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Return and Volatility Spillovers to Industry Returns: Does EMU Play a Role?

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Abstract:
Within a two step GARCH framework we estimate the time-varying spillover effects from European and US return innovations to 10 economic sectors within the euro area, the United States, and the United Kingdom. We use daily data from January 1988 – March 2002. At the beginning of our sample sectors in all three currency areas/blocks formed a quite homogeneous group exhibiting only minor sector-specific characteristics. However, over time sectors became more heterogeneous, that is the response to aggregate shocks increasingly varies across sectors. This provides evidence that sector-specific effects gained in importance. European industries show increased heterogeneity simultaneously with the start of the European Monetary Union, whereas in the US this trend started in the early 1990's. Information technology and non-cyclical services (including telecommunication services) became the most integrated sectors worldwide, which are most affected by aggregate European and US shocks. On the other hand, basic industries, non-cyclical consumer goods, resources, and utilities became less affected by aggregate shocks. Volatility spillovers proved to be small and volatile.

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1 Introduction

The introduction of the euro at the beginning of 1999 is likely to have an impact on the allocation of capital within the euro area. With the introduction of the euro, exchange rate risk between European Monetary Union (EMU) member states has been eliminated. Stocks in the participating countries are since then quoted in one currency, the euro, rather than in different domestic currencies.

At the same time, there is evidence of a closer co-movement of national stock markets. The source of the increase in co-movements can be attributed to the declining importance of country-specific factors in determining stock prices as Brooks and DelNegro (2002) argue. In addition, Campbell et al. (2001) provide evidence that returns at the firm level show increasingly idiosyncratic risk, which points at a strengthened influence of firm-specific factors. Fratzscher (2001) investigated the spillover effects of European and US returns to several national equity returns. He found evidence of an increased impact of aggregate European shocks on most European stock markets over time, which was, however, rather a cyclical than a smooth, linear process.

This paper investigates how industry returns are affected by innovations to European and US equity markets. We compare the results for the euro area with those for the US and the UK. In addition, we repeat the results obtained by Fratzscher (2001) for spillovers to country returns to compare the dynamics of spillover effects to industry and country returns. We employ a generalized autoregressive conditional heteroskedasticity (GARCH) framework to take time variation and persistence in the volatility into account and perform rolling estimations to explore the time-varying nature of the return and volatility spillover effects. Against this background, we revisit the relative importance of sector- and country-specific effects in stock returns. In addition, international equity markets recently experienced a huge increase and, following that, a sharp correction of the value of technology stocks. Consequently, part of this paper is to investigate to what extent shifts of the importance of sector-specific and country-specific factors is due to IT stock valuations.

We find that at the beginning of our sample sectors in all three currency areas/blocks formed a quite homogeneous group exhibiting only minor sector-specific characteristics. However, over time sectors became more heterogeneous, that is the response to aggregate shocks increasingly varies across sectors. This provides evidence that sector-specific effects gained in importance. European industries show increased heterogeneity simultaneously with the start of the European Monetary Union, whereas in the US this trend started in the early 1990's. Information technology and non-cyclical services (including telecommunication services) became the most integrated sectors worldwide, which are most affected by aggregate European and US shocks. On the other hand, basic industries, non-cyclical consumer goods, resources, and utilities became less affected by aggregate shocks. Volatility spillovers proved to be small and volatile.

The remainder of the paper is organized as follows. Section two gives an overview over the literature, section three outlines the econometric framework we are using. Section four presents the data, section five discusses the results and section six concludes.

2 Relevant Literature

There is a long tradition investigating co-movements in international stock markets. Several approaches were pursued. First, starting from a solid theoretical foundation, different versions of the Capital Asset Pricing Model (CAPM), which was developed by Sharpe (1964), Lintner (1965), and Mossin (1966), have been applied. In the CAPM asset returns in excess of the risk free interest rate are proportional to the non-diversifiable market risk. Therefore, a single factor drives asset returns. In fully integrated markets, stocks and portfolios depend only on the market risk factor. In countries with different currencies, exchange rate risk is another risk factor of individual returns. In completely segmented markets, excess returns depend only on the local price of risk. Hardouvelis et al. (1999), for example, estimated several versions of the CAPM allowing for a time-varying degree of financial integration, modelled as the weight of the EU-wide risk factor as opposed to country-specific risk factors. They found that during the period from 1991-1995 local risk factors accounted for an average of 77% of total expected returns across the 11 starting members of EMU and the UK. From 1996-1998 the average impact of local risk factors dropped to 34%, suggesting a considerable increase in stock market integration over time.

Second, Brooks and DelNegro (2002), Heston and Rouwenhorst (1994, 1995), Rouwenhorst (1999), and Campbell et al. (2001) followed a more micro-based approach. Heston and Rouwenhorst (1994, 1995) and Rouwenhorst (1999) collected individual stock returns and run cross sectional regressions on country and industry dummies to quantify the sector-specific and the country-specific components of stock returns. Until the late nineties, country effects by far outreached sector-specific effects.

Brooks and DelNegro (2002) estimated a factor model, which distinguishes firm level equity returns in a global factor, a country-specific, an industry-specific and a firm-specific component. Compared to the Heston and Rouwenhorst approach, the factor model relaxes the assumption that all firms have the same exposure to their given country or industry factor. Over the 1990’s they found evidence of an increased importance of the global factor, an unchanged impact of industry factors and, most importantly, a waned impact of country-specific factors in stock markets. Their results suggest that the increased co-movement of national stock markets is mainly due to the decline of the importance of country-specific factors.

Campbell et al. (2001) investigated the long run behaviour of the volatility of stocks and its sources at the market, industry and firm level. As already outlined, the CAPM predicts a proportional relation between industry returns and the market return as well as between individual stock returns and the respective industry return or market return. The degree of proportionality is measured by the respective beta. To circumvent the problem of time varying betas Campbell et al. computed weighted averages of firm-level volatility across firms in one industry, weighted averages of industry volatility across industries and market volatility. That allowed for a beta-free variance decomposition, since the weighted betas aggregate out. They found that firm volatility is clearly the largest component of volatility of US stocks explaining about 72 per cent of the unconditional mean of total volatility of an average firm. The shares of market volatility and industry volatility are 16 per cent and 12 per cent, respectively. While market and industry volatilities in levels are stable of the sample period (despite some spikes during recessions and crashes), the average firm volatility measure increased steadily over the sample period (also in addition to some spikes during recessions and crashes). That points at a declining correlation among individual stock returns, which is actually the case as Campbell et al. show.

Third, some authors used more aggregate measures such as country and sector returns to investigate the relation between country and sector-specific factors or to estimate their interdependence with European or international returns. Along those lines, Fratzscher (2001) investigated the size of spillovers from European and US stock markets to individual countries using a trivariate GARCH model. He found evidence for a higher degree of integration between equity markets of several European countries since 1996, which, as he argues, is mainly attributable to a decrease in exchange rate volatility.

Berben and Jansen (2002) developed a novel bivariate GARCH model with smoothly time-varying correlation to test for an increase in co-movements between equity returns at the market and the industry level. They found that in the period 1980-2000 conditional correlations between Germany, the UK, and the US have doubled and that no specific sectors played a dominant role in this process of integration. Conditional correlations with Japan remained at the low level of the 1980’s.

Adjaoute and Danthine (2000, 2001) used country returns and returns of the same sector in different countries and calculated sub-period correlations as well as dispersions of weekly sector and country returns. They found upward trending correlations (and decreasing dispersion) for the pre-euro or convergence period. However, after the introduction of the euro, correlations between sectors and countries are significantly lower (higher dispersions) than before. One possible conclusion is that dispersions fluctuate cyclically and are unrelated to the degree of integration.

Baele (2002) investigated the magnitude and the time-varying nature of volatility spillovers from aggregate European and US equity market indices to 13 local European equity markets. Baele proceeded in two steps. First, he estimated several bivariate models to isolate pure European and pure US innovations. Second, these innovations were used as additional explanatory variables for several local county returns. The novelty of the paper was to allow for Markovian regime switches in the shock spillover intensity. Baele found strong evidence for regime switches in spillover intensity. On average, the dominant market for EMU member countries is the aggregate European market, while for most non-EMU countries that role is still played by the US market.

3 Framework of Analysis

We proceed in two steps. First, we estimate a bivariate GARCH model of European and US equity returns in order to identify European and US shocks. Second, a univariate GARCH(1,1) model is estimated, which allows for spillover effects in returns and volatilities from the euro area and the US to the *i*th sector or country.

Equity returns are assumed to consist of a predictable, m_t, and an unpredictable part, e_t.

$$\begin{bmatrix} r_{EMU,t} \\ r_{US,t} \end{bmatrix} = \begin{bmatrix} m_{EMU,t} \\ m_{US,t} \end{bmatrix} + \begin{bmatrix} e_{EMU,t} \\ e_{US,t} \end{bmatrix}$$

The predictable part is rudimentary modelled as a constant. The unpredictable part is assumed to consist of the innovations to returns while allowing for spillover effects from the euro area to the US and vice versa. Note that because of the difference in trading hours US shocks are only allowed to affect European returns on the following day.

$$\begin{bmatrix} m_{EMU,t} \\ m_{US,t} \end{bmatrix} = \begin{bmatrix} c_{EMU} \\ c_{US} \end{bmatrix}$$

$$\begin{bmatrix} e_{EMU,t} \\ e_{US,t} \end{bmatrix} = \begin{bmatrix} 0 & g_{EMU,US} \\ g_{US,EMU} & 0 \end{bmatrix} \begin{bmatrix} e_{EMU,t} \\ e_{US,t-1} \end{bmatrix} + \begin{bmatrix} e_{EMU,t} \\ e_{US,t} \end{bmatrix}$$

The vector of innovations, e_t, is assumed to be normal distributed conditional on the past information set, Ω_{t-1}, that is $e_t | \Omega_{t-1} \sim N(0, H_t)$. The assumption of conditionally normal distributed innovations does not *per se* contradict the empirical evidence of excess kurtosis in the unconditional returns. Conditional normal distributed innovations are able to produce excess kurtosis in the unconditional returns when volatility exhibits some persistence.

The time-varying variance covariance matrix, H_t, for euro area and US returns is assumed to follow a modified vech specification, which restricts the matrices A and B to be diagonal (i.e. variances and the covariance depend only on own lagged values and own lagged squared innovations). However, we allow for volatility spillovers between the euro area and the US. Again, to take the difference in trading hours into account US volatility can be affected by contemporaneous squared innovations to the euro area aggregate, while the reverse is only possible with a lag.

$$H_t = \begin{bmatrix} s^2_{EMU,t} & s_{EMU,US,t} \\ s_{EMU,US,t} & s^2_{US,t} \end{bmatrix}$$

$$\begin{bmatrix} s^2_{EMU,t} \\ s^2_{US,t} \\ s_{EMU,US,t} \end{bmatrix} = \begin{bmatrix} w_{EMU} \\ w_{US} \\ w_{EMU,US} \end{bmatrix} + \begin{bmatrix} a_{11} & 0 & 0 \\ 0 & a_{22} & 0 \\ 0 & 0 & a_{33} \end{bmatrix} \begin{bmatrix} e^2_{EMU,t-1} \\ e^2_{US,t-1} \\ e_{EMU,t-1} e_{US,t-1} \end{bmatrix} + \begin{bmatrix} b_{11} & 0 & 0 \\ 0 & b_{22} & 0 \\ 0 & 0 & b_{33} \end{bmatrix} \begin{bmatrix} s^2_{EMU,t-1} \\ s^2_{US,t-1} \\ s_{EMU,US,t-1} \end{bmatrix} + \begin{bmatrix} d_1 e^2_{US,t-1} \\ d_2 e^2_{EMU,t} \\ 0 \end{bmatrix}$$

After having obtained estimates for the innovations to euro area and US returns, we proceed with step two by estimating the GARCH (1,1) model for the return of the *i*th sector/country allowing for spillover effects in returns and volatilities from the euro area and the US to the *i*th sector/country.

Note that US return innovations are only allowed to affect European returns with a lag of one day because of the difference in trading hours. However, if the industry *i* consists of US firms, innovations to the US market can contemporaneously affect sector returns and therefore the lagged innovations to the US market are replaced by their contemporaneous equivalencies.

$$r_{i,t} = c_i + b1_i e_{EMU,t} + b2_i e_{US,t(-1)} + e_{i,t}$$

$$s^2_{i,t} = vc_i + va_i e^2_{i,t-1} + vb_i s^2_{i,t-1} + vd_i e^2_{EMU,t} + ve_i e^2_{US,t(-1)}$$

Our main focus is on the spillover coefficients of aggregate euro area and US innovations to the return and the volatility of sector (or country) *i*, that is $b1_i, b2_i, vd_i, ve_i$. The more the return r_i is affected by European (US) shocks the more it is regarded as being integrated on the European (international) level. Further, $b1_i$ and $b2_i$ measure the degree of co-movement with the aggregated euro area and US market, respectively. A coefficient close to one on the corresponding aggregated home market implies minor specific effects in sector or country returns and therefore little diversification gains.

The parameters of the system are estimated via maximizing a multivariate or an univariate log likelihood function, respectively. Since the conditional distribution of the innovations are assumed to be Gaussian, the conditional distribution of the returns is also Gaussian and the likelihood function for one observation is given by

$$f\left(y_t \mid m_t, y_{t-1}, y_{t-2}, \ldots, y_0\right) = \frac{1}{\sqrt{2ps_t^2}} \exp\left(\frac{-\left(y_t - m_t\right)^2}{2s_t^2} \right).$$

The likelihood function of the entire sample is the product of the likelihood functions of all individual observations. Equivalently, the log likelihood function $L(q)$ of the entire sample is the sum of the log likelihood functions of all individual observations:

$$L(q) = \sum_{t=1}^{T} \log f\left(y_t \mid m_t, y_{t-1}, y_{t-2}, \ldots, y_0; q\right) = -\frac{T}{2}\log(2p) - \frac{1}{2}\sum_{t=1}^{T}\log\left(s_t^2\right) - \frac{1}{2}\sum_{t=1}^{T}\log\left(\frac{\left(y_t - m_t\right)^2}{s_t^2} \right).$$

In the multivariate case the part of the log likelihood function to be maximized becomes

$L(q) = -\frac{1}{2}\sum_{t=1}^{T}\left(\log\left|H_t\right| + e'_t H_t^{-1} e_t\right)$. (Of course, this formula could also be applied to the univariate case, where vectors and matrices at time *t* would shrink to dimension 1x1.) Initial values are obtained using the Simplex algorithm, after that the numerical maximization procedure of Berndt, Hall, Hall, and Hausmann (1974) is employed to estimate the coefficients.

4 Data

We use stock market indices for the euro area, the US, and the UK from Datastream International at daily frequency. At the industry level, we follow the broad distinction of 10 economic sectors according to the Financial Times Actuaries, which Datastream uses: basic industries, cyclical consumer goods, cyclical services, financials, general industrials, information technology, non-cyclical consumer goods, non-cyclical services, resources, and utilities (see table 1 for a more detailed description). Datastream indices target 80% coverage of market capitalization of the relevant investable universe.

