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An empirical analysis of international equity market co-movements: implications for informational efficiency

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Abstract

Relying on the common statement that New York is a leader market in the world, this paper investigates whether the American market drives the performance of other world's stock markets and whether the interdependence becomes higher in periods of economic downturn and poor market performance (asymmetry in stock market co-movements). Results confirm that the behavior of major stock markets in the world is partly explained by co-movements with America's exchange and, more importantly, that there is evidence for an asymmetric behavior. Additionally, estimated results are consistent with the notion of informationally efficient stock markets, as the transmission of news from America to the rest of the world is completed within few days.

JEL Class.: C22, C52, G14, G15
Keywords: International equity markets, univariate GARCH, asymmetry in equity market co-movements, informational efficiency.

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1 Asymmetry in international equity market co-movements: an economic explanation

In recent years, America's stock market has slumped as its economy has slowed dramatically and the American stock exchange seems to be driving the rest of the world's stock markets down with it. In other words, it appears that the US stock market acts as a leader market in the world driving the performance of other world's stock markets.

Traditionally, investors have widely benefited from international diversification. Nowadays, to the contrary, stock markets seem to move more in step with one another and domestic stock markets are driven by global factors rather than by local factors. This implies that, to reduce risk, investors should diversify more by industry than by country[1].
Globalization and developments in information technology have contributed to increase the importance of worldwide factors in determining changes in stock prices and have made international stock markets more correlated[2].
There are some reasons that may explain why economic fundamentals matter less than in the past in determining the behavior of domestic stock markets. First, the reduction of controls on capital mobility has increased cross-border

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[1] Fratzscher (2001) and Adjaouté and Danthine (2002).

[2] The correlation between changes in American and European share prices has risen from 0.4 in the mid-1990's to 0.8 in 2000. "The Economist", March 22nd, 2001.

trading of shares, pushing towards a more globalized equity market. Second, big companies are now listed in more than one market. Third, as a result of mergers and acquisitions, overseas profits account for a bigger part of many companies' overall profits. Fourth, the internet has made it easier for investors to collect information on foreign firms and to compare firms operating within the same sector even though in different countries.

In particular, stock markets seem to disregard of national economic prospects, and to imitate more strongly the American market, in periods of downward economic trend. In the past, American recessions used to affect the rest of the world through trade, while now stock markets represent a more powerful channel to spread financial contagion across countries.

But why are stock markets in the world so badly affected by a recession in the USA and a consequent fall in the American exchange? In other words, why do international stock market linkages tend to be asymmetric, increasing when economic growth is low and market performance poor?

This paper is aimed at addressing this issue, providing some economic explanations and empirically assessing whether or not this evidence is confirmed for major European exchanges, namely London, Frankfurt, Paris and Milan, and for Tokyo[3].

Over the last 15 years, America has been the main driver of the world economy[4].
Many economists believed that America's rapid pace of growth was mainly explained by a large financial and economic bubble and that, once the bubble burst in the late '90s, America's economy would have started to decrease sharply. This would have allowed European countries to catch up with the USA, as their economies were more free from financial imbalances.
America's growth rate has indeed decreased in the late '90s, but growth in the euro area and in Japan has also slowed and consequently the growth gap between America and respectively Europe and Japan has not fallen. In fact, the gap has even widened in very recent years. The euro area performed slightly better than American only in 2001, but since then America's economy has always played the leader. A narrower gap is not only important for Europe and Japan, but for the whole global economy which would benefit from more spread growth.
Why did not the gap narrow as expected?

Before answering this question, we should be aware that America's superior performance might be overestimated, because its population is growing

[3]The USA, Europe and Japan represent the three main economic areas in the world. Hartmann *et al.* (2003).

[4]Morgan Stanley calculates that America has accounted for over three-fifths of global growth since 1995.

faster. Considering GDP growth per head, the gap is generally smaller. Additionally, official numbers may suffer of differences in measurement methodologies. For example, American official statistics use output per man-hour in the non farm business sector to measure productivity, while productivity in the euro area is measured using GDP per worker in the whole economy. This measure includes the public sector, which traditionally has a lower productivity, and ignores the fact that average hours worked have decreased as part-time jobs have increased. Comparing GDP per man-hour for both economies, America's productivity still leads, but with a narrower margin[5].

Whichever measures are used, labor productivity growth has risen over the past decade in America and fallen in Europe[6].
This leads to the first explanation for Europe's inability to catch up with America, since its bubble burst in 2000. Namely, European policymakers argue that labor market reforms have slowed productivity growth in Europe. To make the job market more flexible and promote hiring, European countries have introduced different solutions, such as part-time jobs, temporary contracts, cuts in social security contributions for low-paid jobs, which have increased the number of inexperienced and less qualified workers in the market so depressing productivity growth, at least in the short-run. Deeper reforms are still required and, even though they may have a negative impact in the short run, they cannot be further postponed.

Second, looser fiscal and monetary policies in America have encouraged inspirational levels of consumer spending which has meant that America's economic downturn has been significantly cushioned. Moreover, with the combination of lower mortgage rates and higher house prices, American households have been encouraged to refinance their loans and this has in turn reduced their liquidity constraints. In Europe, even though house prices have risen, it is still too costly to refinance mortgages and sustain consumer spending like the Americans. Clearly, America's desire to rely on consumer spending to drive the economy is good in the short run but in the long run American consumers might suffer financial imbalances and sharply reduce their spending. This is particularly possible if a shock to employment or house prices force consumers to realize their inability to pay their debts.

Third, American companies have recently been helped by a weaker dollar which has increased their exports and profits while reducing trading partners' exports and profits. Europe is indeed one of the larger trading partners with America and a fall of the dollar against the euro has meant degradation in

[5]In the five years to 2000, for example, GDP per worker rose by an annual average of 2.5% in the USA and by just 1.2% in the euro area. GDP per hour worked, instead, rose by 2.1% in America and by 1.6% in the euro area. "The Economist", November 8th, 2001.

[6]"The Economist", November 14th, 2002.

Europe's net exports.

Fourth, while in America the investment boom has been financed through bonds and equities, in the euro zone banks have played the dominant role in lending, resulting in significantly less efficient spreading of risks. Again, this has helped to contain the negative impact of the downturn in America.

