)	GER(+) IT(+) FR*(+)	9 - 11
EMS d_{1x}^{k}	FR(-)	FR(-) IT(-)	FR(-) IT(-)		BE(-) FR(-)	FR(-) GER(-) IT(-)	FR(-) IT(-)	FR(-) GER(-) IT(-) UK(-)	16
LGFX d_{2x}^{k}	UK(+)	FR(-) IT(+) UK(+)	IT(+) UK(+)	UK*(+)	GER*(-) UK(+)	UK(+)	FR(+) UK(+)	BE(+) GER(+) UK(+)	13 - 15
ASYM d_{3x}^{k}	BE(+)	GER(+) IT(+)	IT*(+)	BE(+)		BE(+) GER(+) IT(+)	GER(+)	BE(+)	9 - 10
TOTAL	3	8	5 - 6	1 - 2	5 - 6	9 - 10	6	10 - 11	47 - 52
FX EFFECT IN MEAN	UK	FR GER* IT UK*	IT UK	BE	BE FR UK	BE GER IT	FR IT UK	BE FR GER IT UK	20 - 22

Note : This table reports the cases when the coefficients of the variables that determine the importance of the mean spillovers (see equations (4a) and (4b) for industry stock returns) are significant at the 5 percent level. An asterisk denotes a 10 percent level of significance. The sign of the coefficient is indicated between parentheses. The line TOTAL indicates the number of significant cases for each industry stock return. The last line of the table reports the cases for which the null of 'no FX effects in the conditional mean' is rejected at the 5 (10 %) level of significance. For each test, the number of possible cases is 38 : (7 industries + domestic market)*5 countries - 2 missing industries (Support services in Italy and Electronics in Belgium).

In order to determine the sign of the significant mean spillover effects, we compute the eight different values which the coefficients q^{k}_{t-1} and q^{G}_{t-1} may take for all possible combinations of values of the dummy variables which characterize FX innovations in equations (4a) and (4b)[15]. Among all significant coefficients of spillover in mean, the estimated value is positive in 64 percent of all across regime parameter combinations reported in Table A.1 of the Appendix. This result implies that for many sectors, the expected stock return increases (decreases) with observed effective depreciation (appreciation) of the currency. Across regimes, positive spillovers are more frequently observed in the “Old EMS” than in the "New EMS" regime, when the absolute exchange rate return is extreme rather than small or when the currency unexpectedly appreciates (negative return).

The change in exchange rate regime, as captured by the EMS dummy, has a significant impact on the mean spillover effect from the FX market in about 40 percent of all cases (16 cases out of 38, at the 5 % level of significance). The *evidence for this EMS effect* is strongest for the traded sectors, in particular Engineering, and for France and Italy. As reported in Table 2 (see line 2), the coefficient of the EMS dummy variable is always negative, when significant. In order to study the direction of the impact of exchange rate regime change on the spillover in mean ($\phi^{k}_{j,t-1}$), we compute, for each of the 16 significant cases identified in Table 2 (see line 2), the 8 estimated values that $\phi^{k}_{j,t-1}$ may take according to equation 4a [16]. Each value corresponds to a particular combination of the three dummy variables which characterize the exchange rate shock. Figure 1 plots these estimated values of $\phi^{k}_{j,t-1}$ for EMS=1 ("New EMS" period) against the estimated values of $\phi^{k}_{j,t-1}$ for EMS=0 ("Old EMS" period). Figure 1 shows that the mean spillover was mostly positive during the Old EMS period. One can also observe that the transition to the "New EMS"

---

15 The eight different regime combinations generated by the three dummy variables for each sector-country case are detailed in the Appendix, Table A1. We report only those 22 sector-country cases for which H_{mean}=0 is rejected. We therefore consider 22*8=176 different spillover parameter combinations.

16 The calculations are necessary to provide a proper and correct interpretation on how the importance of the spillover effect is affected by the events / regime changes as to which each dummy variable refers. Indeed, a negative (positive) coefficient on any of the three dummy variable means either a weakening (reinforcement) of a positive spillover effect, a stronger (weaker) negative spillover, or a change from a positive to negative (a negative to positive) spillover.

period - with a more flexible exchange rate - implied either the weakening of a positive mean spillover or a change in the direction of the mean spillover, from positive to negative.