Our sample starts on 1 January 1988 and ends on 31 March 2002 for a total of 3717 observations. Returns are computed as the first difference of the logarithm of the index. All indices are total return indices. Euro area returns and US returns are expressed in US dollar, whereas UK and country returns are in local currency. Tables 2-5 show some descriptive statistics of the country and industry returns. All returns have a positive mean and most of them are negatively skewed. The returns show the well-known properties of excess kurtosis (leptokurtic) and autocorrelations in squared returns. The hypothesis of normal distributed returns (Jarque-Bera) is always rejected at the 1% level of significance.

Table 6 displays the average correlation coefficient of the return of each industry (and the aggregate) with the remaining industries in the same currency area. Table 7 repeats this exercise for the set of country returns. It is obvious that over the entire sample period correlations among the different sectors within one currency area decreased steadily (with the information technology sector in the UK being the only exception) while correlations among countries generally increased (Austria and Belgium are the exceptions here). However, while these trends are very similar across industries and countries, the level of co-movement remains very different. For example, the correlation among industries is relatively high in the euro area (0.68) and relatively low in the UK (0.45). Average cross-country correlations range from 0.29 (US) to 0.58 (Netherlands). However, this simple correlation analysis suggests that over time aggregate shocks increasingly influence country returns, while they have less impact on industry returns. Consequently, country-specific effects seem to have moderated, while sector-specific effects gained in importance.

5 Results

We estimated two versions of our empirical model in order to test the robustness of the results. First, we estimated the model, which was outlined above for 10 economic sectors in the euro area, the US, and the UK as well as some selected countries. The second version was estimated to isolate the impact of the IT bubble in 1999/2001 by excluding the IT sector from aggregate European and US returns.

We report the results of rolling estimations of one year windows for the sectors inside the euro area, the US, the UK, and our set of countries focussing on return spillover effects of European and US shocks to the individual sector. Rolling estimations of one year windows moved month by month translate into 160 observations for each coefficient.

Figure 1 shows the time-varying coefficient of the spillover effect from European return innovations to European industry returns. Figure 2 displays the time-varying coefficient on lagged US innovations in the return equation of the different European industries. Following that, figures 3-8 display the spillover coefficients on European and US return innovations for US industries, UK industries as well as selected countries. As already mentioned, we applied our model also to some countries and thereby replicated the results in the spirit of Fratzscher (2001) to compare the cyclical behaviour of spillover effects to industry returns with the spillover effects to county returns.

We would like to highlight some interesting results.

- Until 1998 most *European industries* are proportionally, roughly one for one, affected by aggregate European innovations (see figure 1). In 1998, coincident with the final decisions about EMU and the participating countries, this relationship breaks down. Some sectors, such as information technology and non-cyclical consumer services (which include telecommunication services) are now more influenced by aggregate shocks, while basic industries, non-cyclical consumer goods, resources, and utilities are less affected by aggregate shocks.
- The impact of aggregate US return innovations on European industries (figure 2) is generally much smaller, more volatile and exhibits no obvious trend compared to the impact of European return innovations. The only significant departure from that is the information technology sector, which as early as 1995 became more exposed to US shocks.

⇒ *Simultaneous with the final decisions about EMU European sectors became more heterogeneous. However, it remains to be seen, whether the increased heterogeneity among sectors is a feature of a large common currency area or a global trend.*

- Turning to *US industries* (figures 3 and 4), the results are qualitatively similar to those for industries located in the euro area. The impact of European shocks is small (smaller, however, than the impact of US shocks to European sectors) and volatile around a mean of about zero. On the other hand, the impact of domestic shocks on domestic industries in the US starts at about one for one (except utilities) but begins to diverge as early as 1991. As true for the euro area, US information technology is more affected by innovations to the aggregate than other sectors. Basic industries, non-cyclical consumer goods, resources, and utilities also continue to be less affected by aggregate shocks as found for the euro area.
- Despite the fact that *sector returns in the UK* are less correlated than in other currency areas, all sector returns are very similarly affected by European and US shocks (except IT and after 1999 non-cyclical services). However, the degree of similarity declines over time. Again after 1999, the coefficient on the return spillover from the euro area and the US to the IT sector and non-cyclical consumer services sector increases dramatically,

while basic industries, non-cyclical consumer goods, resources, and utilities are the sectors with the lowest impact of European and US shocks.

⇒ *The observation of increased heterogeneity of industry returns is not only a European but also a worldwide phenomenon. However, European sectors show that feature only after the details of EMU became certain, whereas in the US this trend started in the early 1990's. Further investigation using a longer sample period is needed to clarify, whether there is a global trend towards increased sectoral diversity or whether this is a feature of a large common currency area. In addition, a given sector regardless of whether it is located in the euro area, the US, or the UK is in general similarly affected by aggregate shocks. Finally, increased heterogeneity among sectors provides evidence for stronger sector-specific effects in stock returns.*

- Regarding *country returns*, similar, if not identical results as obtained by Fratzscher (2001) emerge. Spillover effects from aggregate euro area returns to country returns exhibit pronounced cyclical behaviour around an upward sloping trend. For some countries (FR, GE, IT, NE, SP, UK) the specifics have moderated, while others (AU, BE, IR) continue to be little affected by aggregate shocks. The peaks and troughs of the spillover effect of European innovations are remarkably similar across our set of countries. The coefficients on US spillover effects are much more diverse across countries.

⇒ *The positive trend in the spillover effects of European shocks to most European countries points at a decrease in country-specific effects in stock returns.*

Figures 9 and 10 summarize the information contained in figures 1-8 by displaying the mean of the spillover coefficients across sectors in each of the previous figures. The closer a sector (country) in the euro area moves with the European aggregate or, in other words, the closer the coefficient on the spillover effect of the European shock is to one, the less sector (country) specific effects are present. Since the average spillover coefficient of aggregate shocks to EMU countries is still smaller than the corresponding average coefficient for euro area industries, we conclude that (weakened) country-specific effects still outweigh (strengthened) sector-specific effects in the euro area. In addition, it is remarkable to what extend the swings in return spillovers between different currency zones coincide across industries and countries (except spillovers from the euro area to US industries). There seem to be large swings in co-movements of country returns as well as industry returns.

Figures 11 and 12 display the standard deviation of the spillover coefficients across sectors, which also illustrate increased heterogeneity among sectors. That feature is very pronounced for sectors in the euro area, the US, and the UK and holds to a far lesser extent for EMU countries. Figures 13 and 14 show the equally weighted average of the volatility spillovers from European and US returns to industry returns in the euro area, the US, and the UK as well as our set of EMU countries. Volatility spillover effects are too small and too volatile to infer any information from it.

How are these results influenced by the IT sector? Prices of IT stocks experienced a substantial boom in 1999/2000, which was even more than offset thereafter. Therefore we used a value-weighted average of returns of all economic sectors except information technology to estimate European and US return innovations. Then, the spillover effects of these "IT-clean shocks" to the different sectors and countries were estimated as before. Qualitatively, all results obtained so far carry over to this specification (see figures 15-22). Nevertheless, some quantitative deviations from the previous results emerge. Figures 23-30 summarize the averaged coefficients for both specifications.

- The *average* impact of domestic aggregate shocks on European and US industries does not decay anymore (as before), but fluctuates around one. Removing the IT component from aggregate returns increases the average impact of domestic aggregate shocks on sectors in the euro area from late 1999 and on sectors in the US from 1995 on.
- The IT component does not, however, have an impact on UK sectors and country returns as well as on spillover effects between different currency areas.

To sum up, this paper provides answers to three key questions.

- First, following our definition of integration, which says that the more the sector is affected by European (US) shocks the more it is regarded as being integrated on the European (international) level, what are the most integrated sectors? The European information technology sector is the one which is most integrated into world markets. It became considerably more exposed to international (meaning US) shocks as early as 1995. It is also the sector which is most affected by European shocks. Non-cyclical services rank second in terms of euro area wide integration, with a hump in 1999/2000, when M&A activities in the telecommunication sector surged. Resources and utilities form the lower end of the ranking as they are least affected by aggregate shocks.
- Second, another interpretation of this result refers to the importance of sector-specific factors in industry returns. A coefficient close to one on domestic market innovations, as found at the beginning of our sample for most European industries, does not leave much space for sector-specific effects. The larger dispersion of the coefficients on domestic aggregate shocks across European sectors after 1998 points at an increase in sector-

specific effects, which coincides with the start of EMU, whereas for US sectors this pattern emerges as early as 1991.

- Third, when comparing the results across currency areas the sectoral pattern of the impact of aggregate shocks on industries in the euro area, the US, or the UK does not differ considerably. In addition, there seem to be cyclical swings in the spillover effects, which are common to all sectors in one currency area and sometimes even common to sectors across currency areas or countries.

6 Conclusion

Using our empirical model of daily return spillover effects enables us to make statements about the degree of integration of different sectors in different currency areas and the presence of country- and sector-specific effects in stock returns. The more the sector is affected by European (US) shocks the more it is regarded as being integrated in the European (world) economy. At the same time, the more the impact of domestic aggregate shocks is different from one the stronger sector (country) specific effects are present in the returns.

We show that at the beginning of our sample sectors in all three currency areas/blocks formed a quite homogeneous group exhibiting only minor sector-specific characteristics. However, over time sectors became more heterogeneous, that is the response to aggregate shocks increasingly varies across sectors. This provides evidence that sector-specific effects gained in importance. European industries show increased heterogeneity simultaneously with the start of the European Monetary Union, whereas in the US this trend started in the early 1990's. Information technology and non-cyclical services (including telecommunication services) became the most integrated sectors worldwide, which are most affected by aggregate European and US shocks. On the other hand, basic industries, non-cyclical consumer goods, resources, and utilities became less affected by aggregate shocks. Volatility spillovers proved to be small and volatile.

Future research could apply more sophisticated versions of the empirical model, which include additional explanatory variables for returns, such as changes in short-term interest rates and the term structure, or allow for asymmetric responses in the spillover process. Another interesting question would be to investigate the sources of the cycles in the spillover effects to UK sectors and European countries, which co-move to a remarkable extent.

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Table 1: FTSE Actuaries

BASIC INDUSTRIES	Chemicals Construction & Building Materials Forestry & Paper Steel & Other Metals
CYCLICAL CONSUMER GOODS	Automobiles & Parts Household Goods & Textiles
CYCLICAL SERVICES	General Retailers Leisure Entertainment & Hotels Media & Photography Support Services Transport
FINANCIALS	Banks Insurance Life Assurance Investment Companies Real Estate Speciality & Other Finance
GENERAL INDUSTRIALS	Aerospace & Defence Electronic & Electrical Equipment Engineering & Machinery
INFORMATION TECHNOLOGY	Information Tech Hardware Software & Computer Services
NON-CYCLICAL CONS GOODS	Beverages Food Producers & Processors Health Personal Care & Household Products Pharmaceuticals & Biotechnology Tobacco
NON-CYCLICAL SERVICES	Food & Drug Retailers Telecommunication Services
RESOURCES	Mining Oil & Gas
UTILITIES	Electricity Gas Distribution Water

Table 2: Descriptive statistics of euro area equity returns

Tables 2-5: Jarque-Bera and Ljung-Box statistics are all significant at the 1% level, except where marked (* = significant at 5% level, ** = significant at 10% level, and *** = not significant)

Euro Area	Mean	Standard Error	Skewness	Kurtosis	Jarque - Bera	Ljung-Box (5) of returns	Ljung-Box (5) of squared returns
Aggregate	0.00038	0.00974	-0.47	9.52	6712	34.78	307.67
Basic Industries	0.00032	0.00992	-0.43	10.12	7957.8	29.58	211.26
Cyc. Consumer Goods	0.00021	0.01144	-0.54	10.81	9603.8	53.79	301.04
Cyc. Services	0.00037	0.00989	-0.38	8.64	5007.6	54.50	360.37

Financials	0.00033	0.01008	-0.48	10.68	9249.4	18.21	592.80
General Industrials	0.00038	0.01105	-0.49	10.09	7920.1	65.33	426.37
Information Technology	0.00071	0.01811	-0.39	7.96	3891.4	25.92	202.20
Non-cyc. Consumer Goods	0.0005	0.00932	-0.32	8.05	4011.9	41.90	672.39
Non-cyc. Services	0.00052	0.01321	-0.21	7.99	3881.7	17.86	249.27
Resources	0.00054	0.01104	-0.17	6.12	1523.4	52.84	555.98
Utilities	0.00041	0.00905	-0.34	8.55	4825.2	10.77**	142.00

Table 3: Descriptive statistics of US equity returns

US	Mean	Standard Error	Skewness	Kurtosis	Jarque - Bera	Ljung-Box (5) of returns	Ljung-Box (5) of squared returns
Aggregate	0.00053	0.00967	-0.39	8.35	4525.5	15.90	315.14
Basic Industries	0.00039	0.01127	-0.05	8.54	4749.5	46.93	231.19
Cyc. Consumer Goods	0.0004	0.01174	-0.38	8.65	5026.8	8.46***	145.30
Cyc. Services	0.00051	0.01123	-0.42	10.15	8011.3	58.21	178.20
Financials	0.00065	0.01121	-0.07	7.43	3039.8	35.27	216.80
General Industrials	0.00057	0.01115	-0.38	9.37	6365.4	53.70	561.77
Information Technology	0.00057	0.01805	0.07	7.96	3807.1	21.87	461.82
Non-cyc. Consumer Goods	0.00062	0.01024	-0.32	8.28	4371.7	14.77*	639.95
Non-cyc. Services	0.0004	0.011	-0.19	6.36	1769.8	39.19	269.67
Resources	0.00048	0.01185	0.11	6.09	1487.7	12.89*	269.22
Utilities	0.00042	0.00806	-0.41	7.78	3637.5	50.97	713.12

Table 4: Descriptive statistics of UK equity returns

UK	Mean	Standard Error	Skewness	Kurtosis	Jarque - Bera	Ljung-Box (5) of returns	Ljung-Box (5) of squared returns
Aggregate	0.00047	0.00859	-0.16	5.52	999.6	34.41	556.52
Basic Industries	0.00033	0.00871	0.08	6.47	1864.3	225.04	442.10
Cyc. Consumer Goods	0.00031	0.0133	0.15	9.45	6448.6	37.11	531.99
Cyc. Services	0.00039	0.0088	0.01	7.68	3384	95.98	397.25
Financials	0.00061	0.01109	0	7.65	3343.1	47.51	541.08
General Industrials	0.00041	0.01033	-0.4	9.18	5998.4	68.67	560.73
Information Technology	0.00056	0.01689	-0.74	18.12	35692	89.58	307.98
Non-cyc. Consumer Goods	0.00055	0.01038	-0.02	6.53	1929.4	141.12	510.97
Non-cyc. Services	0.00036	0.014	0.11	6.13	1518.4	20.26	219.13
Resources	0.00055	0.01229	0.22	6.02	1437.5	41.20	967.56
Utilities	0.00058	0.01007	0.28	6.36	1789.3	37.72	56.57

Table 5: Descriptive statistics of country and euro area equity returns

Country/Area	Mean	Standard Error	Skewness	Kurtosis	Jarque - Bera	Ljung-Box (5) of returns	Ljung-Box (5) of squared returns
Euro Area	0.00038	0.00974	-0.47	9.52	6712.0	34.78	307.67
US	0.00053	0.00967	-0.39	8.35	4525.5	15.90	315.14
UK	0.00047	0.00859	-0.16	5.52	999.6	34.41	556.52
AU	0.00036	0.00963	-0.37	16.25	27222	226.52	670.75
BE	0.00045	0.00802	-0.08	8.88	5351.6	105.86	636.08
FR	0.00056	0.01075	-0.32	6.27	1720.5	20.94	348.47
GE	0.00045	0.01086	-0.85	12.06	13148	14.51*	235.86
IR	0.00061	0.01030	-0.31	10.46	8667.1	53.44	334.35
IT	0.00036	0.01273	-0.23	6.19	1608.6	33.47	512.19
NE	0.00059	0.00948	-0.42	8.23	4343.3	17.39	1235.90
SP	0.00049	0.01112	-0.39	7.58	3335.1	28.96	424.53

Tables 2-5: Jarque-Bera and Ljung-Box statistics are all significant at the 1% level, except where marked (* = significant at 5% level, ** = significant at 10% level, and *** = not significant).