Fifth, Europe and Japan are directly exposed to American economic and financial events in several ways.
Many large European companies, for example, are exposed to demand in America. The American recession has squeezed overseas sales consequently having negative impacts on European growth.
East Asian economies are instead exposed to America's recession through the fall in information technology (IT) spending. Indeed, they are big IT producers and, for a while, they have enjoyed America's boom in IT spending. But now, the same economies are tremendously suffering for the fact that America's spending in IT has sharply decreased.
The fact that European investors have widely financed America's investment boom provides another direct source of exposure. As European markets have not been sustained by economic fundamentals as much as the USA exchange[7], European investors have rather invested in America, benefiting from free capital mobility. Therefore, in periods of boom, the USA stock market has performed better than European exchanges in attracting capital. This 'capital flight' from Europe to America signals the main economic difference between Europe and America. While America has benefited from attracting capital from overseas to boost investment and spread risk, Europe has foregone possible investment at home to, instead, invest in America's high return exchanges. It is true that European investors have benefited from higher returns on their capital, therefore improving their spending, but investment, the absolutely crucial element in all macroeconomic growth theory, has vastly diminished in Europe.
Then, when America's shares have started to plunge, European investors have started to suffer losses, which have partly eroded their spending capability and indirectly Europe's growth. Relying on the traditional assumption of risk aversion, and on the fact that stock markets are today much more correlated than in the past, it is reasonable to think that investors have started to sell both their American and European share holdings, causing a plunge of European shares also. Indeed, when America suffers significant falls in

[7]Some economists argue that the performance of European stock markets in periods of boom is more explained by an optimistic feeling 'imported' from overseas than by domestic fundamentals. Therefore, in periods of recession, they are not able to sustain an autonomous growth and they tend to completely share in America's downturn. IRS (2002).

growth, Europe's consumer spending is hit and the European market, that is by now under invested in, finds it difficult to cope.
Consequently, while Europe has failed to share with America the economic growth of the last years and European stock markets have not been as crucial as the USA exchange to promote growth[8], they have shown high dependence from the American exchange in periods of recession, sharing the economic downturn.

To sum up, we can say that, over the last decade, the world economy has relied too much upon America and that Europe and Japan have so far failed to narrow the growth gap with America. This is due to the fact that America has been able to contain its recession and in the meanwhile growth has also slowed in Europe and Japan for different reasons. Therefore, while in boom America has grown more than both Europe and Japan, in recession the three economies have all fallen moving more in step with one another.
As the economy has slowed dramatically, also stock markets have started to slump. Therefore, relying on the assumption that changes in equity prices reflect short run expected economic growth, we empirically assess whether main world stock markets show indeed stronger interdependence with the US exchange in periods of combined poor market performance.
As previously anticipated, our analysis refers to major European exchanges, London, Frankfurt, Paris and Milan, and to Japan and covers the period January 1, 1990, through February 21, 2003, which broadly corresponds to the economic cycle analyzed in this section.

2 Graphical evidence for asymmetry

Before formally testing for the asymmetric behavior of international equity market co-movements, we provide a graphical analysis targeted at observing to what extent co-movements exist and to what extent they vary. For this graphical analysis, we use the time series of the daily price index for each market, i.e. Dow Jones for America, FTSE100 for UK, DAX30 for Germany, CAC40 for France, Mibtel for Italy and NIKKEI225 for Japan. Data are expressed in domestic currencies.
We use daily data because they seem to better capture the existence of possible interactions. Indeed, according to Eun and Shim (1989), "a month or even a week may be long enough to obscure interactions that may last only

[8]It has been calculated that, in the five years before 2000, given the same performance of stock markets the American cycle has shown a three time superior growth path than the European one. IRS (2002).

for a few days[9]".

Figure 1, for example, plots the Dow Jones index and the FTSE100. We clearly observe that the two price index series tend to move together over the period 1990-2003. However, to support our hypothesis of asymmetry in international equity market linkages, it is crucial to check whether the two series co-move more when both the two markets are performing badly. Broadly speaking, a poor performance is defined by $(P_2 - P_1)/P_1 < 0$, i.e. by a negative return index. To observe this aspect, we restrict the analysis to a narrower period, namely the one delimited by a circle in figure 1. In figure 2, referred to the period 1998-2000, we are able to observe that a sharp fall in the US market is fully shared by the UK market while a sharp rise in the US market is not shared by the UK market with the same intensity. The arrows in figure 2 are used to capture this behavior. The downward slope of the arrows, corresponding to a fall in the markets, is indeed almost the same for both US and UK, while the upward slope of the arrows, corresponding to a rise in the markets, is different. Indeed, the arrow is steeper for America than for UK.

The evidence for asymmetry is confirmed when considering the co-movements between the Dow Jones index and the DAX30. As we can observe in figure 3, the two series tend to move in the same direction over the period of our interest. Additionally, figure 4, which focuses on the sub-period depicted by the circle line in figure 3, shows that downside co-movements are stronger than upside. Again, the interpretation is that a sharp fall in the US market is shared by the German market while a rise does not happen with the same strength in the two markets. Besides the explanations provided in section 1, this observation is supported by a recent statement of the OECD saying Europe, in general, has fully shared in the downturn of the American market while only slightly prospering from its previous boom.

Turning our attention to pair co-movements between America and France, we find that also in this case our hypothesis is not contradicted by the graphical evidence. Figure 5 plots the the two series over the 12 years, while figure 6, referred to the period 1998-2000, confirms the strength of downside co-movements relative to upside co-movements.

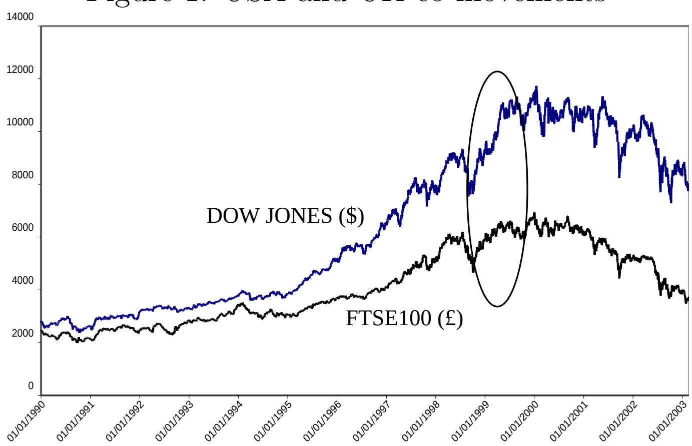
From figure 7, referred to cross-border linkages between America and Italy, it appears that, in general, the Italian market tends to imitate the performance of the USA exchange and that when the US market is performing poorly the Italian market falls as well, confirming that downside linkages are quite strong.

The case of Japan, instead, is peculiar because the Dow Jones and the

[9] Eun and Shim (1989), p. 242.