There is evidence of a *size effect*, even if it is less pronounced : FX spillover coefficients in mean were significantly altered in 34 % of cases when extreme foreign exchange shocks were observed the week before (13 cases out of 38, at the 5 % level[17]). Non traded sectors (6 cases out of 19) and traded sectors (6 cases out of 14) are similar in this respect. Among countries, the evidence is very strong for the UK. For most cases, the coefficient of the size dummy LGFX is positive. For the significant cases reported in Table 2 (line 3), we have plotted in Figure 2 the estimated values of the mean spillover $c^{k}_{j,t-1}$ for the two regimes LGFX=1 and LGFX=0. Figure 2 suggests that large exchange rate innovations induce either an amplification of positive mean spillovers or a change in the sign of mean spillovers, from negative to positive.

Evidence of *asymmetry* in exchange rate effects is limited to 9 cases (about 25 % of the 38 cases, see Table 2, line 4). The sign of the ASYM dummy is consistently positive. The spillover coefficient in mean is thus algebraically larger when the (lagged) foreign exchange innovation is negative. A more detailed analysis shows that the mean spillover either increases when positive or turns from negative to positive when ASYM switches from 0 to 1 [18]. In the first instance, this means for example, that the stock return decreases more strongly following last period's unexpected appreciation of the domestic currency than it increases following last period's unexpected depreciation of the same magnitude[19].

[17] Which is much more than what could be expected in an random sample with a 5 % level of significance.

[18] The corresponding figure for the estimated values of $c^{k}_{j,t-1}$ is not reported.

[19] Note that we postulate in this interpretation that actual and unexpected changes in the exchange rate have the same sign (see equation 4a and 1a).