Table 6: Average correlation coefficients of industry *i* and aggregate index returns with returns of remaining industries ($i \neq j$) in the euro area, the US, and the UK

	Euro Area				US				UK			
Sample period / Index	1/88 - 3/02	4/90 - 3/94	4/94 - 3/98	4/98 - 3/02	1/88 - 3/02	4/90 - 3/94	4/94 – 3/98	4/98 - 3/02	1/88 - 3/02	4/90 - 3/94	4/94 – 3/98	4/98 – 3/02
Aggregate	0.84	0.92	0.84	0.79	0.73	0.79	0.78	0.65	0.69	0.75	0.7	0.63
Basic Industries	0.74	0.87	0.73	0.65	0.54	0.64	0.6	0.43	0.52	0.65	0.55	0.4
Cyc. Consumer Goods	0.71	0.83	0.71	0.65	0.56	0.61	0.57	0.49	0.4	0.52	0.36	0.34
Cyc. Services	0.75	0.87	0.73	0.67	0.63	0.7	0.67	0.55	0.58	0.66	0.62	0.49
Financials	0.76	0.87	0.76	0.69	0.6	0.67	0.65	0.53	0.56	0.64	0.57	0.5
General Industrials	0.76	0.87	0.75	0.69	0.64	0.69	0.68	0.56	0.51	0.62	0.55	0.42
Information Technology	0.57	0.78	0.56	0.52	0.47	0.57	0.48	0.41	0.32	0.23	0.27	0.37
Non-cyc. Consumer Goods	0.7	0.86	0.74	0.58	0.54	0.62	0.62	0.41	0.45	0.58	0.49	0.33
Non-cyc. Services	0.68	0.83	0.71	0.6	0.54	0.62	0.56	0.44	0.45	0.58	0.47	0.38
Resources	0.52	0.71	0.59	0.41	0.35	0.33	0.45	0.24	0.35	0.4	0.46	0.27
Utilities	0.64	0.8	0.6	0.55	0.4	0.55	0.51	0.26	0.36	0.45	0.41	0.27
Average over all industries	0.68	0.83	0.69	0.6	0.53	0.6	0.58	0.43	0.45	0.53	0.48	0.38

Table 7: Average correlation coefficients of country *i* and euro area returns with returns of remaining countries ($i \neq j$).

	Euro Area	US	UK	AU	BE	FR	GE	IR	IT	NE	SP	Average over all countries
Full sample	0.54	0.29	0.53	0.38	0.48	0.57	0.57	0.39	0.47	0.58	0.53	0.48
1/88-3/90	0.34	0.10	0.32	0.20	0.28	0.35	0.40	0.32	0.24	0.43	0.34	0.30
4/90-3/94	0.47	0.27	0.46	0.43	0.49	0.53	0.52	0.36	0.35	0.50	0.49	0.44
4/94-3/98	0.51	0.26	0.54	0.46	0.54	0.55	0.54	0.43	0.42	0.58	0.50	0.48
4/98-3/02	0.66	0.36	0.64	0.43	0.52	0.67	0.66	0.43	0.63	0.66	0.63	0.56

Figure 1: Return spillovers from European return innovations to different European industries (B1…)

BASIC = basic industries, CYCGD = cyclical consumer goods, CYSER = cyclical services, GENIN = general industrials, ITECH = information technology, NCYCG = non-cyclical consumer goods, NCYSR = non-cyclical services, RESOR = resources, TOTLF = financials, and UTILS = utilities;
EM = European Monetary Union, US = United States, UK = United Kingdom.

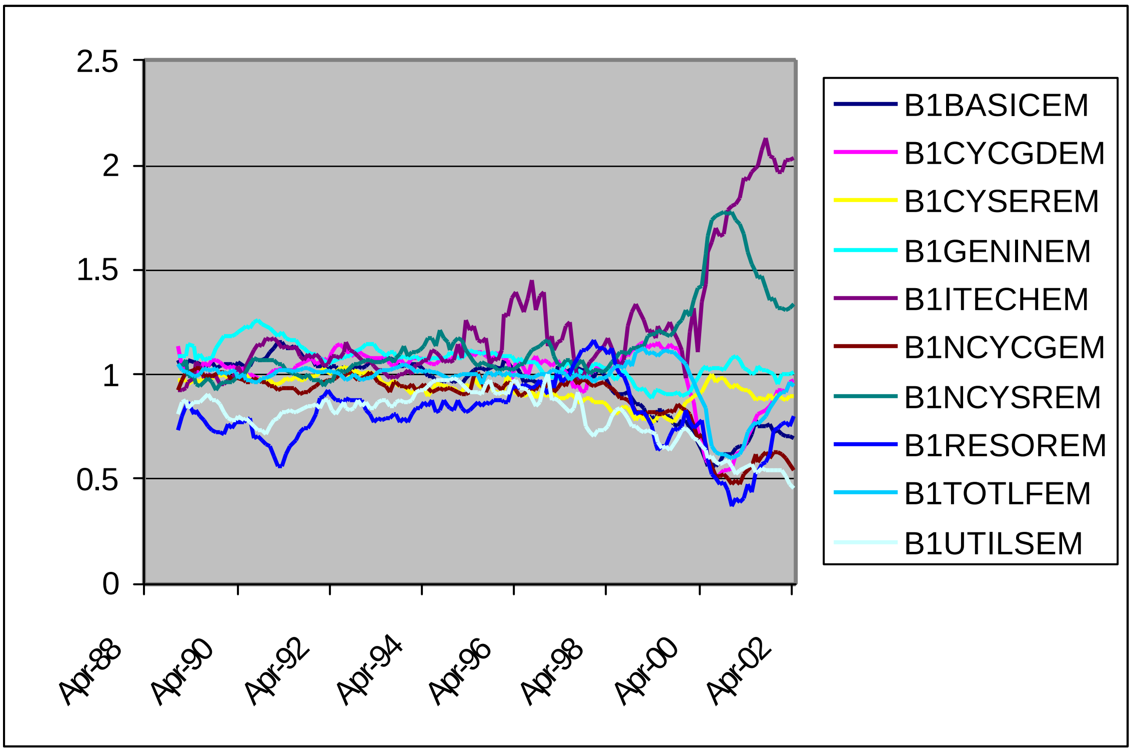


Figure 2: Return spillovers from US return innovations to different European industries (B2…)

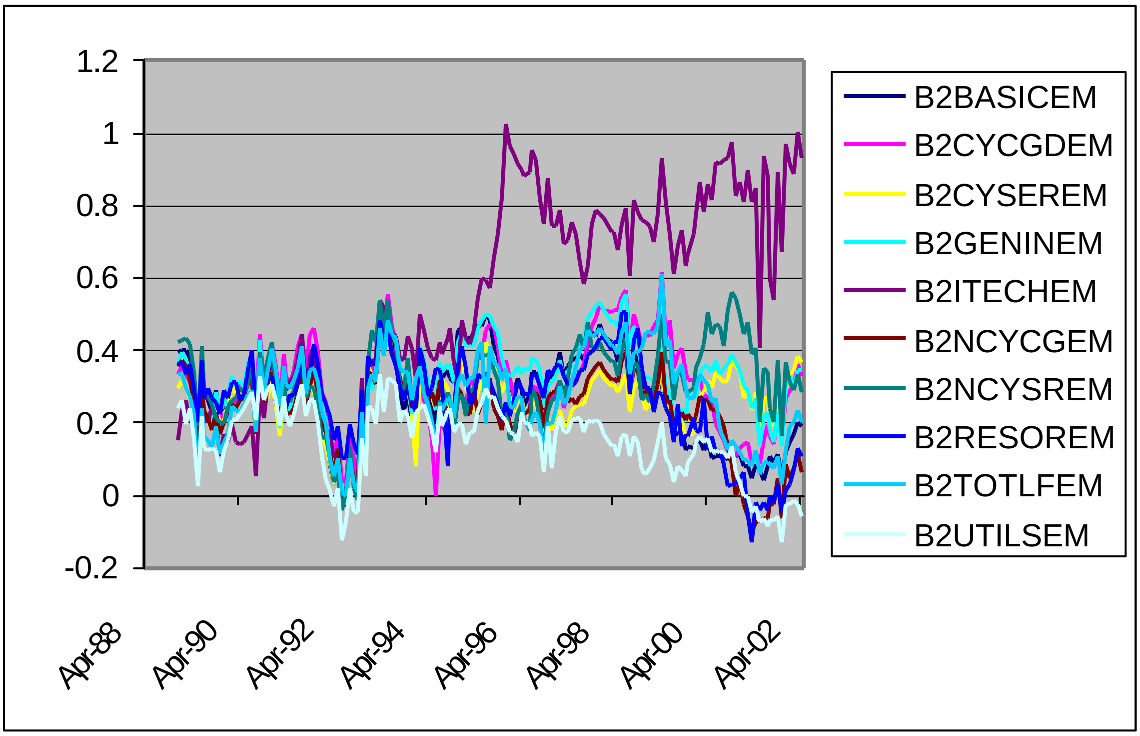


Figure 3: Return spillovers from European return innovations to different US industries (B1…)

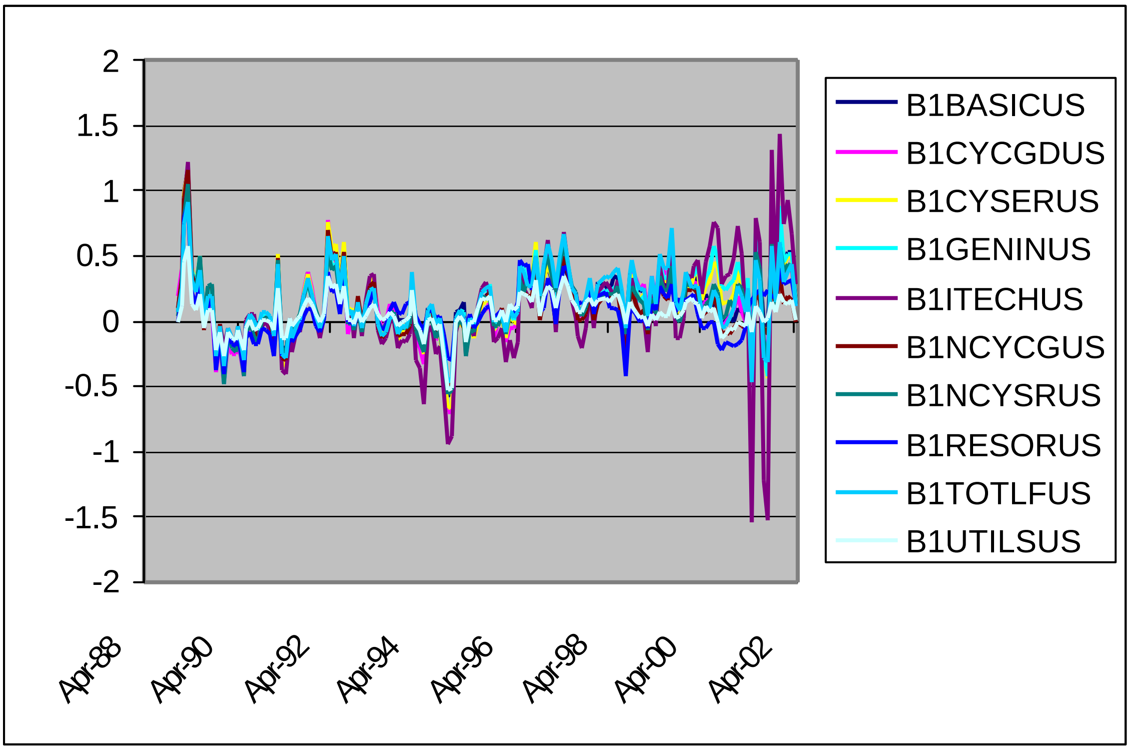


Figure 4: Return spillovers from US return innovations to different US industries (B2…)

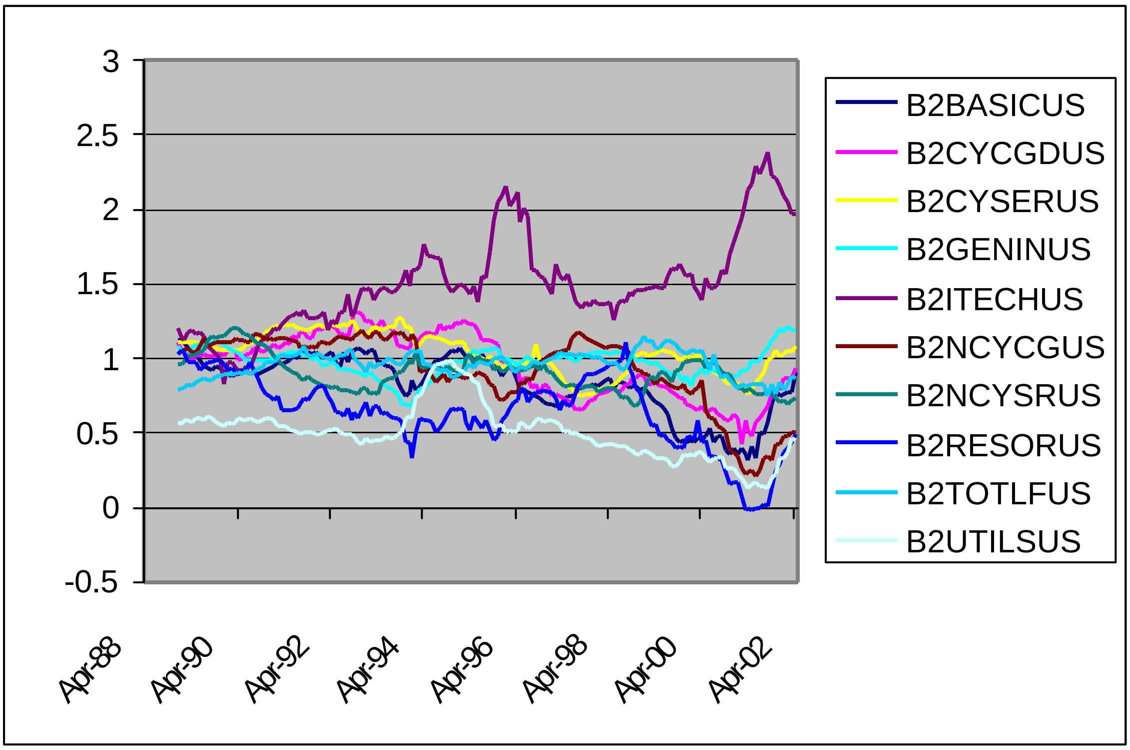


Figure 5: Return spillovers from European return innovations to different UK industries (B1…)