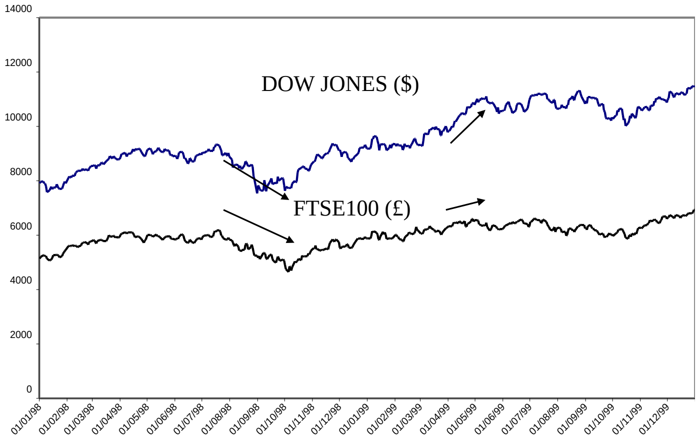
Nikkei225 do not move together in the first half of the sample period, namely from 1990 through 1997. A plausible explanation could be the dramatic independent growth experienced by Asian stock markets, included Japan. Indeed, those years witnessed an extraordinary performance of the so called Asian tigers which is not comparable to the performance of any other country. After 1997, namely after the Asian financial and currency crisis, the two series start to move together showing, in line with the evidence observed for the other countries, stronger downside correlation.
Hence, the case of Japan is interesting because it seems to support two assumptions we have made. First, effects are mono-directional, i.e. Asia did not manage to sink the world into recession with it and America only suffered a little. Second, Asia follows America stronger during periods of bad performance. Although not conclusive, this graphical analysis provides some evidence for our hypothesis that cross-border linkages between respectively European stock markets and Tokyo stock market with America are generally higher when America falls into recession and its stock market slumps. Therefore, we feel encouraged to continue our analysis and test more formally for our hypothesis.

Figure 1: USA and UK co-movements



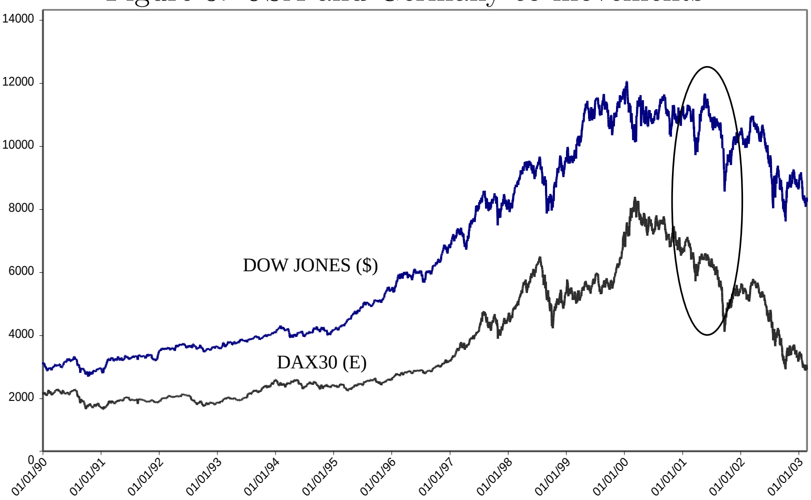
Comments: The figure plots the time series of the daily price index for the USA and the UK, over the period 1990-2003. The two series are expressed in domestic currencies. The circle delimits the period 1998-2000, plotted in figure 2.

Figure 2: Asymmetric behavior for USA and UK



Comments: The figure plots the Dow Jones index and the FTSE100 over the period 1998-2000. The arrows are aimed at capturing the asymmetric behavior of cross-border linkages, showing that a fall in the US market is fully shared by the UK, while a rise in America's exchange is not shared with the same intensity by the UK market.

Figure 3: USA and Germany co-movements



Comments: The figure plots the time series of the daily price index for the USA and Germany, over the period 1990-2003. The two series are expressed in domestic currencies.

Figure 4: Asymmetric behavior for USA and Germany

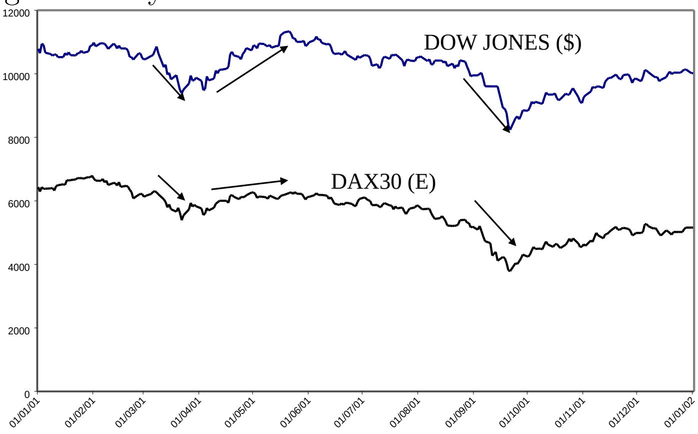
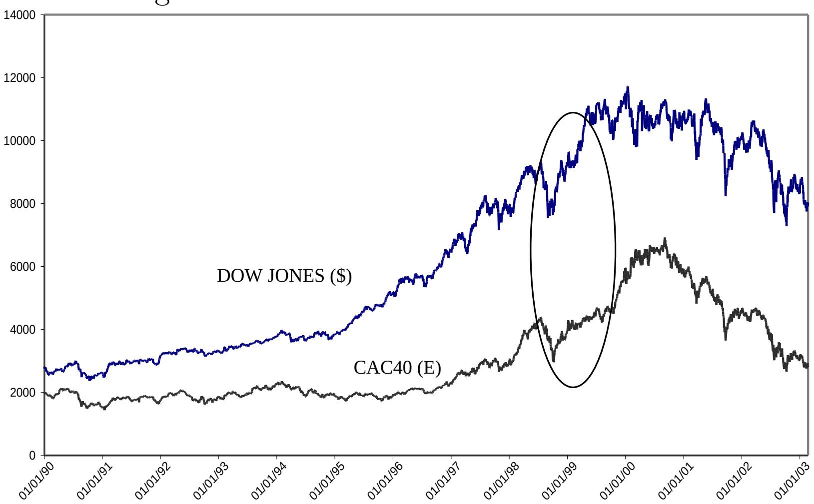


Figure 5: USA and France co-movements



Comments: The figure plots the time series of the daily price index for the USA and France, over the period 1990-2003. The two series are expressed in domestic currencies.