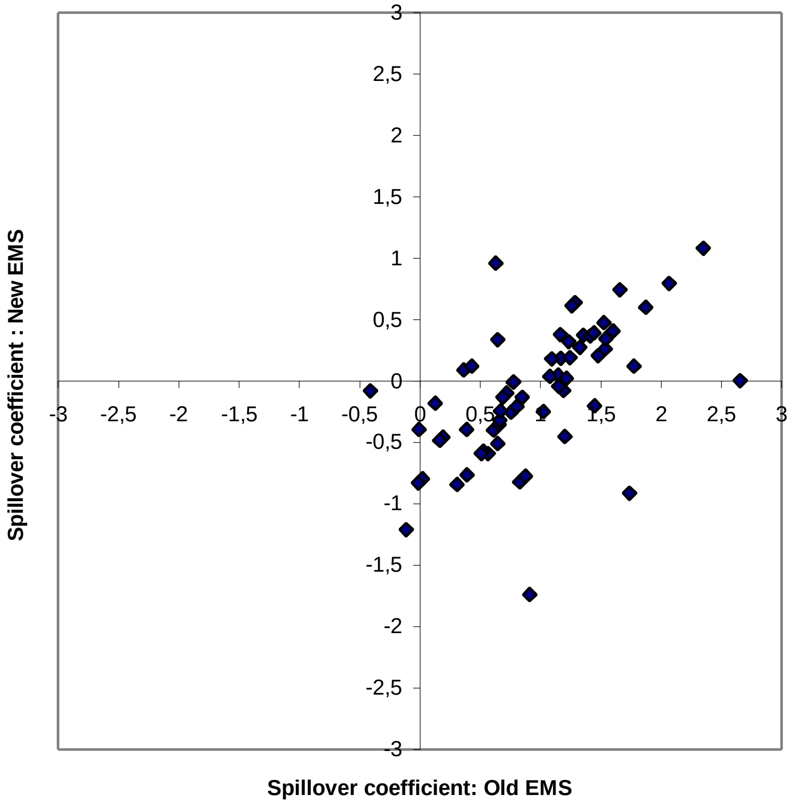

Figure 1. Spillover in mean : EMS effect

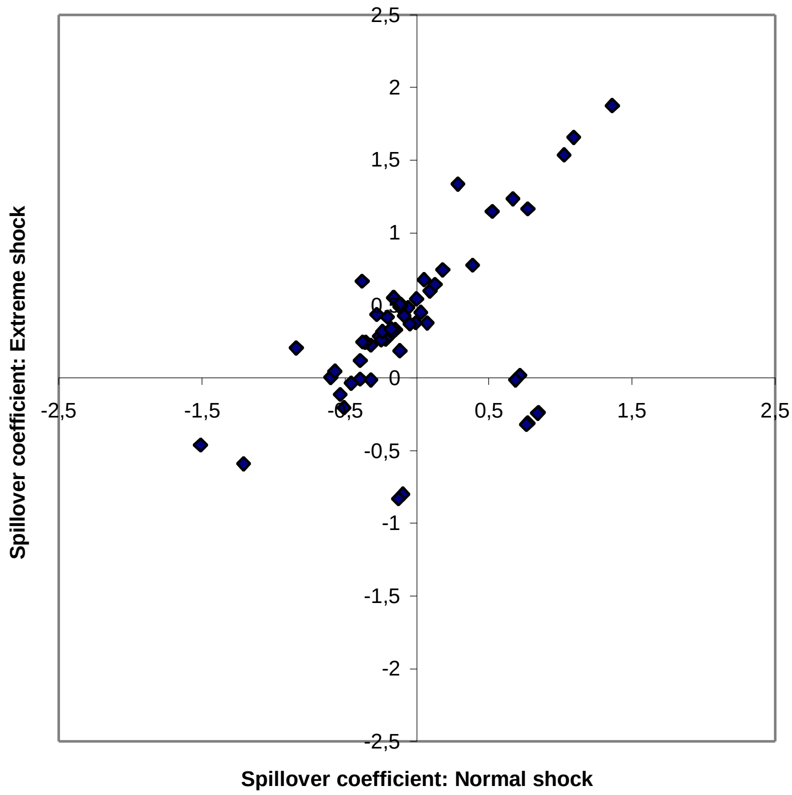

Figure 2. Spillover in mean : Size effect

5. Foreign exchange market effects on conditional variances

5.1. FX volatility spillover

Significant evidence on spillovers in variance from the FX market to aggregate and industry stock returns is reported in Table 3. In addition to individual tests on the coefficients in equations (4c) and (4d), Table 3 includes the results for the joint test of no spillover in variance:

$$H_{variance}: y_{0x}^{k} = y_{1x}^{k} = y_{2x}^{k} = y_{3x}^{k} = 0 \ (x = j, M, \text{ and } j=1, 7)$$

Table 3. Volatility spillovers from the foreign exchange market

	Market	Banks	Insurance	Food &retail	Support services	Chemical	Electronic	Engineer	**Total**
Constant y_{0x}^{k}	BE(+) UK(+)		BE(+)		BE(+)	BE(+) GER(+) UK(+)	FR(+) GER(+) IT(-)	BE(+) GER(+) IT(+) UK(+)	14
EMS y_{1x}^{k}	GER(+) IT*(-)	GER(+) IT(-)	GER(+) IT(-)	IT*(-)		GER(+) IT(-)	GER(+)	GER(+) IT(-) UK(-)	11 - 13
LGFX y_{2x}^{k}	GER(-) IT(+)	GER(-) IT(+)	BE(-) FR(+) GER(-) IT(+)			IT(+)	FR*(-) GER(-) IT(+)	BE*(-) UK(-)	12 - 14
ASYM y_{3x}^{k}		UK(-)			BE*(-)	GER(-)		FR*(-) GER(-) UK(-)	4 - 6
TOTAL	5 - 6	5	7	0 - 1	1 - 2	7	6 - 7	10 - 12	41 - 47
FX EFFECT IN VARIANCE	BE GER IT UK	BE FR GER IT UK		BE	GER	BE GER IT UK	FR IT	BE GER IT UK	21

Note :This table reports the cases when the coefficients of the variables that determine the importance of the volatility spillovers (see equations (2c) and (2d) for industry stock returns) are significant at the 5 percent level. An asterisk denotes a 10 percent level of significance. The sign of the coefficient is indicated between parentheses. The line TOTAL indicates, for the aggregate and industry stock returns, the number of significant cases. The last line of the table reports the cases for which the null of 'no FX effects in the conditional variance' is rejected at the 5 (10 %) level of significance. For each test, the number of possible cases is 38 : (7 industries + domestic market)*5 countries - 2 missing industries (Support services in Italy and Electronics in Belgium).

Volatility spillovers appear to be globally significant in a large number of cases ($H_{variance}$=0 is rejected in 21 out of 38 cases, at the 5 % level). For the aggregate stock market, they are significant in all countries but France. At the industry level, the evidence is the strongest for the traded industries, in particular Chemicals and Engineering. The evidence is strong for Banks but weak for the other non traded sectors. At the country level, the evidence is strongest for Belgium and Italy (5 cases out of 7) and weakest for France (2 cases out of 8).

It is interesting to note that the cases for which spillover in volatility is significant do not closely overlap with the cases for which spillover in mean is significant. Of the 21 cases for which the spillover coefficient in volatility is significant, there are no more than 13 cases for which spillover in mean is significant.