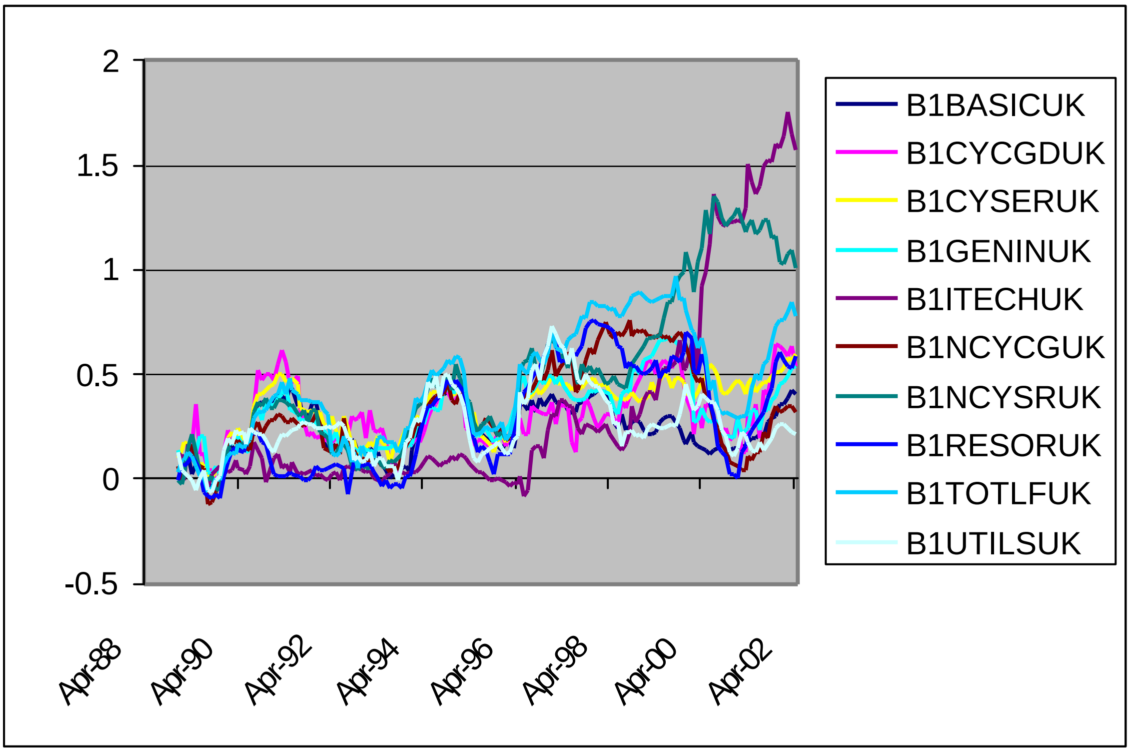


Figure 6: Return spillovers from US return innovations to different UK industries (B2…)

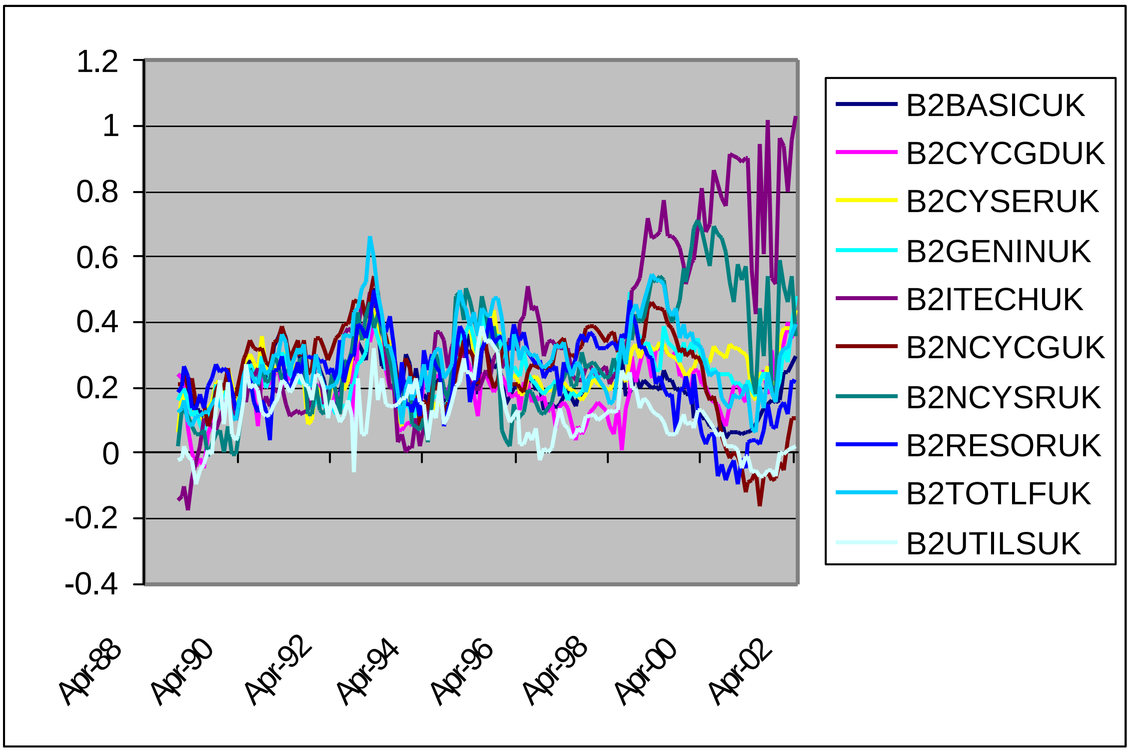


Figure 7: Return spillovers from European return innovations to different countries (B1…)

AU = Austria, BE = Belgium, FR = France, GE = Germany, IR = Ireland, IT = Italy, NE = Netherlands, SP = Spain, UK = United Kingdom, and JA = Japan.

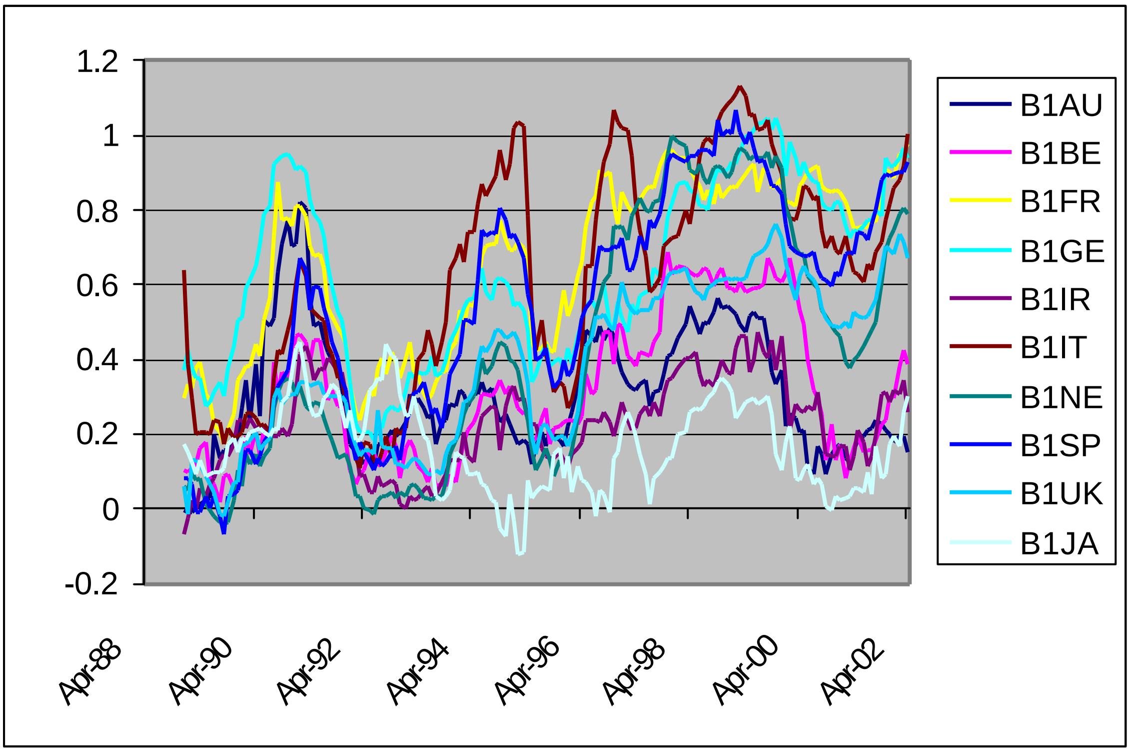


Figure 8: Return spillovers from US return innovations to different countries (B2…)

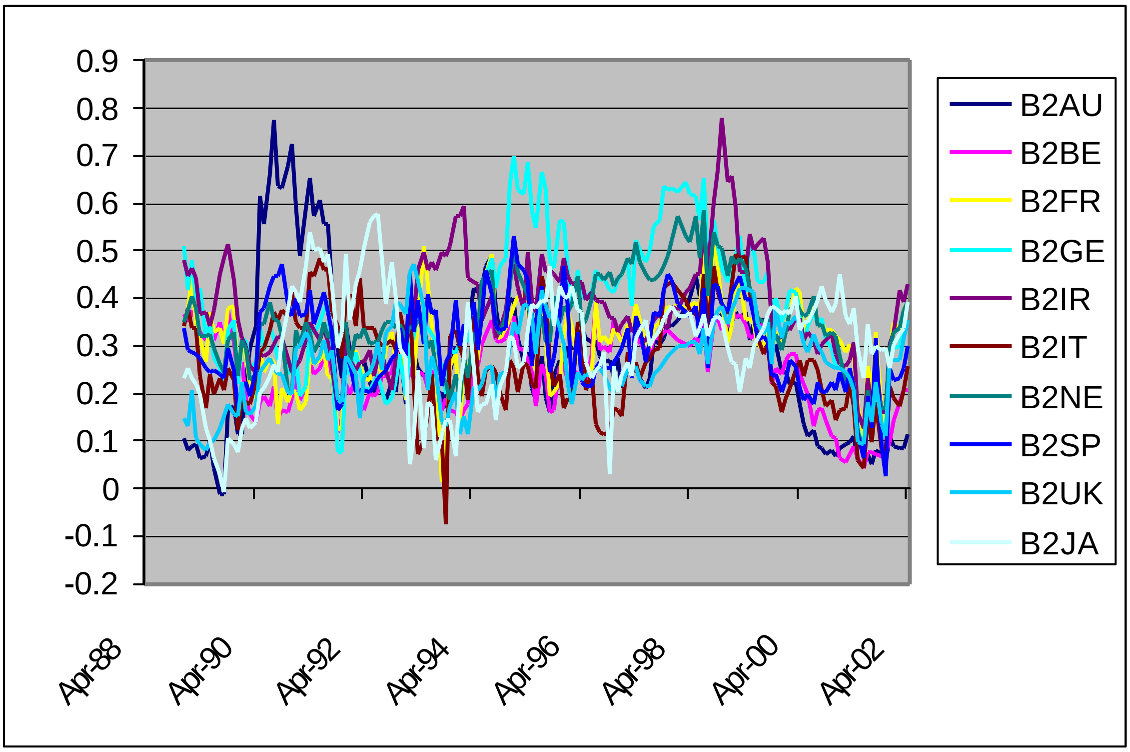


Figure 9: Averages of spillover effect from European return innovations to all industry returns in the euro area, the US, the UK and selected EMU countries, respectively (B1…)

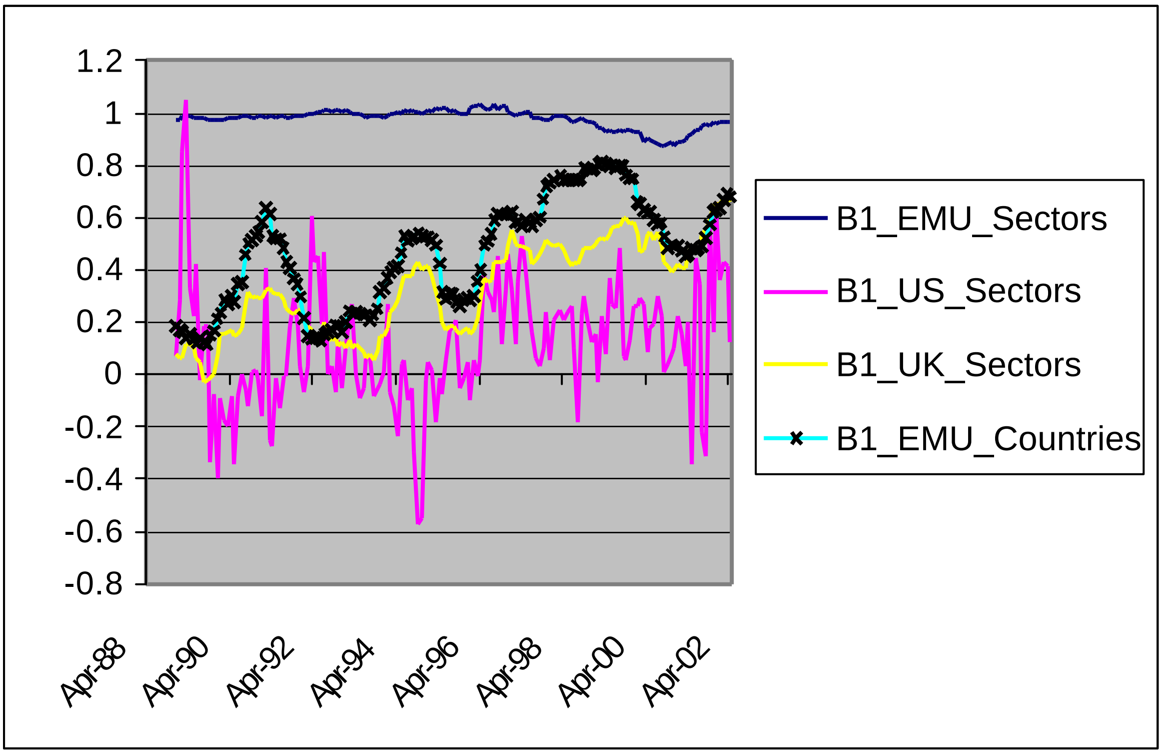


Figure 10: Averages of spillover effect from US return innovations to all industry returns in the euro area, the US, the UK and selected EMU countries, respectively (B2…)