Figure 6: Asymmetric behavior for USA and France

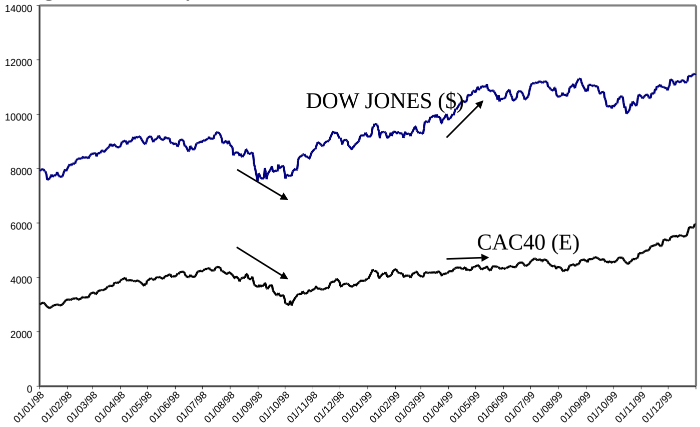
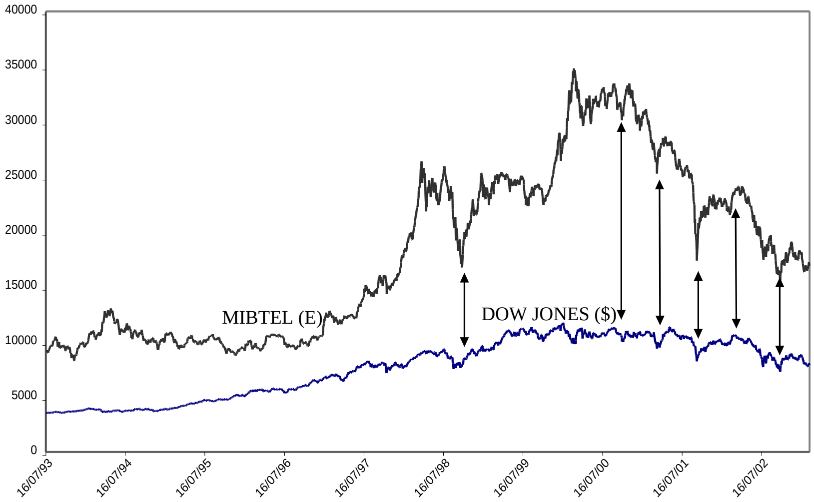
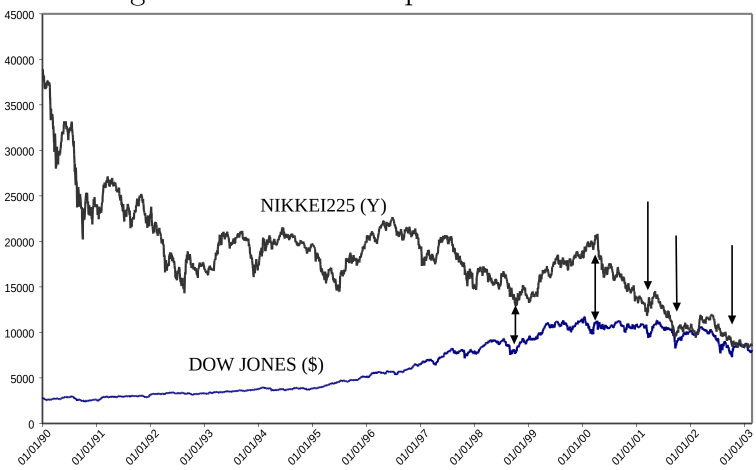


Figure 7: USA and Italy co-movements



Comments: The figure plots the time series of the daily price index for the USA and Italy, over the period 1990-2003. The two series are expressed in domestic currencies.

Figure 8: USA and Japan co-movements



Comments: The figure plots the time series of the daily price index for the USA and Japan, over the period 1990-2003. The two series are expressed in domestic currencies.

3 Econometric model for asymmetry

3.1 The theoretic model

The rationale behind the econometric model is coherent with the idea of asymmetry in cross-border equity market co-movements presented in section 1. Namely, relying on the common statement and evidence that New York is a leader market in the world, we want to assess whether a fall in this market drives the rest of the world's markets down with it. This should cause other world's markets to react more strongly to changes in the US stock market and subsequently imply that cross-border linkages are higher when the stock markets of each pair of countries (America and respectively each other country included in our analysis) are performing badly. Therefore, our model does not consider the eventuality that other world's markets may affect the behavior of the US exchange. In fact, we do not know a priori whether the American exchange is in turn affected by news arising from other markets, as it acts as an 'intermediary of news'. However, such an eventuality does not entail a problem of endogeneity as all the variables we use are predetermined. Moreover, we can refer to previous works which have already dealt with the problem. Eun and Shim (1989), for example, estimate a nine market VAR model to observe whether multilateral interactions exist. Their results strongly indicate that the US market is, by far, the most influential in the world. Indeed, innovations in the US market are rapidly transmitted to other markets in a clearly recognized pattern, whereas no single foreign market can significantly explain the US market movements.

In financial economics, ARCH and GARCH (General Autoregressive Conditional Heteroskedasticity)[10] type models are often used to specify residuals of financial time-series such as exchange rates and stock market returns. These models are indeed designed to capture the volatility clustering which is often observed in those series. Therefore, imposing a GARCH(1,1) structure on the conditional variances, we are able to use a model that better suits the characteristics of our series.
Consequently, we estimate, for each pair of countries, a regression equation with residuals specified, in the most general case, by a GARCH(1,1) model. An important limitation of the traditional symmetric GARCH process is that, although it captures volatility clustering, it does not allow negative and positive past shocks to have a different effect on future conditional second moments. In other words, only the magnitude, not the sign of lagged innovations determines conditional variance. To capture the asymmetric responses of conditional second moments, different versions of the traditional GARCH model have been proposed[11]. In our analysis, we consider different possibilities, and try to adopt the most suitable GARCH type for each model we estimate.

A general representation of our model is suggested by the following equations:

$$R_t^y = \alpha + \sum_{i=1}^{m} \gamma_i R_{t-i}^y + \sum_{j=0}^{n} \beta_j R_{t-j}^{USA} + \sum_{j=0}^{n} \delta_j D1^y R_{t-j}^{USA} + \epsilon_t \tag{1}$$

$$h_{y,t} = a + b\epsilon_{t-1}^2 + c h_{y,t-1} \tag{2}$$

where equation 2 is the GARCH(1,1) model and $h_{y,t}$ is the time-varying conditional variance of the return series. The coefficients b and c capture respectively the ARCH and GARCH effect and their significance indicate successful elimination of heteroskedasticity. Moreover, stationarity of the GARCH(1,1) model is imposed through the condition $b + c < 1$.