The transition to a more flexible exchange rate regime had a limited impact on the importance of the FX volatility spillover : in only 11 cases out of 38 is the *EMS effect* significant at the 5 % level (line 2 in Table 3). The evidence is slightly stronger for the traded industries (6 cases out of 14) than for the non traded industries (5 cases out of 19). It also appears that the sensitivity of the stock return volatility to FX volatility, as measured by the squares of the estimated values of $y^{k}_{j\,t-1}$ (computed according to equation 4c, for the cases when the EMS dummy is significant) increased or decreased in approximately the same number of cases when the country adopted a more flexible exchange rate (see Figure 3)[20]. In a few instances, the importance of the volatility spillover then increased sharply.

The *size* of exchange rate shocks only matters for volatility spillovers in a limited number of cases. Again, the evidence is slightly stronger for the traded sector (6 cases out of 14) than for the non traded sector (6 cases out of 19). Figure 4 (which graphs the squares of $y^{k}_{j\,t-1}$ for the two regimes described by the LGFX dummy, when this dummy is significant) indicates that the volatility spillover usually weakens when exchange rate shocks become large. This points to some non-linearity (concavity) in the FX volatility transfer to the stock market.

Very few cases of *asymmetric effects* can be identified (4 out of 38, at the 5 % level). In those few instances, one can observe that the volatility spillover coefficient is lower when the effective exchange rate has unexpectedly appreciated the preceding period[21].

We note that the pattern of significance, across countries and industries, of the three information variables in the variance spillover coefficients is very different from the pattern observed for mean spillover effects. This again confirms the usefulness of including FX spillover effects both into the anticipated and the unanticipated components of industry stock returns. Imposing the constraint that these two spillover coefficients are identical, as done in many studies using an extended CAPM approach, is therefore not borne out by the empirical evidence.

---

[20] Figure 3 and 4 are constructed along the same methodology as Figures 1 and 2.

[21] The corresponding figure for the squares of $y_{j\,t-1}^{k}$ is not reported.