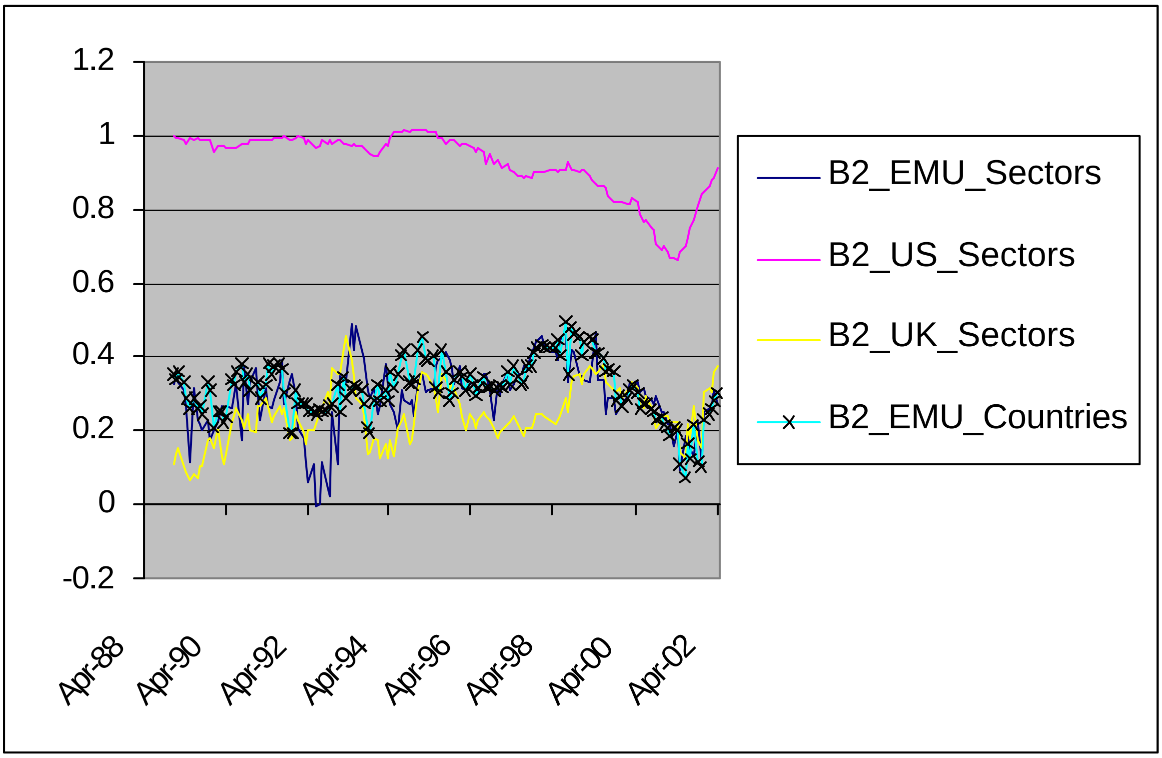


Figure 11: Increasing heterogeneity: Standard deviations of spillover effect from European return innovations to all industry returns in the euro area, the US, the UK and selected EMU countries, respectively (B1…)

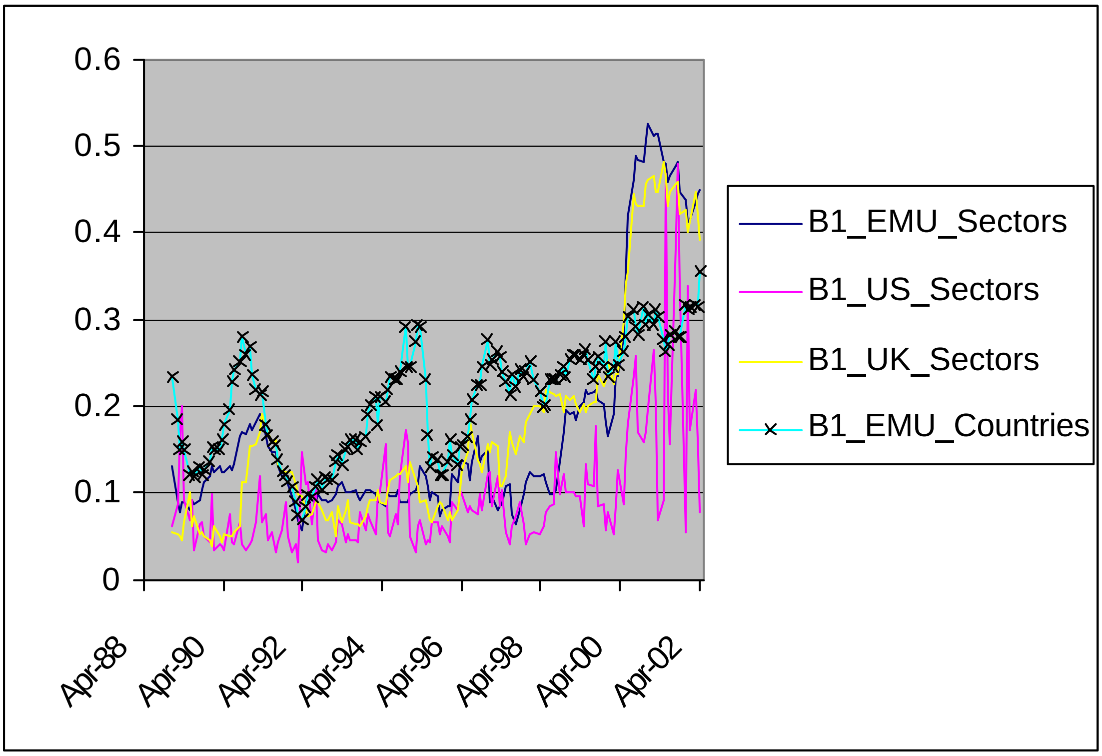


Figure 12: Increasing heterogeneity (2): Standard deviations of spillover effect from US return innovations to all industry returns in the euro area, the US, the UK and selected EMU countries, respectively (B2…)

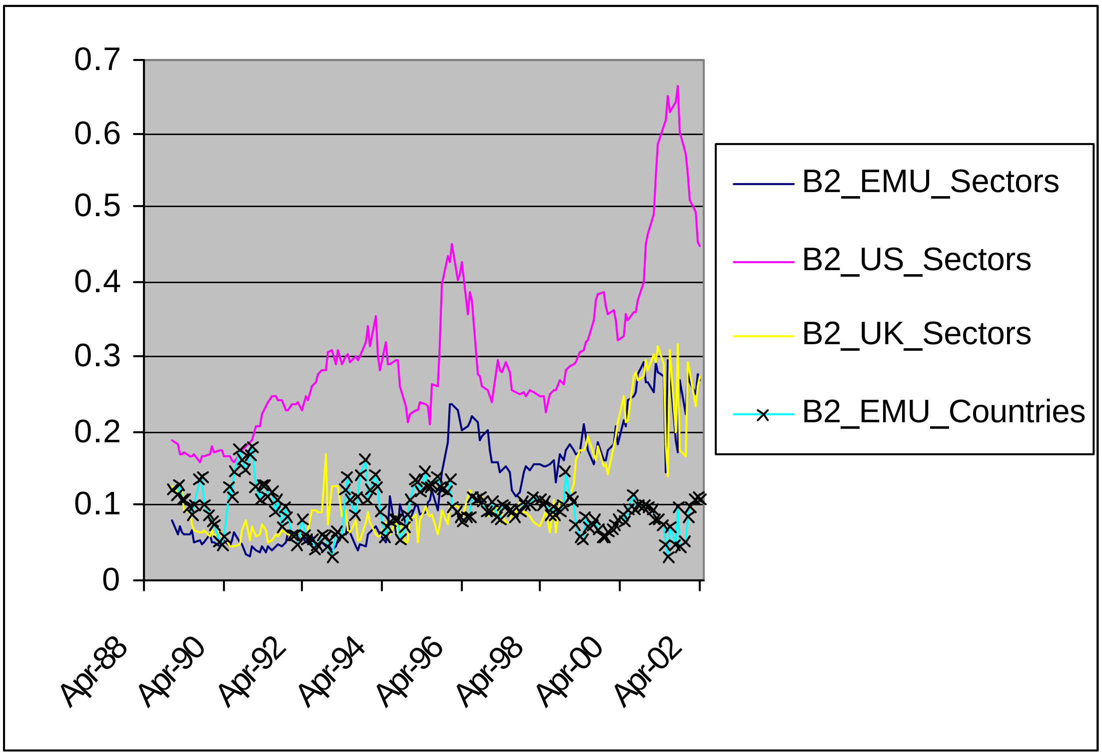


Figure 13: Averages of volatility spillovers from the euro area to all industries in the euro area, the US, the UK and selected EMU countries (VD…)

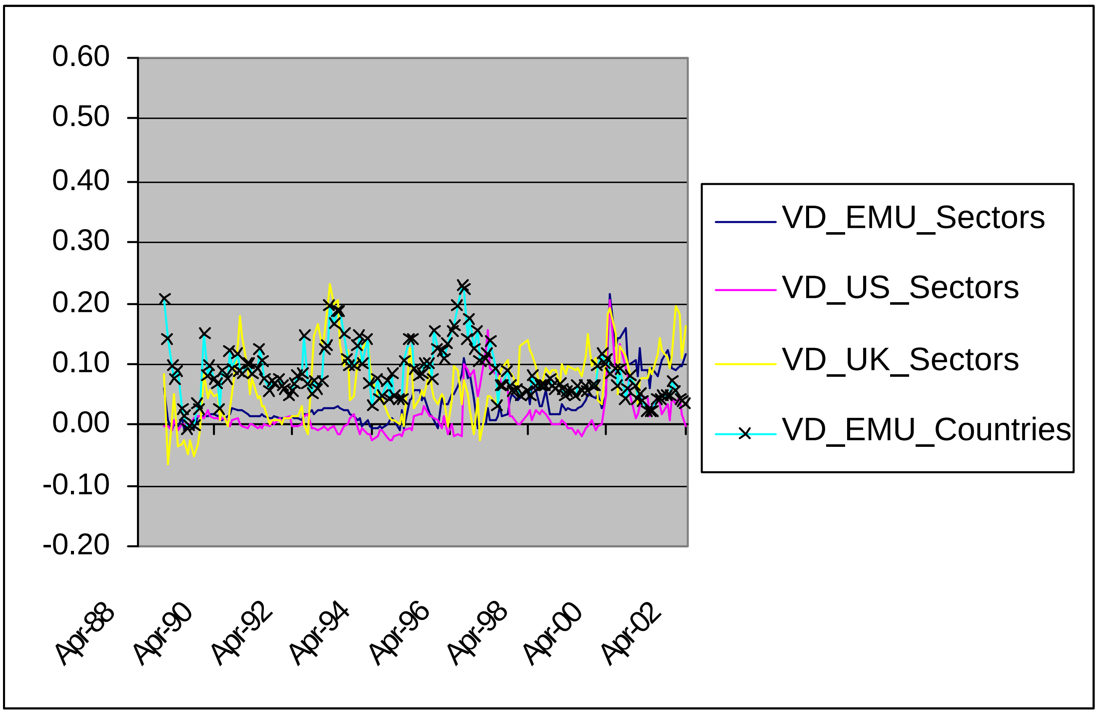


Figure 14: Averages of volatility spillovers from the US to all industries in the euro area, the US, the UK and selected EMU countries (VE…)

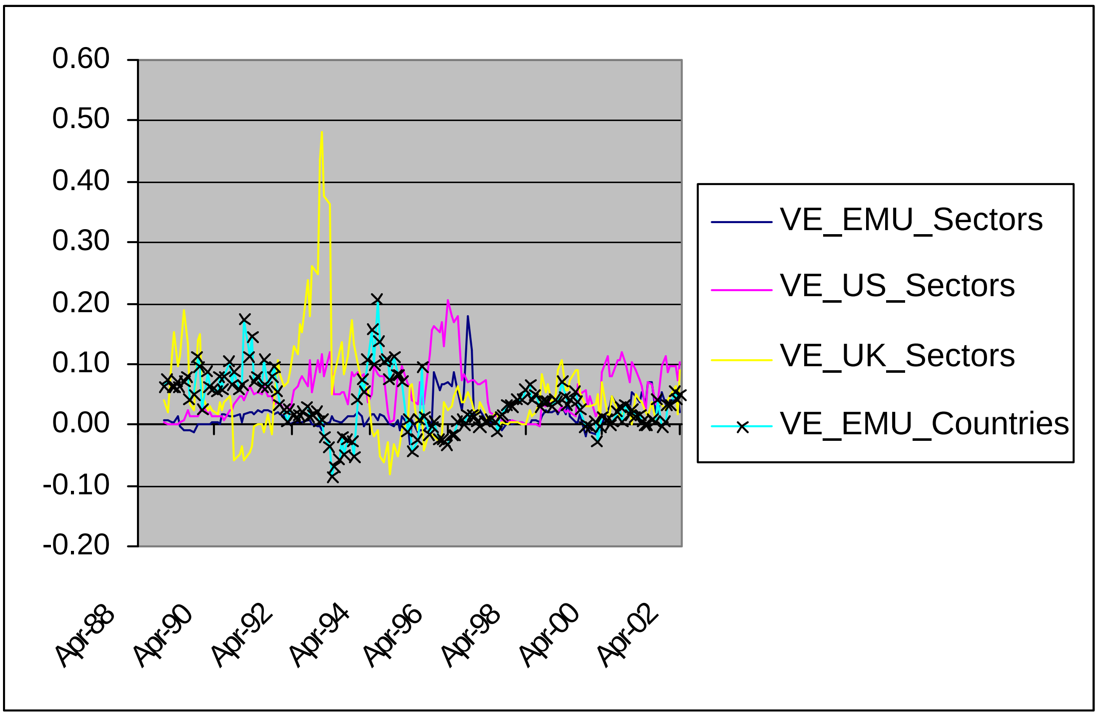


Figure 15: Return spillovers from European return innovations to different European industries (B1…) when the IT sector is excluded from aggregated European and US indices