R_t^{USA} is the daily percentage return of the Dow Jones index and R_t^y is the same variable referred to the other country considered in the model, UK for example, as we are analyzing pair co-movements. The model also includes an autoregressive part, R_{t-i}^y. The correct number of lags for each variable is determined, when estimating the equations, through a 'General to Simple'

[10] Engle (1982) and Bollerslev (1986).

[11] Asymmetric Power ARCH (APARCH) and Exponential GARCH (EGARCH) just to mention some of them.

approach and the Portmanteau statistics provides a guide to the presence of autocorrelation.
The estimated coefficient β measures the change in the mean of country y stock returns when US stock returns change by 1 unit.
$D1^y R_t^{USA}$ is instead a multiplicative dummy variable and is used to capture the asymmetric behavior of return co-movements. The first step to create the variable is to build the dummy $D1^y$ which takes the value of 1 when returns are below average in both the USA and the other given country (down-down case) and 0 otherwise[12]. In this way, we obtain five dummies called $D1^{UK}$, $D1^{GER}$, $D1^{FR}$, $D1^{IT}$ and $D1^{JAP}$.
We are aware that choosing the average to distinguish between up and down situations, we risk to associate a bad performance to periods in which returns are below the average but still high. For example, the daily average for the series R_t^{USA} is 0.036%, which corresponds to an annual compound return of 9.4%. This latter is calculated using the following expression: $r_a = (1 + r_d)^{250} - 1$, where r_a is the annual return and r_d the daily one. Moreover, we assume a working year of 250 days. In other words, we are saying that the US market is down when returns are below the annual average return of 9.4%, which is quite high. A possible way out is to consider a different bound, say a risk- free rate of return which can be taken as a benchmark for the market. As risk averse investors expect to earn more investing in stocks than in risk-free assets, bonds for example, it sounds reasonable to associate a bad performance to periods which show returns below this benchmark. We could therefore consider series of risk-free rate of returns for each country included in our analysis and calculate the corresponding average. In fact, we have tried to follow this procedure and observed that these averages are quite high for the period we consider, sometimes even higher than the annual compound rate for equities calculated as explained before. Additionally, risk-free rates of returns ignore the risk premium required by investors for holding risky assets, which can be quite high.
Given these considerations, we are comfortable in using our D1 dummy variables to build the multiplicative dummy variables, $D1^y * R_t^{USA}$. In this way,

[12]According to the explanation in section 1, we are interested in assessing whether a fall in the US stock market drives a fall in other world's markets and consequently whether cross-border interdependence between the US exchange and respectively the equity market of each other country included in the analysis becomes higher with respect to cases in which America's exchange is growing and the other country's market is either growing (up-up case) or performing bad (out-of-phase case). Additionally, it might be possible that, for short periods, other world's markets grow while the US exchange falls (again out-of-phase case). Therefore, the dummy takes the value of 1 in cases of joint bad performance for both America and the other given country, and zero otherwise. For the definition of the three states of the world see Erb *et al.* (1994).

we obtain five new variables, namely $D1^{UK}R_t^{USA}$, $D1^{GER}R_t^{USA}$, $D1^{FR}R_t^{USA}$, $D1^{IT}R_t^{USA}$ and $D1^{JAP}R_t^{USA}$.
The estimated coefficients of these variables, δ, capture the extra impact that a one unit change in US stock returns has on the change of the expected value of the other country's returns, in periods of joint low performance. In particular, given our hypothesis, we expect to observe, on a priori grounds, significantly positive δ. Ultimately, we interpret this as a sign that, in the down-down case, the change in the mean of country y stock returns, when US stock returns increase by 1 unit, rises on average from β to $(\beta + \delta)$.

3.2 Data

We now move to the statistical description of the database and the variables we use in the model. As explained in section 2, the original data are the time series of the daily price index for the stock market of each country considered in the analysis [13]. As argued before, we believe that daily data are more appropriate to capture interactions that may last only few days and which could instead be obscured using weekly or monthly data. In other words, daily data better describe the characteristics of stock markets without weakening the interpretation of estimated results in terms of the average tendency suggested by the economic analysis in section 1.
Our series are expressed in domestic currencies and cover the period January 1990 through February 2003. Therefore, the sample period is long enough to appeal to the asymptotic theory if the null hypothesis of normality of residuals is rejected.

Stock market indexes are notorious for having non-stationary features. To overcome this problem, the original series are adjusted to be I(0) processes. We know that for an asset that does not pay dividend the following relationship holds: $R_t = (P_t - P_{t-1})/P_{t-1}$, where R_t is the simple net return. This relationship, in turn, is approximately equal to: $R_t = lnP_t - lnP_{t-1}$. Using this relationship, and multiplying by 100, we calculate, for each market considered in the analysis, daily percentage changes in price indexes, i.e. daily percentage returns. These new series, as explained in section 3.1, are called R_t^{USA}, R_t^{UK}, R_t^{GER}, R_t^{FR}, R_t^{IT} and R_t^{JAP} and are used in the model allowing us to avoid the non-stationarity problem. Indeed, we carry out the Augmented Dickey Fuller (ADF) test and find that the null hypothesis of unit root is rejected for all the new series at any conventional level of significance. The general equation for the ADF test is:

[13] The source for the series is Datastream.

$$\Delta z_t = (\phi - 1)z_{t-1} + \sum_{j=1}^{p} \varphi_j \Delta z_{t-j} + \epsilon_t \qquad (3)$$

The null hypothesis of unit root is $H_0 : (\phi - 1) = 0$ and is tested against the alternative, $H_1 : (\phi - 1) < 0$. In our case, Δz_t are daily percentage returns, R_t^{USA} for example. In table 1, we report the coefficients, the standard errors and the t-values relevant for the ADF test.

Table 1: ADF test results

Variable	Coefficient	Standard error	t-value
R_{t-1}^{USA}	-1.0167	0.024002	-42.358
R_{t-1}^{UK}	-1.0158	0.023871	-42.554
R_{t-1}^{GER}	-1.0348	0.024227	-42.711
R_{t-1}^{FR}	-0.9957	0.023866	-41.719
R_{t-1}^{IT}	-0.9474	0.027839	-34.032
R_{t-1}^{JAP}	-1.0824	0.024432	-44.304

Comments: Critical values used in ADF test are: 5%=-3.414, 1%=-3.966. The null hypothesis is therefore rejected at both 5% and 1% level of significance for all the series.