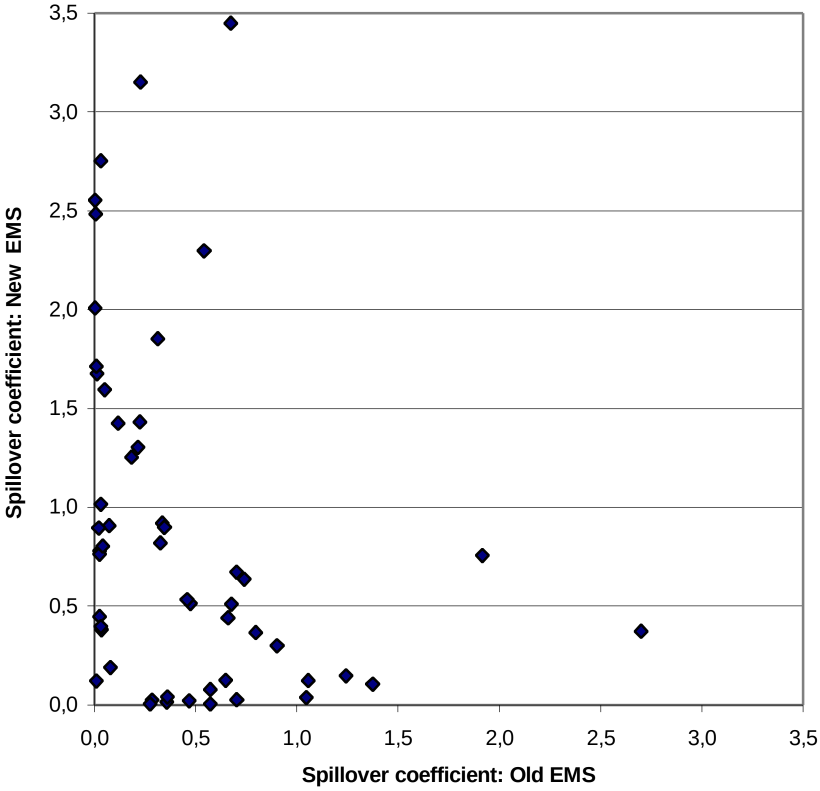

Figure 3. Spillover in variance : EMS effect

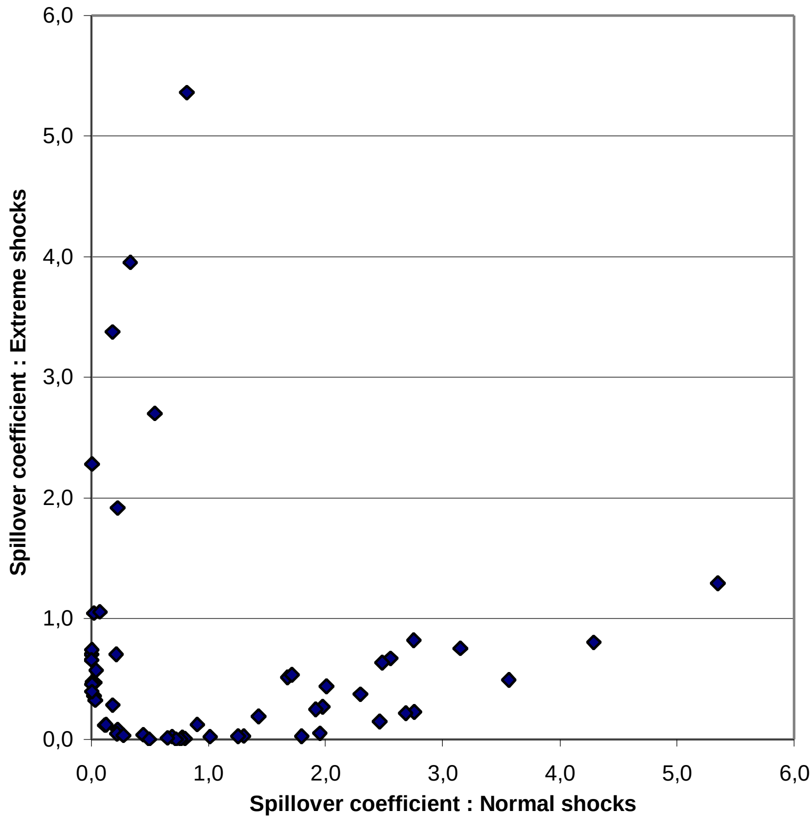

Figure 4. Spillover in variance : size effect

5.2. Decomposition of the conditional industry variance

Although significant FX spillover effects have been identified, it remains to be seen whether their contribution to the volatility of industry stock returns is important, relative to that of the domestic stock market factor. To assess this, we decomposed the industry conditional stock return variance into the respective contributions of the two factors. The proportions are derived from equation (5a). Their average value over the whole sample period is reported in Table 4.

With a few exceptions, innovations on the domestic stock market account for the largest part of the conditional variance of industry stock returns. Conversely, the proportion of the variance accounted for by exchange rate innovations is very small: over the sample period, it never exceeds 10 percent on average. Across countries, the relative influence of exchange rate shocks is, for most sectors, the largest in Italy. One may also notice that the average relative influence of the exchange rate factor is close to zero for almost every sector in France and in the UK. Across sectors, non traded and traded industries exhibit similar patterns of relative factor contributions. The same conclusions hold when one looks at the pattern through time of the conditional variance decomposition [22]. However, Italy is a notable exception, with episodes during which exchange rate shocks accounted for more than 30 percent of industry stock return volatility. One of those corresponds to the transition to the New EMS regime in August 1992[23].

---

[22] See Table A2 of the Appendix, which reports the 5% and 95% fractiles of the distribution of the FX contributions to the conditional stock return variance.

[23] A second episode occurred in October 1995, which coincides with a "speculative attack" on the French franc by U.S. hedge funds which provoked tensions within the ERM (IMF, 1996, p. 45).

Table 4. Decomposition of the conditional variance of industry stock returns

		Banks	Insurance	Food and retail	Support services	Chemical	Electronic	Engineering
Belgium	Stock	0.517	0.543	0.366	0.027	0.573	N.A.	0.452
	Forex	0.011	0.050	0.050	0.010	0.026	N.A.	0.061
France	Stock	0.691	0.573	0.489	0.342	0.557	0.608	0.465
	Forex	0.006	0.020	0.003	0.002	0.008	0.008	0.007
Germany	Stock	0.640	0.661	0.106	0.179	0.586	0.623	0.691
	Forex	0.023	0.029	0.002	0.019	0.058	0.032	0.034
Italy	Stock	0.697	0.705	0.257	N.A.	0.523	0.548	0.442
	Forex	0.089	0.102	0.013	N.A.	0.084	0.066	0.072
UK	Stock	0.652	0.510	0.238	0.418	0.427	0.390	0.515
	Forex	0.007	0.002	0.010	0.003	0.015	0.004	0.024

Note : This table reports the value, averaged over the whole sample period, of the part of the variance of the industry stock return *j* in country *k*, $s^{2\,k}_{j\,t}$ (see equation (5a)), that is accounted for by the variance of the aggregate stock market return (line "Stock") and the variance of the effective exchange rate return (line "Forex"). The variance ratios are computed as: $VM^{k}_{j\,t} = [\, f^{2\,k}_{j}\, h^{\;k}_{M\,t}\,] /\, s^{2\,k}_{j\,t}$ and $VEF^{k}_{j\,t} = [y^{\,2\,k}_{\;j\,t-1}\, h^{\;k}_{EF\,t}\,] /\, s^{2\,k}_{j\,t}$.