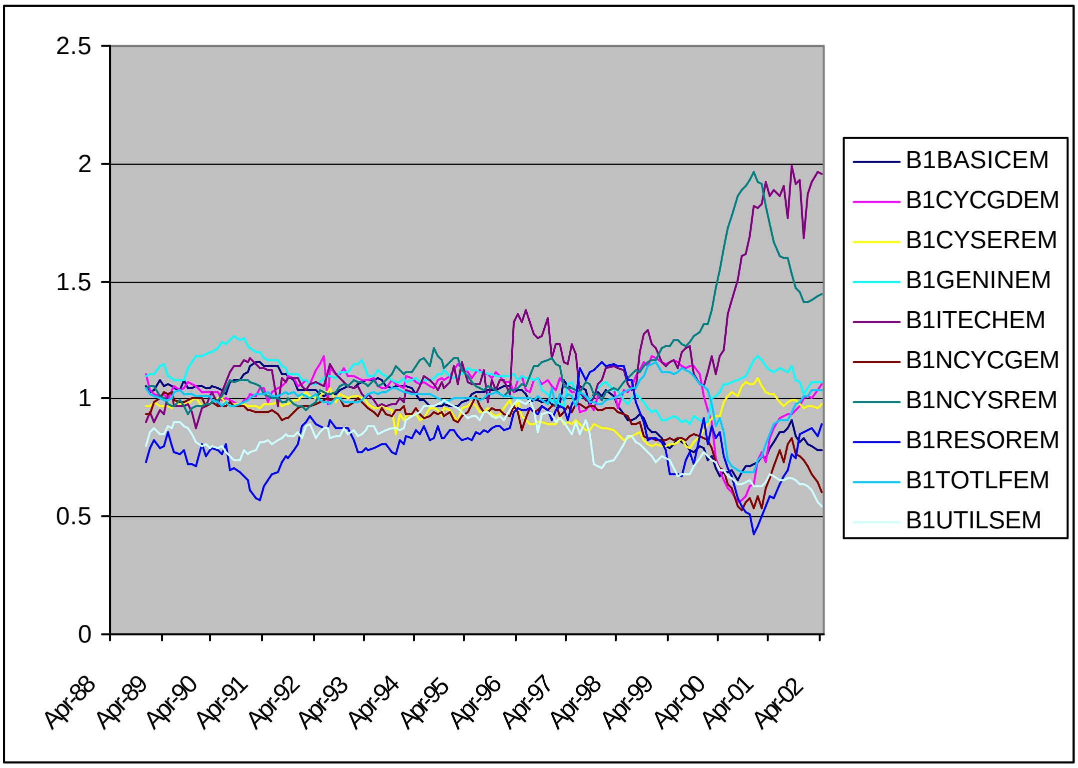


Figure 16: Return spillovers from US return innovations to different European industries (B2…) when the IT sector is excluded from aggregated European and US indices

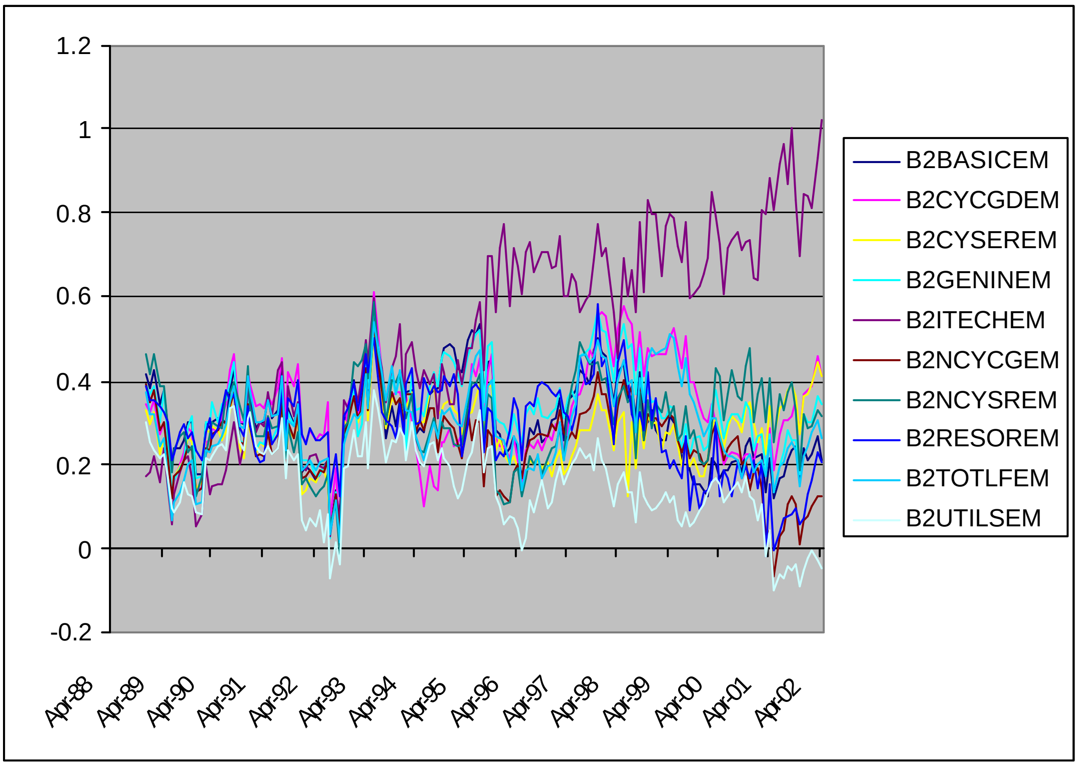


Figure 17: Return spillovers from European return innovations to different US industries (B1…) when the IT sector is excluded from aggregated European and US indices

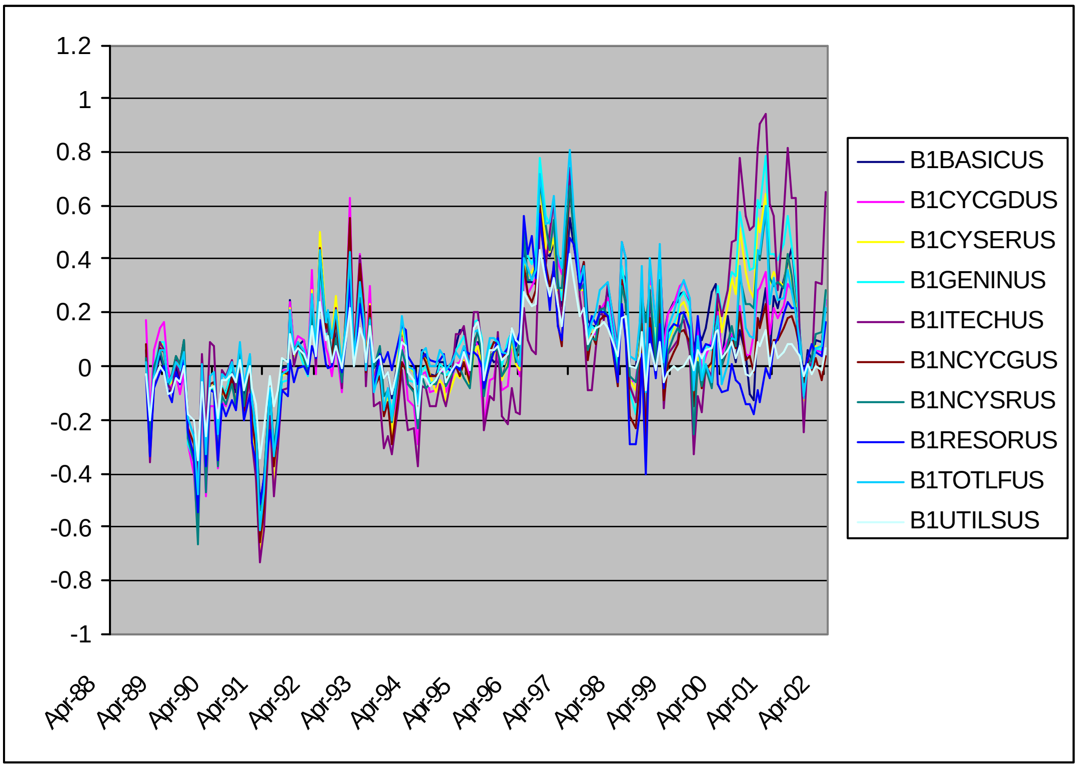


Figure 18: Return spillovers from US return innovations to different US industries (B2…) when the IT sector is excluded from aggregated European and US indices

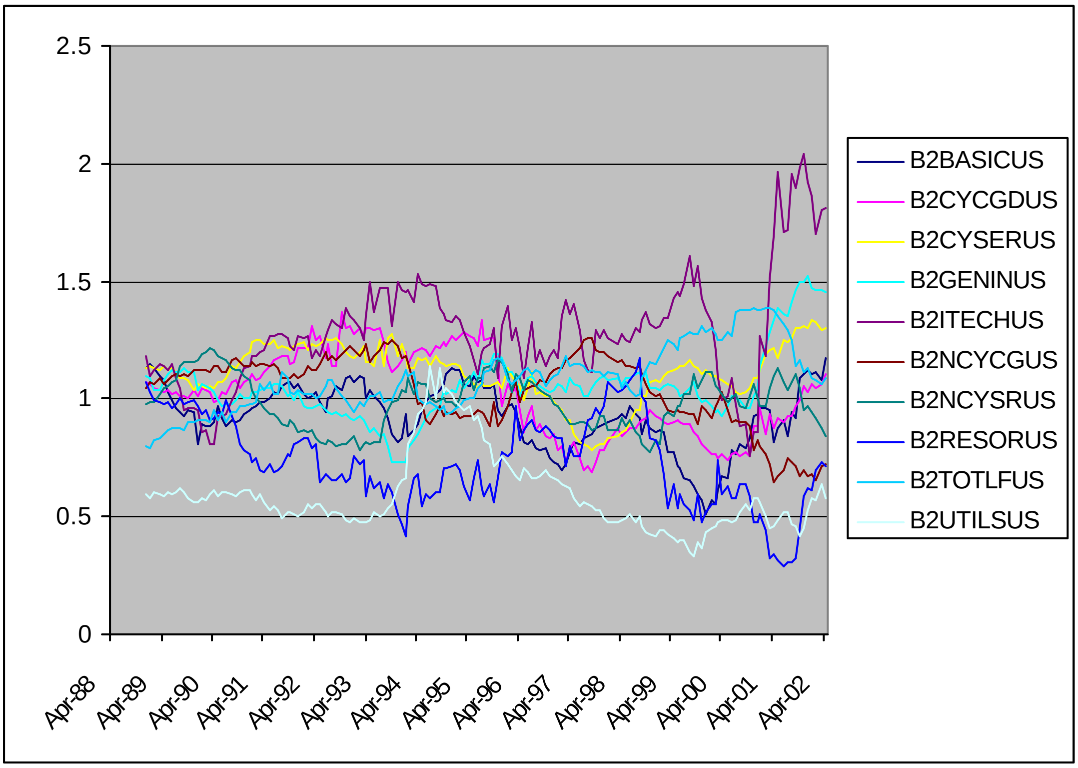


Figure 19: Return spillovers from European return innovations to different UK industries (B1…) when the IT sector is excluded from aggregated European and US indices

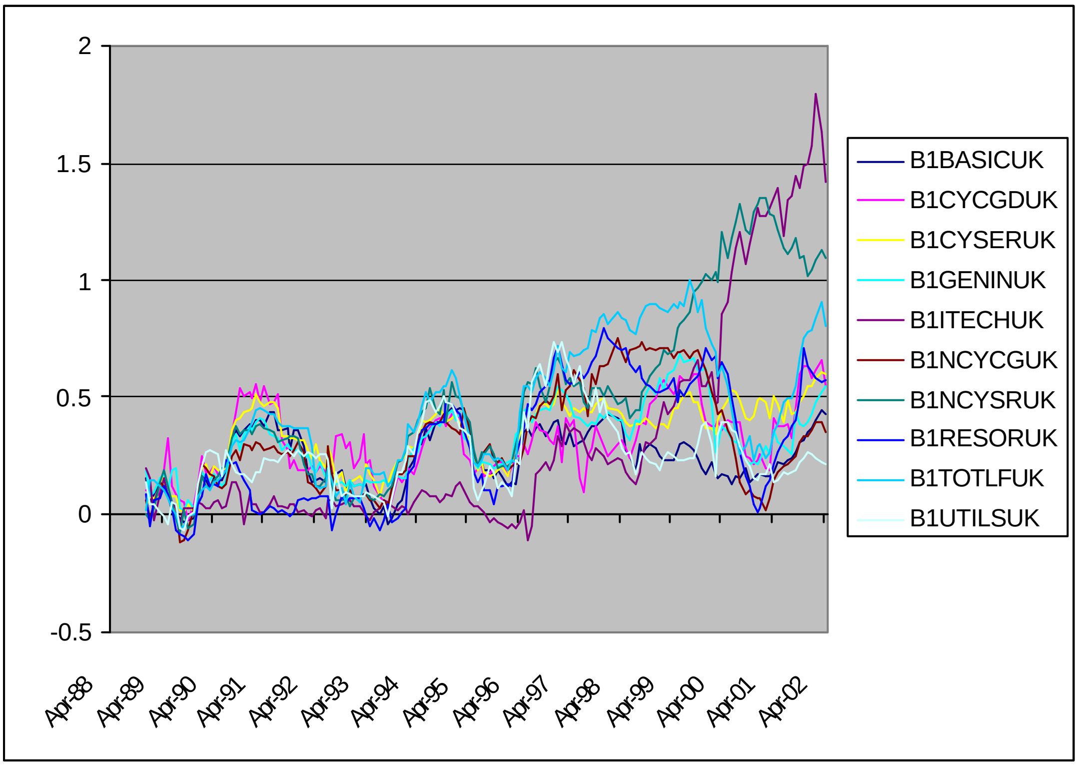


Figure 20: Return spillovers from US return innovations to different UK industries (B2…) when the IT sector is excluded from aggregated European and US indices

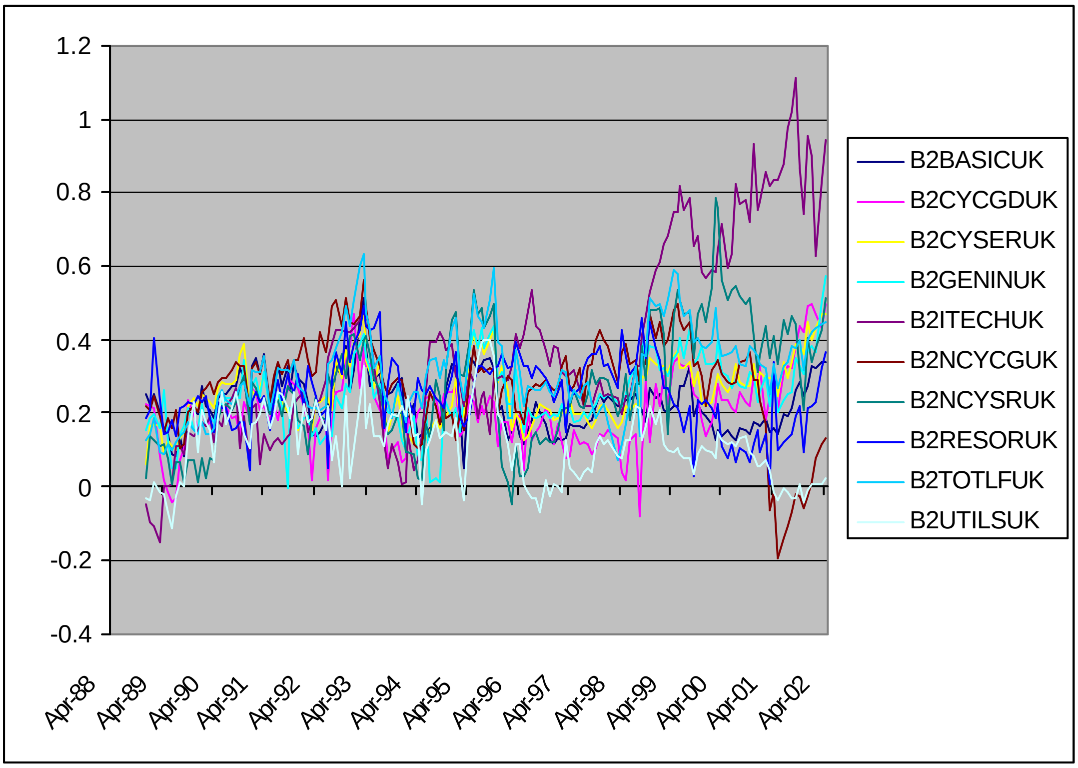


Figure 21: Return spillovers from European return innovations to different countries (B1…) when the IT sector is excluded from aggregated European and US indices