As for the multiplicative dummy variables, $D1^{UK}R_t^{USA}$, $D1^{GER}R_t^{USA}$, $D1^{FR}R_t^{USA}$, $D1^{IT}R_t^{USA}$ and $D1^{JAP}R_t^{USA}$, we do not need to carry out the ADF test. Indeed, a stationary variable multiplied by a binary variable is still a stationary variable.

An important aspect to consider in using our data and interpreting the results is the existence of *time zones* in financial markets. Flavin *et al.* (2001) use a gravity model to see how geographic variables matter in explaining the behavior of stock markets. One of these geographical variables is called 'overlapping opening hours' and is simply the number of common opening hours of each pair of countries. As the authors point out, this variable is expected to be closely related to the distance measure. In fact, this is not always the case, because financial markets that are far apart can still be in the same time zone. Their hypothesis that this variable is an important one to explain equity market correlation is confirmed by estimated results, which show that the more hours of common trading the greater the degree of equity price co-movement. In terms of efficiency, that is our ultimate goal, this may indicate that markets are reacting to 'global news' and changes in one market simultaneously affect other markets. Alternatively, these results could witness stock market contagion or herd behavior among investors.
A different way to capture the importance of simultaneity between markets

is suggested by King and Wadhwami (1990), who consider whether or not markets are open at the same time rather than the number of common trading hours.
In line with these works, we also include the time zone aspect in our econometric framework. More precisely, we first express the opening hours of each market in the local time of the US market and second check, for any calendar day, whether trading hours of each pair of countries overlap or not. Finally, we build an appropriate model for each pair of countries.
In the case of Tokyo and New York, for example, their equity markets are never open together. Indeed, when the US stock market opens, at 9.30 a.m., it is 11.30 p.m. in Japan and the Japanese market has obviously already closed. This means that news arising from the US can only affect the Japanese stock market the day after. Therefore, in the econometric model for these two markets, we only consider the lag effect of both R_t^{USA} and $D1^{JAP}R_t^{USA}$.
As far as correlation between Europe and America, it is generally calculated relating the value of European indexes at closing time to the value of the America's index at closing time the day before. However, this relationship is changing and contemporaneous linkages have increased over the last few years for at least two reasons.
First, the overlapping time between America's exchange and some European markets has increased. Traditionally[14], there are two hours overlapping between the New York exchange and Europe's markets. When the US market opens (9.30 a.m.) it is 2.30 p.m. in the UK and 3.30 p.m. in both France and Italy. Given the fact that the UK stock market closes at 4.30 p.m. and the French and Italian at 5.30 p.m., there are, as said, two hours overlapping. However, since May 2000, the Italian exchange is open longer due to 'after hour' trading and this has increased the overlapping time with the New York exchange. Also the overlapping period with Germany is now longer than in the past as, again since May 2000, Frankfurt stock market is open until 8 p.m. and when the US exchange opens it is only 3.30 p.m. in Germany.
Second, European markets have been interested by a boom in trading on line which implies that European investors can now react to news arising from New York in real time and this is increasing the contemporaneous correlation between Europe and the USA.
As a matter of facts, the correlation between the USA stock market and the European markets calculated with values at closing time on the same day has widely increased from 2000 to 2001 becoming even higher than correlation calculated with one day lag[15].

[14]We are not considering differences due to daylight saving time.
[15]IRS (2001) and IRS (2002).

Given these considerations, and having observed that European stock markets at closing time strongly respond to events in the US market on the same day, we believe that the inclusion of the contemporaneous effect is important to capture how efficient and quick is the transmission of information and we do not think that, in doing so, we overestimate the importance of the overlapping hours. Therefore, when considering pair co-movements between the USA and respectively the UK, Germany, France and Italy, we use the value of their price index at closing time on the same day and we include both contemporaneous and lag effects for R_t^{USA} and the multiplicative dummy variables. As explained, the same motivations do not apply for Japan, where only lag effects are considered.

3.3 Estimated results

We now present and discuss the model for each pair of countries and interpret corresponding estimated results in terms of asymmetry.

USA-UK model

We start estimating equations 1 and 2 for USA and UK and we find that the appropriate specification for residuals is an asymmetric GARCH(1,1) model. Therefore, equation 2 can be rewritten as:

$$h_{uk,t} = a + b\epsilon_{t-1}^2 + ch_{uk,t-1} + dD_{t-1}\epsilon_{t-1}^2 \tag{4}$$

$h_{uk,t}$ is the time-varying conditional variance of R_t^{UK} and the dummy variable D_{t-1}, which takes the value of 1 if $\epsilon_{t-1} < 0$ and 0 if $\epsilon_{t-1} > 0$, captures the asymmetry. In general, d is expected to be positive in most empirical cases so that a negative shock increases future volatility or uncertainty while a positive shock eases the effect on future uncertainty. This is in contrast to the standard GARCH model, where shocks of the same magnitude, positive or negative, have the same effect on future volatility. In macroeconomic analysis, financial markets and corporate finance, a negative shock usually implies bad news, leading to a more uncertain future. Consequently, for example, shareholders would require a higher expected return to compensate for bearing increased risk in their investment.
The correct number of lags is one for both the autoregressive part and the other regressors included in equation 1.
Results arising from the estimation of the two equations are reported in table 2. Descriptive statistics are contained in table 3. The Portmanteau statistics confirms the absence of residual serial correlation and the ARCH test the

Table 2: ESTIMATED RESULTS FOR UK

Variable	Coefficient	SE	t-statistics	p-value
$constant$	0.138	0.019	7.24	0.000
R_{t-1}^{UK}	-0.083	0.016	-4.94	0.000
R_{t}^{USA}	0.118	0.023	5.08	0.000
R_{t-1}^{USA}	0.217	0.020	10.6	0.000
$D1^{UK}R_{t}^{USA}$	0.60	0.048	12.5	0.000
$D1^{UK}R_{t-1}^{USA}$	0.06	0.043	1.38	0.168
a	0.004	0.004	1.05	0.292
b	0.067	0.012	5.61	0.000
c	0.923	0.014	67.2	0.000
d	0.256	0.118	2.15	0.031

Comments: The table reports estimated coefficients, robust standard errors, t-statistics and p-values of equations 1 and 2, relative to pair co-movements between the USA and the UK.

Table 3: Descriptive statistics for UK

Test	Statistics	p-value
Normality test	$\chi_2^2 = 235.98$	0.000
ARCH test	$F_{2,3414} = 0.62224$	0.537
Portmanteau statistics	$\chi_{57}^2 = 69.249$	0.128

Comments: The null hypothesis of normality of residuals is rejected at any conventional level of significance. The null hypotheses of homoskedasticity and absence of serial correlation are instead accepted at any conventional level of significance.