6. Foreign exchange market effects on conditional correlations

In this section, we use our estimates to examine the role of the two factors in shaping the international correlations of industry stock returns. The contribution of each factor to the international correlation between industry's *j* returns in country *k* and Germany is computed according to equation (5b). Results are reported in Table 5.

Over the full sample, the average international correlation ranges from 0.083 to 0.496. Slightly more than half of them are higher than 0.3. The lowest ones concern two non-traded sectors (Food and Retail and Support Services). Note that industry returns have lower conditional correlations than aggregate stock market returns[24].

It appears from Table 5 that the domestic stock market is again the dominant factor explaining the international correlation among industry stock returns. The contribution of the foreign exchange factor is very modest, though usually positive: indeed its average value is close to zero for most industry returns. The contribution is particularly small for Italy and the UK. This can be attributed to the small correlation between the Italian (British) FX return and the German FX return[25]. A more detailed analysis, taking the whole time profile of contributions into account (see Table A3 in the Appendix), broadly confirms these conclusions. For Belgium and France, the FX contribution becomes occasionally higher, for example during the turbulent exchange rate period in July/August 1993 and October 1995 [26].

Table 5. Decomposition of the conditional correlation of industry stock returns

		Banks	Insurance	Food and retail	Support services	Chemical	Electronic	Engineering
Belgium	Total	0.405	0.426	0.083	0.113	0.408	N.A.	0.399
	Stock	0.353	0.367	0.119	0.040	0.357	N.A.	0.343
	Forex	0.012	0.025	0.003	0.007	0.020	N.A.	0.029
France	Total	0.496	0.477	0.119	0.298	0.394	0.445	0.404
	Stock	0.439	0.406	0.149	0.164	0.378	0.403	0.369
	Forex	0.002	0.010	0.001	-0.001	0.006	0.008	0.004
Italy	Total	0.309	0.326	0.138	N.A.	0.254	0.268	0.243
	Stock	0.287	0.293	0.064	N.A.	0.237	0.253	0.231
	Forex	0.003	0.004	0.000	N.A.	0.006	0.004	0.004
UK	Total	0.402	0.346	0.135	0.218	0.320	0.289	0.374
	Stock	0.384	0.339	0.089	0.169	0.289	0.295	0.346
	Forex	-0.002	-0.001	0.002	0.000	-0.006	-0.002	-0.003

Note : This table reports how much of the estimated correlation among industry stock returns (line “Total”) is accounted for by the correlation among aggregate stock return (line “Stock”) and the correlation among effective exchange rate returns (line “Forex”). The contributions of the two factors are derived from equation (5b) and are defined as follows: $CM^k_{j\,t} = l_{jM\;t-1}^{\;k}\, r_M^{k,G}$ and $CEF^k_{j\,t} = \lambda_{jEF\;t-1}^{\;k}\, r_{EF}^{k,G}$. All data are sample averages.

24 The conditional correlation of domestic stock market returns with Germany equals 0.618 for Belgium, 0.659 for France, 0.431 for Italy, and 0.589 for the UK.

25 The conditional correlations of FX returns with Germany are as follows : Belgium : 0.885, France : 0.734, Italy : -0.112, UK : -0.316.

26 Although it can then be up to four times higher, it nevertheless remains modest relatively to the contribution of the domestic stock market factor.

7. Conclusions

In this paper, we developed a two factor – two country model to investigate the impact of foreign exchange markets on the conditional distribution of industry stock returns. The model has been estimated for a set of European countries and a selection of industries, over the 1990-1998 period. In line with earlier studies, we show that exchange rate fluctuations exert a significant, but small influence on the mean and volatility of industry stock returns. Our analysis confirms that industries from traded sectors are usually more sensitive to exchange rates than industries from non-traded sectors, both in mean and volatility. Our analysis investigated more closely whether the importance of the spillover effects from the foreign exchange markets is influenced by the exchange rate regime, the magnitude and the directions of exchange rate disturbances. We show that, within the EMS, the transition to a regime with greater exchange rate flexibility tends to decrease the generally positive (negative) effect a currency depreciation (appreciation) has on industry mean returns; it also matters, in a limited number of cases, for volatility spillovers. We also find that the influence of the FX market on the mean and, to a lesser extent, on the volatility of industry stock returns is modified when exchange rate innovations are abnormally large. Occasional evidence of asymmetric effects of FX shocks is also reported. We also examined the contribution of the exchange rate factor to the conditional correlation coefficients between industry returns of our set of European countries and Germany. We find that the FX contribution is positive, but in general tiny.