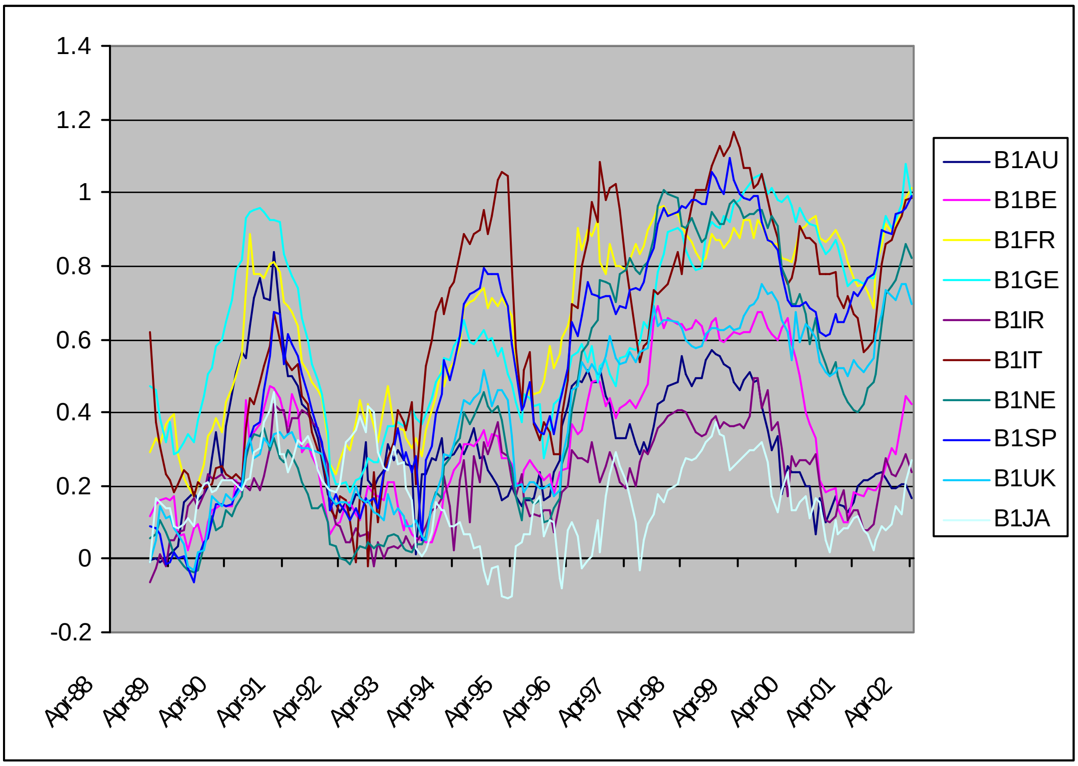


Figure 22: Return spillovers from US return innovations to different countries (B2…) when the IT sector is excluded from aggregated European and US indices

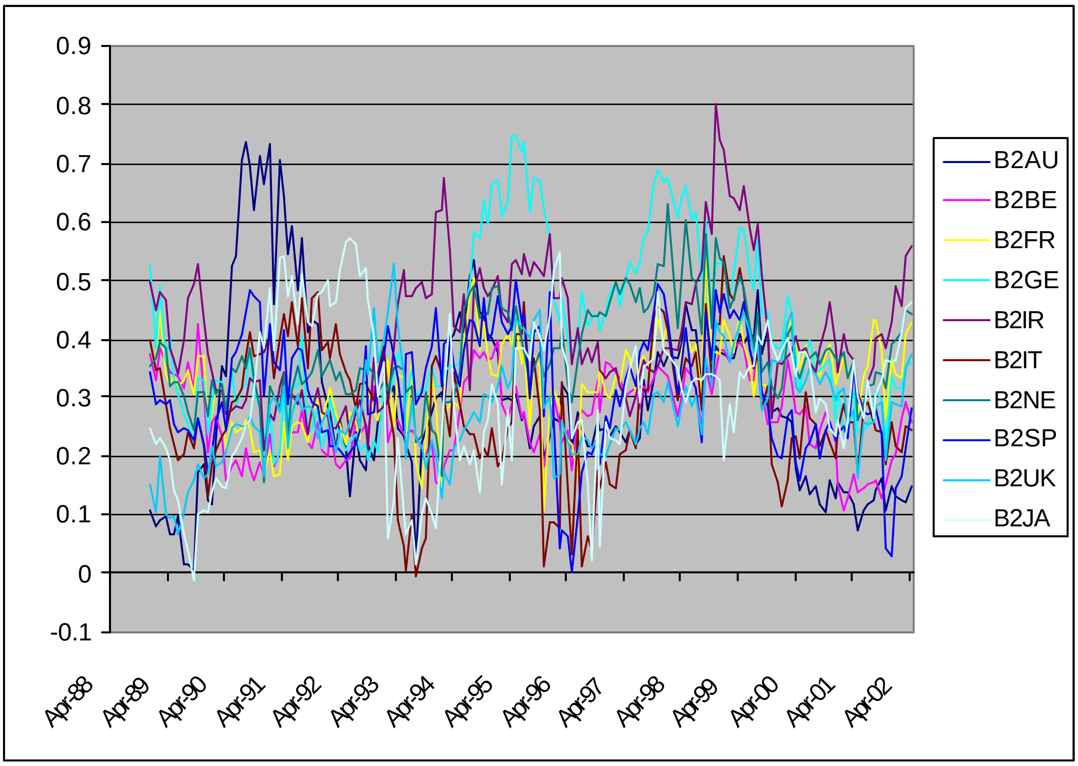


Figure 23: Return spillovers from European return innovations to different European industries (B1…): Averages of the two estimated specifications

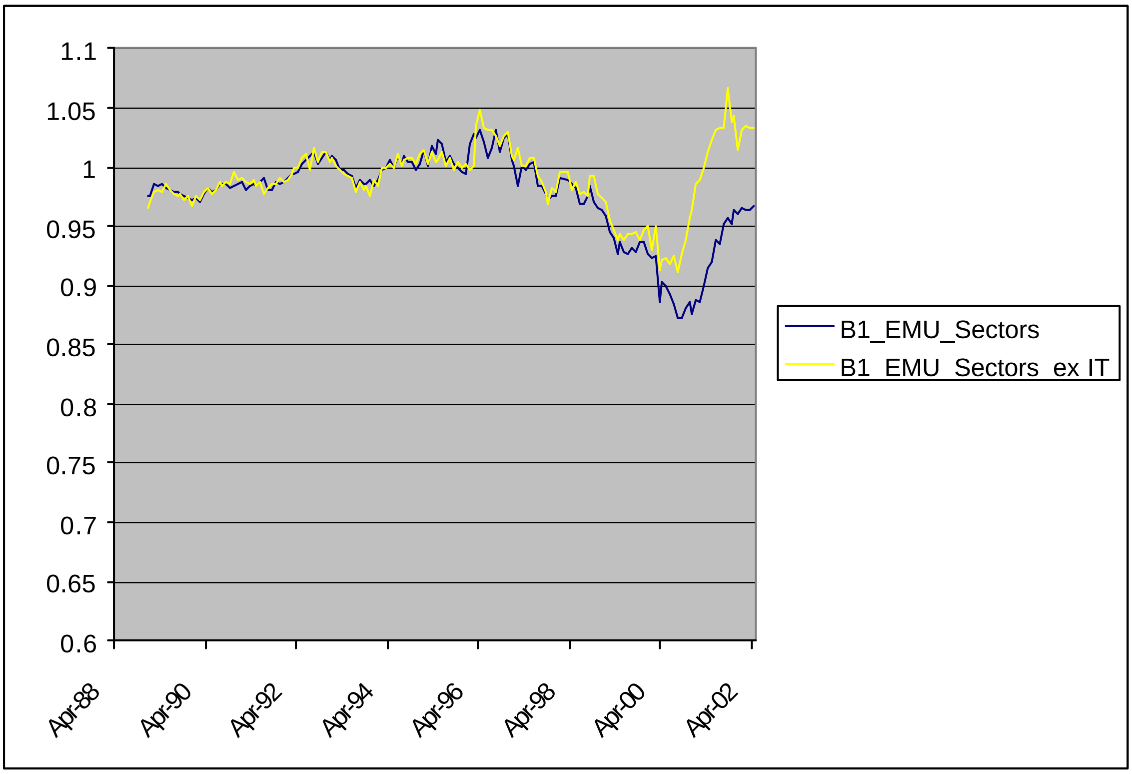


Figure 24: Return spillovers from US return innovations to different European industries (B2…): Averages of the two estimated specifications

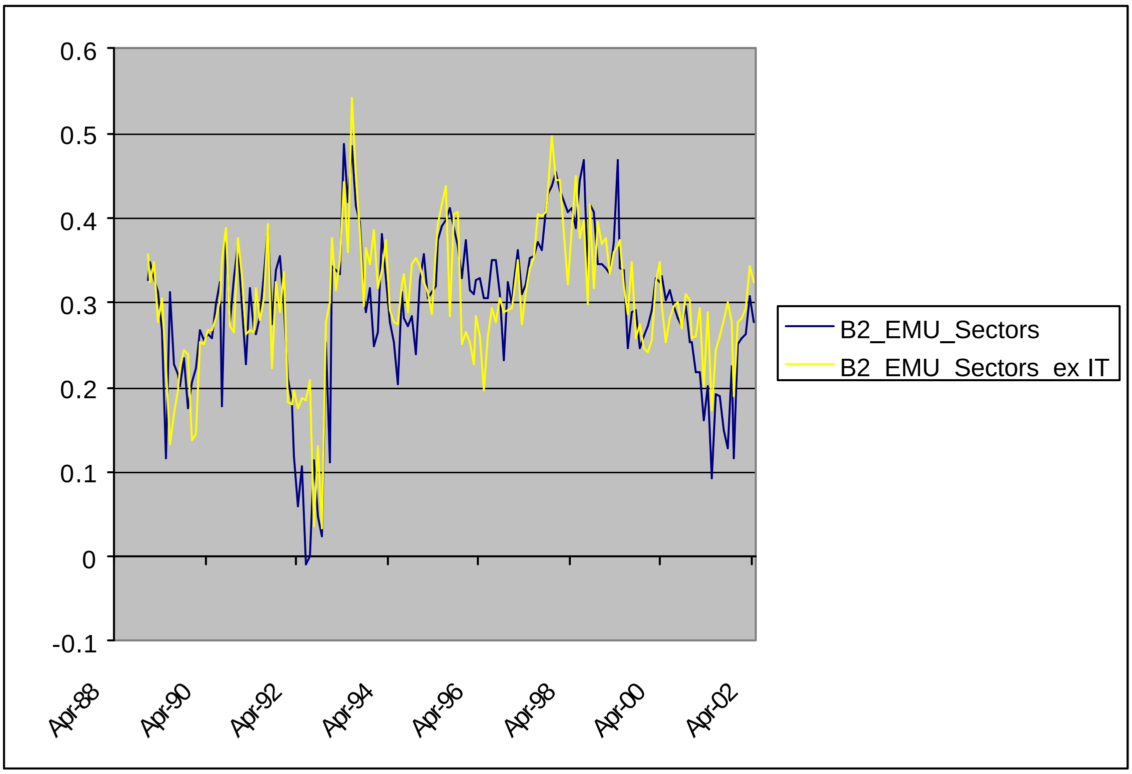


Figure 25: Return spillovers from European return innovations to different US industries (B1…): Averages of the two estimated specifications

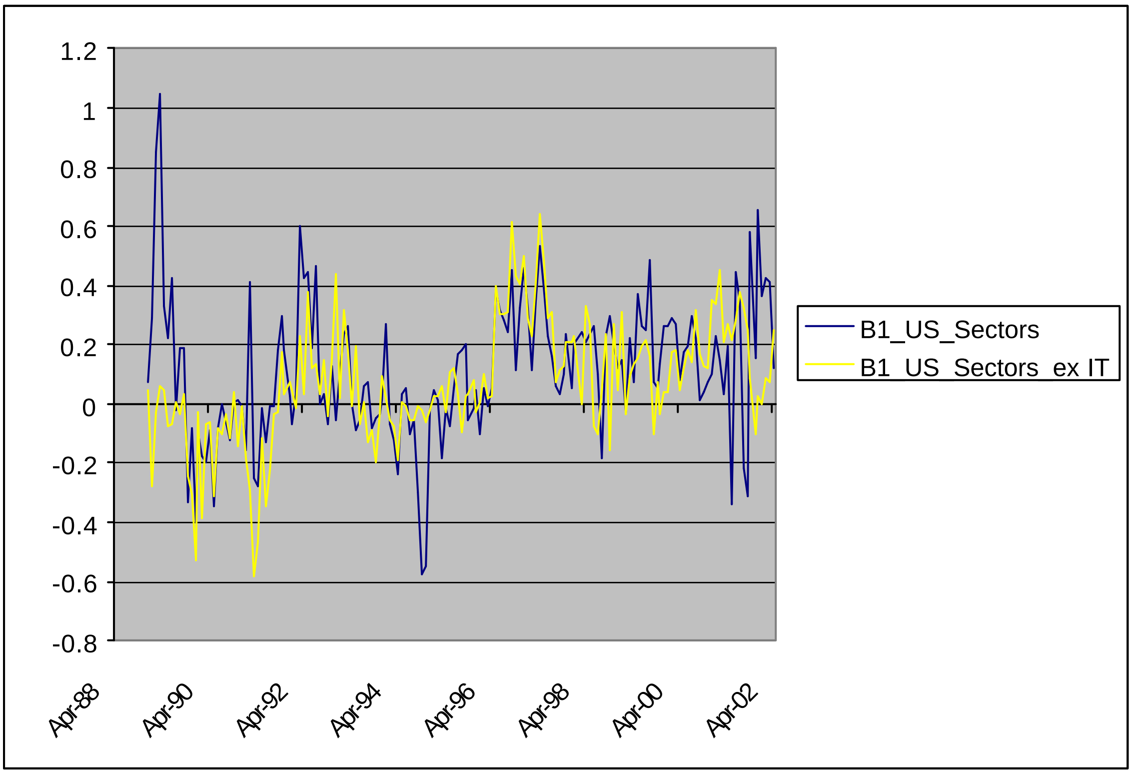


Figure 26: Return spillovers from US return innovations to different US industries (B2…): Averages of the two estimated specifications