Table 4: Overall significance of R_t^{USA} and $D1^{UK}R_t^{USA}$

Variable	χ_2^2	p-value
R_t^{USA} and R_{t-1}^{USA}	154.868	0.000
$D1^{UK}R_t^{USA}$ and $D1^{UK}R_{t-1}^{USA}$	300.189	0.000

Comments: The null hypothesis of overall insignificance is rejected at any conventional level of significance.

absence of heteroskedasticity. The null hypothesis of normality is instead rejected, but, as argued before, we can appeal to the asymptotic theory, given the size of our sample. The ARCH and GARCH parameters, namely b and c, are significant and also the asymmetric effect in the GARCH(1,1) equation, d, is significantly positive, in line with most empirical studies.
As for our hypothesis, we first observe that there is interdependence between the two markets, as confirmed by the coefficients of R_t^{USA} and R_{t-1}^{USA}, both significantly positive. For example, we estimate that, on average, UK stock returns increase by 0.118% when US stock returns increase by 1%. β_1, in turn, suggests that the lag effect is even stronger. These results imply a quick reaction of the UK market, which starts on the same day, during the overlapping hours, and continues the day after, to news arising from the American market.
Secondly, we find support for the asymmetric effect, as the coefficient of $D1^{UK}R_t^{USA}$ is positive and significant. In particular, the estimated δ_0 suggests that, in periods of poor performance of the two stock markets, the interdependence on the same day rises from 0.118% to 0.718%. Therefore, in the down-down case, UK stock returns increase, on average, by 0.718% on the same day, given an increase in US stock returns by 1%.
The coefficient for $D1^{UK}R_{t-1}^{USA}$ is instead not significant, indicating that the asymmetric effect is only contemporaneous.
We also test for the overall significance of R_t^{USA} and $D1^{UK}R_t^{USA}$. χ^2 values for the Wald tests are reported in table 4 and confirm that the variables R_t^{USA} and $D1^{UK}R_t^{USA}$, and corresponding lags, are both significant.

Summing up, we find that changes in US stock returns affect, on average, changes in the mean of UK stock returns and that part of the transmission of information happens on the same day, suggesting a quick and rapid responsiveness of the UK market. Additionally, we clearly observe a contemporaneous asymmetric behavior suggesting that the interdependence between the two exchanges increases in the 'down-down' case.

USA-Germany model

A similar type of analysis is carried out for the other pair of countries. In the case of Germany, residuals are specified by a GARCH(1,1) model without the asymmetric effect d, as this is not significant.
Again, the selected number of lags is one for both the autoregressive part and the other regressors included in equation 1. The model does not suffer of heteroskedasticity and autocorrelation, while again the null of normality is rejected. Table 5 reports estimated coefficients and corresponding t-statistics, while table 6 reports descriptive statistics.

Table 5: ESTIMATED RESULTS FOR GERMANY

Variable	Coefficient	SE	t-statistics	p-value
$constant$	0.168	0.022	7.47	0.000
R_{t-1}^{GER}	-0.099	0.018	-5.55	0.000
R_t^{USA}	0.140	0.030	4.56	0.000
R_{t-1}^{USA}	0.399	0.027	14.4	0.000
$D1^{GER}R_t^{USA}$	0.846	0.072	11.8	0.000
$D1^{GER}R_{t-1}^{USA}$	-0.009	0.064	-0.15	0.879
a	0.020	0.008	2.41	0.016
b	0.077	0.013	5.96	0.000
c	0.910	0.013	68.6	0.000

Comments: The table reports estimated coefficients, robust standard errors, t-statistics and p-values of equations 1 and 2, relative to pair co-movements between the USA and Germany.

Frankfurt is considered a major stock exchange in Europe and accordingly we would expect results to mirror those for UK. Our expectations are not contradicted. Coefficients of R_t^{USA} and R_{t-1}^{USA} are significantly positive, meaning that also Frankfurt stock market shows strong and quick responsiveness to news arising from New York. Moreover, as in the case of UK, and as we will observe for France and Italy, the coefficient of R_t^{USA} is smaller than the coefficient of R_{t-1}^{USA}. This indicates that, even though European markets are affected by events in the US stock exchange on the same day, a significant part of the transmission of information happens with one day lag.
The asymmetric effect in the case of Germany is particularly strong indicating that, in the down-down state of the world, the change in the mean of German stock returns rises, on average, from 0.140% to 0.986% given a change of US stock returns by 1%. Again, the asymmetric effect is only contemporaneous.

Table 7 reports χ^2 values that confirm the overall significance of R_t^{USA} and $D1^{GER}R_t^{USA}$.

Table 6: Descriptive statistics for Germany

Test	Statistics	p-value
Normality test	$\chi_2^2 = 986.76$	0.000
ARCH test	$F(2, 3415) = 0.21692$	0.8050
Portmanteau statistics	$\chi_{57}^2 = 65.061$	0.2166

Comments: The null hypothesis of normality of residuals is rejected at any conventional level of significance. The null hypotheses of homoskedasticity and absence of serial correlation are instead accepted at any conventional level of significance.

Table 7: Overall significance of R_t^{USA} and $D1^{GER}R_t^{USA}$

Variable	χ_2^2	p-value
R_t^{USA} and R_{t-1}^{USA}	278.433	0.0000
$D1^{GER}R_t^{USA}$ and $D1^{GER}R_{t-1}^{USA}$	343.185	0.0000

Comments: The null hypothesis of overall insignificance is rejected at any conventional level of significance.

USA-France model

Turning our attention to pair co-movements between France and US, we find very similar evidence. Also in this case, residuals are specified by a GARCH(1,1) model and the correct number of lags for both R_t^{FR} and the other regressors is one.
The estimation provides comforting results in terms of descriptive statistics, which are reported in table 9. Table 8 reports instead estimated coefficients and corresponding t-statistics. Findings are very much in line with those for UK and Germany. Indeed, coefficients of R_t^{USA} and R_{t-1}^{USA} are both significantly positive, indicating the existence of interdependence between France and USA, and the coefficient of $D1^{FR}R_t^{USA}$ is also significant, indicating that the interdependence between the two markets increases by 0.779% in periods of poor market performance for both France and America. Also in the case of France, we observe that part of the transmission of information is contemporaneous, suggesting that Paris stock exchange responds quite quickly to news arising from New York. Moreover, the asymmetric effect is only contemporaneous, as the coefficient of $D1^{FR}R_{t-1}^{USA}$ is not significant.