References

Bartov, E., Bodnar G., Kaul A., 1996. Exchange rate variability and the riskiness of U.S. multinational firms: Evidence from the breakdown of the Bretton Woods system. Journal of Financial Economics 42, 105-132.

Bekaert, G., Harvey C., 1997. Emerging market volatility. Journal of Financial Economics 43, 29-77.

Bodart, V., Reding P., 1999. Exchange rate regime, volatility and international correlations on bond and stock markets. Journal of International Money and Finance 18, 133-151.

Bodnar, G., Gentry W., 1993. Exchange rate exposure and industry characteristics: evidence from Canada, Japan, and U.S.. Journal of International Money and Finance 12, 29-45.

Bollerslev, T., 1987. A conditionally heteroskedastic time series model for speculative prices and rates of return. The Review of Economics and Statistics, 542-547.

Bollerslev, T., 1990. Modelling the coherence in short-run nominal exchange rates: a multivariate generalized approach. Review of Economics and Statistics 72. 498-505.

Diebold, F.X., Lopez, J.A., 1995. Modeling volatility dynamics. NBER Technical Working Paper 173.

Dominguez, K., Tesar, L., 2001. A Re-examination of Exchange Rate Exposure. NBER Working Paper 8128.

Drummen, M., Zimmermann H., 1992. The Structure of European Stock Returns. Financial Analysts Journal, July-August, 15-26.

Griffin, J.M., Stulz , R. M., 1997. International Competition and Exchange Rate Shocks: A Cross-Country Industry Analysis of Stock Returns. NBER Working Paper 6243.

Griffin, J.M., Karolyi G.A., 1998. Another look at the role of industrial structure of markets for international diversification strategies. Journal of Financial Economics 50, 351-373.

Heston, S., Rouwenhorst K., 1994. Does industrial structure explain the benefits of international diversification ?. Journal of Financial Economics 36, 3-27.

International Monetary Fund, 1996. International Capital Markets, World Economic and Financial Surveys, October.

Karolyi G.A., Stulz R.M., 1996. Why Do Markets Move Together ? An Investigation of U.S.-Japan Stock Return Comovements. The Journal of Finance, vol.LI, n°3.

King, M., Sushil W., 1990. Transmission of Volatility between Stock Markets. Review of Financial Studies, 3, 5-33.

King, M., Sentana, E., Sushil W., 1994. Volatility and Links between Stock Markets. Econometrica, 62, 901-933.

Longin, F., Solnik B., 1995. Is the correlation in international equity returns constant: 1960-1990 ?. Journal of International Money and Finance 14, 3-26.

Ng, A., 2000a. Volatility spillover effects from Japan and the USQ to the Pacific-Basin. Journal of International Money and Finance 19, 207-233.

Ng, A., 2000b. Shock Spillovers: The Case of the Developed Markets in Europe. Unpublished paper, September.

Roll, R., 1992. Industrial Structure and the Comparative Behavior of International Stock Market Indices. The Journal of Finance, Vol. XLVII, N°1, 3-41

Tong, Y. L., 1990. The Multivariate Normal distribution, chap. 9. Springer Verlag, Springer series in statistics.

Appendix

Table A1 Distribution of significant *positive* spillovers coefficients from the FX market to expected stock market returns

	Normal shock (LGFX=0)				Large shock (LGFX=1)				
	Old EMS (EMS=0)		New EMS (EMS=1)		Old EMS (EMS=0)		New EMS (EMS=1)		
	Shock + (ASYM=0)	Shock - (ASYM=1)	Shock + (ASYM=0)	Shock - (ASYM=1)	Shock + (ASYM=0)	Shock - (ASYM=1)	Shock + (ASYM=0)	Shock - (ASYM=1)	
Belgium (4)	1	4	0	2	3	4	0	3	17
France (4)	3	4	2	1	4	3	0	1	18
Germany (3)	2	3	0	2	2	3	1	3	16
Italy (5)	5	5	3	4	5	5	3	5	35
UK (6)	1	0	0	1	6	6	6	6	26
	12	16	5	10	20	21	10	18	112