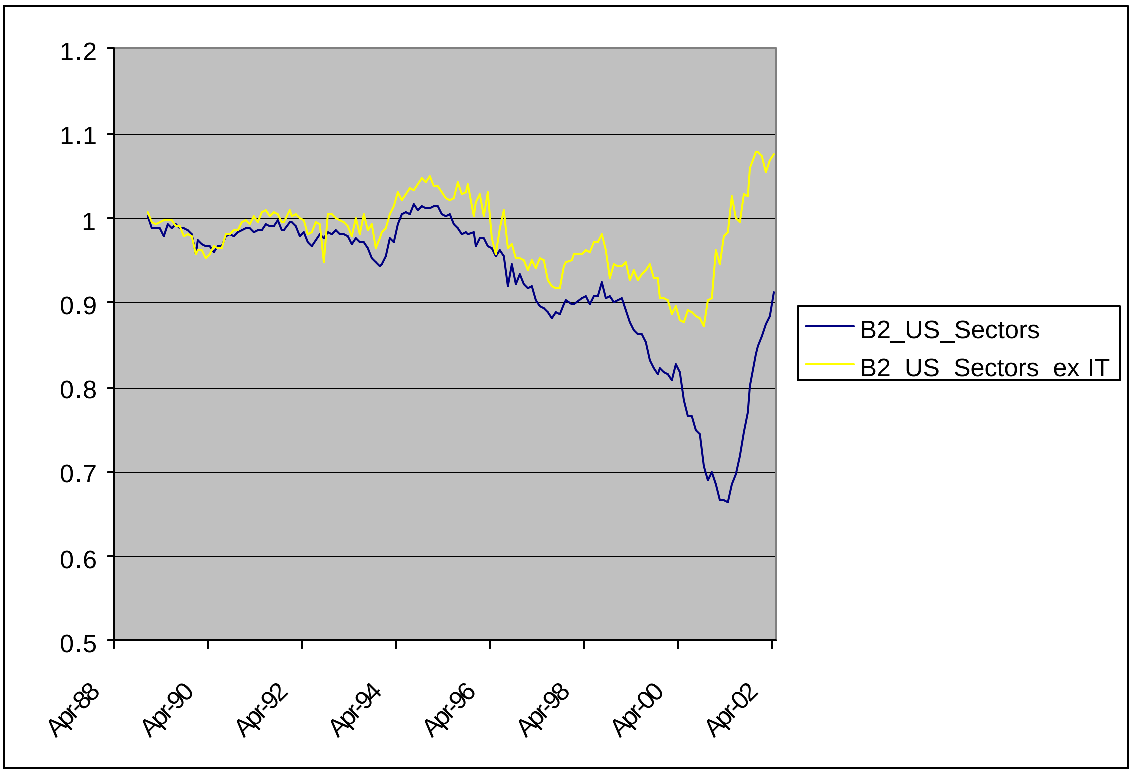


Figure 27: Return spillovers from European return innovations to different UK industries (B1…): Averages of the two estimated specifications

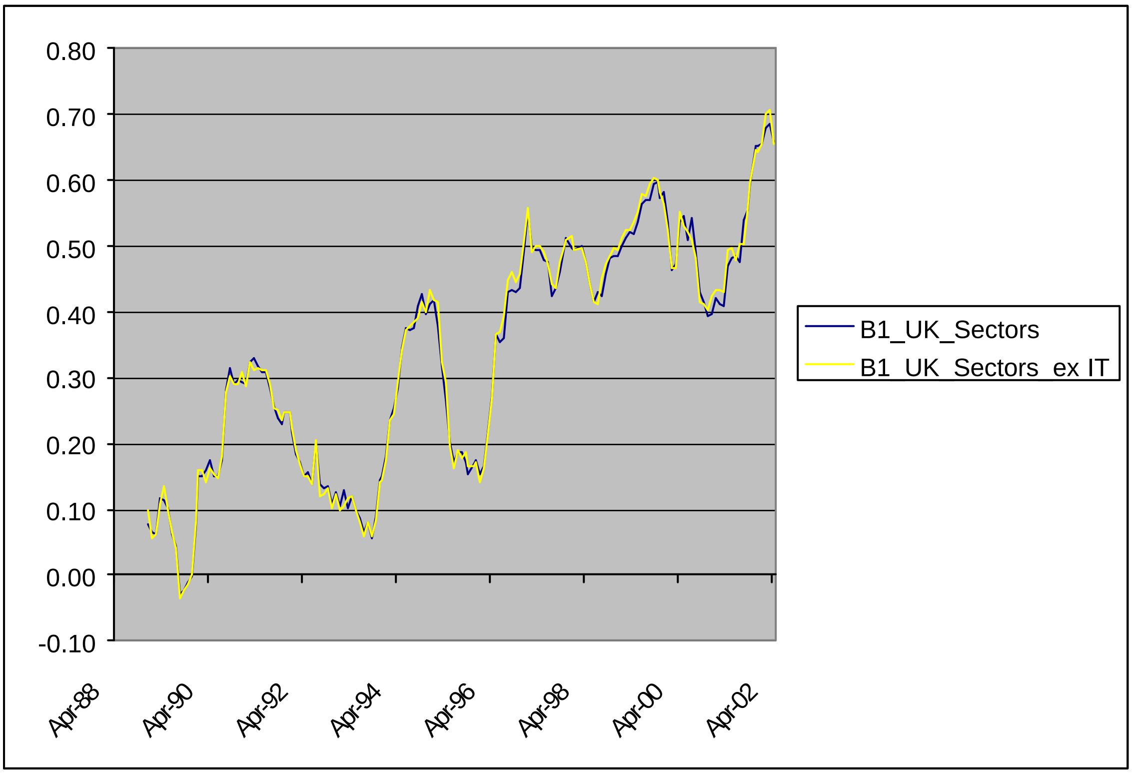


Figure 28: Return spillovers from US return innovations to different UK industries (B2…): Averages of the two estimated specifications

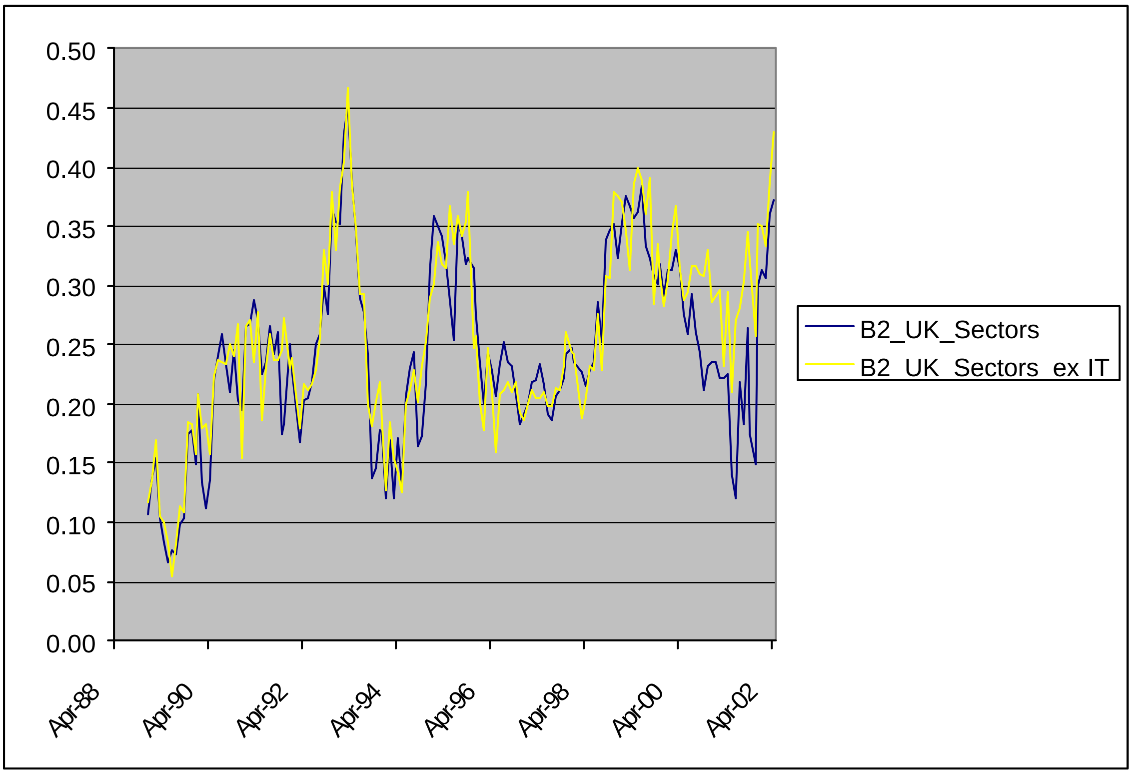


Figure 29: Return spillovers from European return innovations to different countries (B1…): Averages of the two estimated specifications

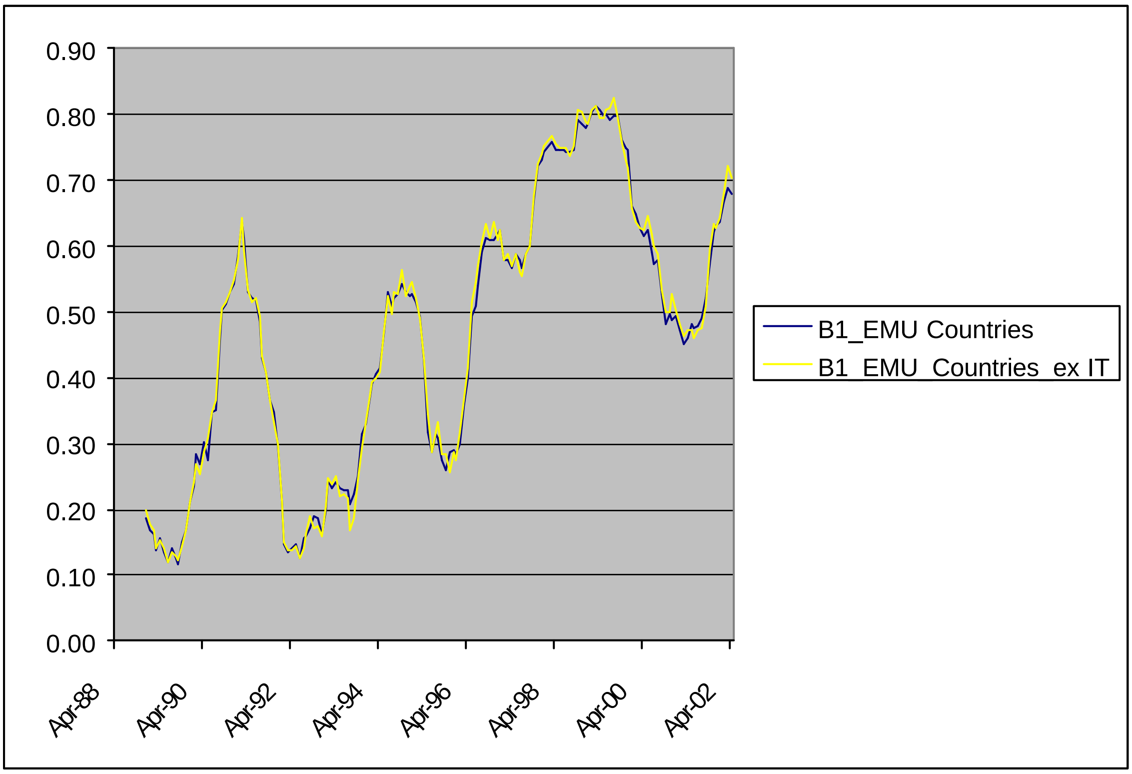
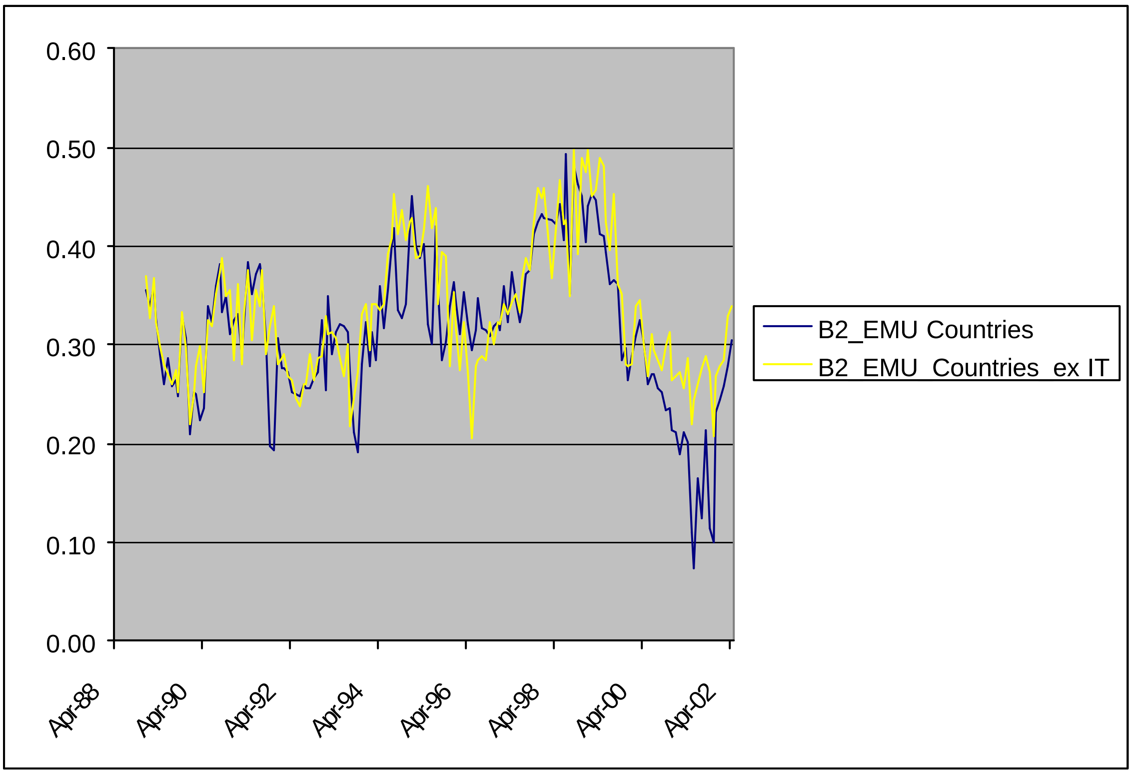


Figure 30: Return spillovers from US return innovations to different countries (B2…): Averages of the two estimated specifications



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