Note : This table reports the frequencies of significant *positive* spillover FX coefficients in the specification of the mean industry return (equations 4a and 4b) for those cases when the FX effect is globally significant (i.e. H_{mean}: $\delta_{0x}^k = \delta_{1x}^k = \delta_{2x}^k = \delta_{3x}^k = 0$ is rejected). Each cell corresponds to a different combination of values of the dummy variables which characterize the FX innovations (size, regime and sign). For example, the number 4 in column 3 for Belgium is the number of times the estimated spillover coefficient in mean is positive for the LGFX=0, EMS=0 and ASYM=1 specific regime combination. For Belgium, the maximum number in any cell is 4, as H_{mean} =0 is rejected for 4 sectors (see Table 2 in the text). This maximum number is, for each country, reported within brackets in column 1. As there are in total 22 industry-country cases for which the FX effect in mean is significant (see Table 2 in the main text), there are 176 possible regime parameter combinations (22*8). Of those, the 112 which are reported in the table correspond to a positive spillover coefficient.

Table A2 Distribution of the FX contribution to the conditional variance of industry stock returns

		Banks	Insurance	Food and retail	Support services	Chemical	Electronic	Engineering
Belgium	Low05	0.001	0.005	0.005	0.000	0.002	N.A.	0.007
	Mean	0.011	0.050	0.050	0.010	0.026	N.A.	0.061
	High95	0.036	0.115	0.178	0.043	0.074	N.A.	0.148
France	Low05	0.000	0.000	0.000	0.000	0.000	0.001	0.001
	Mean	0.006	0.020	0.003	0.002	0.008	0.008	0.007
	High95	0.022	0.115	0.009	0.010	0.032	0.026	0.020
Germany	Low05	0.001	0.002	0.000	0.002	0.001	0.001	0.001
	Mean	0.023	0.029	0.002	0.019	0.058	0.032	0.034
	High95	0.085	0.097	0.007	0.046	0.203	0.117	0.123
Italy	Low05	0.000	0.000	0.001	N.A.	0.002	0.006	0.002
	Mean	0.089	0.102	0.013	N.A.	0.084	0.066	0.072
	High95	0.332	0.405	0.050	N.A.	0.339	0.280	0.246
UK	Low05	0.000	0.000	0.001	0.000	0.005	0.000	0.000
	Mean	0.007	0.002	0.010	0.003	0.015	0.004	0.024
	High95	0.032	0.008	0.030	0.014	0.032	0.016	0.077

Note : This table reports the Mean, the 5 % (Low05) and the 95% (High95) fractiles of the distribution of the proportion of the conditional variance of the industry stock return which is explained by the FX factor (as given by $VEF_{j\,t}^{k} = [y^{2\,k}_{j\,t-1}\, h_{EF\,t}^{k}] \,/\, s^{2\,k}_{j\,t}$ according to equation (5a)).

Table A3 Distribution of the FX contribution to conditional international correlations among industry stock returns

		Banks	Insurance	Food and retail	Support services	Chemical	Electronic	Engineering
Belgium	Low05	-0.003	-0.010	-0.012	-0.006	-0.011	N.A.	-0.014
	Mean	0.012	0.025	0.003	0.007	0.020	N.A.	0.029
	High95	0.041	0.074	0.013	0.030	0.071	N.A.	0.103
France	Low05	-0.005	-0.005	-0.002	-0.009	-0.013	-0.003	-0.011
	Mean	0.002	0.01O	0.001	-0.001	0.006	0.008	0.004
	High95	0.016	0.047	0.003	0.005	0.036	0.028	0.026
Italy	Low05	-0.001	-0.003	-0.001	N.A.	-0.001	-0.001	-0.001
	Mean	0.003	0.004	0.000	N.A.	0.006	0.006	0.004
	High95	0.013	0.016	0.001	N.A.	0.022	0.013	0.016
UK	Low05	-0.010	-0.006	0.000	-0.004	-0.018	-0.009	0.000
	Mean	-0.002	-0.001	0.002	0.000	-0.006	-0.002	-0.003
	High95	0.001	0.001	0.005	0.004	0.001	0.001	0.010

Note : This table reports the Mean, the 5 % (Low05) and the 95% (High95) fractiles of the distribution of the contribution of FX factor to the international correlation of industry stock returns (as given by $CEF_{j\,t}^{k} = \lambda_{jEF\,t-1}^{k}\; r_{EF}^{k,G}$ according to equation (5b)).