Wald tests confirm the overall significance of R_t^{USA} and $D1^{FR}R_t^{USA}$, as we can see from table 10.

Table 8: ESTIMATED RESULTS FOR FRANCE

Variable	Coefficient	SE	t-statistics	p-value
$constant$	0.177	0.024	7.30	0.000
R_{t-1}^{FR}	-0.078	0.017	-4.45	0.000
R_t^{USA}	0.187	0.030	6.07	0.000
R_{t-1}^{USA}	0.302	0.026	11.5	0.000
$D1^{FR}R_t^{USA}$	0.779	0.072	10.9	0.000
$D1^{FR}R_{t-1}^{USA}$	0.011	0.056	0.199	0.842
a	0.032	0.011	2.94	0.003
b	0.066	0.012	5.58	0.000
c	0.909	0.017	53.2	0.000

Comments: The table reports estimated coefficients, robust standard errors, t-statistics and p-values of equations 1 and 2, relative to pair co-movements between the USA and France.

Table 9: Descriptive statistics for France

Test	Statistics	p-value
Normality test	$\chi_2^2 = 278.14$	0.000
ARCH test	$F(2, 3415) = 0.69578$	0.4988
Portmanteau statistics	$\chi_{57}^2 = 51.163$	0.6927

Comments: The null hypothesis of normality of residuals is rejected at any conventional level of significance. The null hypotheses of homoskedasticity and absence of serial correlation are instead accepted at any conventional level of significance.

Table 10: Overall significance of R_t^{USA} and $D1^{FR}R_t^{USA}$

Variable	χ_2^2	p-value
R_t^{USA} and R_{t-1}^{USA}	182.932	0.0000
$D1^{FR}R_t^{USA}$ and $D1^{FR}R_{t-1}^{USA}$	296.713	0.0000

Comments: The null hypothesis of overall insignificance is rejected at any conventional level of significance.

USA-Italy model

When considering pair co-movements between US and Italy, we have to take into account that the sample period is shorter, as data for the Mibtel index are only available from July 16, 1993. However, also in this case we obtain results coherent with our hypothesis. Residuals are specified by a GARCH(1,1) model. The appropriate number of lags to avoid autocorrelation, selected through a General to Simple approach, is two for both the autoregressive part and the other regressors in equation 1. Descriptive statistics, reported in table 12, confirm that the model does not suffer of heteroskedasticity and autocorrelation, while residuals are non-normal. As before, we can appeal to the asymptotic theory, as the number of observations is still big enough.
Estimated coefficients and associated t-statistics are reported in table 11. The Italian stock exchange seems to mirror the behavior of other major European stock markets. Indeed, coefficients of R_t^{USA} and R_{t-1}^{USA} are both significant, confirming the responsiveness of the Italian stock market to the American one. The coefficient of R_{t-2}^{USA} is instead not significant.
As for asymmetry, we observe that interdependence in the down-down case rises both on the same day and with one day lag. Therefore, besides the contemporaneous asymmetry observed in previous models, there is also a lag effect.
Finally, Wald tests confirm the overall significance of R_t^{USA} and $D1^{IT}R_t^{USA}$, as shown in table 13.

A common feature which can be observed in all the estimates so far commented is that the coefficients of the autoregressive part are all significantly negative, except the coefficient of R_{t-1}^{IT}. The interpretation is not straightforward. May be, such a negative relationship can be interpreted as a 'technical' adjustment of the market to events occurred the day before.

Table 11: ESTIMATED RESULTS FOR ITALY

Variable	Coefficient	SE	t-statistics	p-value
$constant$	0.198	0.032	6.17	0.000
R_{t-1}^{IT}	-0.033	0.021	-1.57	0.117
R_{t-2}^{IT}	0.038	0.021	1.79	0.073
R_{t}^{USA}	0.133	0.033	4.02	0.000
R_{t-1}^{USA}	0.130	0.028	4.66	0.000
R_{t-2}^{USA}	0.028	0.027	1.03	0.304
$D1^{IT}R_{t}^{USA}$	0.736	0.064	11.5	0.000
$D1^{IT}R_{t-1}^{USA}$	0.137	0.062	2.22	0.026
$D1^{IT}R_{t-2}^{USA}$	-0.115	0.060	-1.92	0.055
a	0.054	0.015	3.66	0.000
b	0.099	0.020	5.01	0.000
c	0.865	0.024	36.0	0.000

Comments: The table reports estimated coefficients, robust standard errors, t-statistics and p-values of equations 1 and 2, relative to pair co-movements between the USA and Italy.

Table 12: Descriptive statistics for Italy

Test	Statistics	p-value
Normality test	$\chi_2^2 = 122.31$	0.000
ARCH test	$F(2, 2487) = 0.54224$	0.5815
Portmanteau statistics	$\chi_{48}^2 = 65.146$	0.0502

Comments: The null hypothesis of normality of residuals is rejected at any conventional level of significance. The null hypotheses of homoskedasticity and absence of serial correlation are instead accepted at any conventional level of significance.

Table 13: Overall significance of R_t^{USA} and $D1^{IT}R_t^{USA}$

Variable	χ_3^2	p-value
R_t^{USA} and R_{t-1}^{USA} and R_{t-2}^{USA}	40.1511	0.0000
$D1^{IT}R_t^{USA}$ and $D1^{IT}R_{t-1}^{USA}$ and $D1^{IT}R_{t-2}^{USA}$	217.518	0.0000

Comments: The null hypothesis of overall insignificance is rejected at any conventional level of significance.

USA-Japan model

Finally, we turn our attention to Japan to see whether conclusions so far drawn can be extended to non-European markets.
In the model for Japan, as explained before, we only include lag effects. Namely, we include one lag for both the autoregressive part and the other regressors. Residuals are once again specified by a GARCH(1,1) model.
Also in this case, general descriptive statistics, reported in table 15, reveal that the model does not suffer of autocorrelation and heteroskedasticity.
Estimated coefficients are instead reported in table 14.

Table 14: ESTIMATED RESULTS FOR JAPAN

Variable	Coefficient	SE	t-statistics	p-value
constant	0.006	0.024	0.250	0.802
R_{t-1}^{JAP}	-0.064	0.020	-3.27	0.001
R_{t-1}^{USA}	0.334	0.030	11.1	0.000
$D1^{JAP}R_{t-1}^{USA}$	0.114	0.071	1.61	0.108
a	0.057	0.019	3.05	0.002
b	0.090	0.014	6.31	0.000
c	0.885	0.017	50.7	0.000

Comments: The table reports estimated coefficients, robust standard errors, t-statistics and p-values of equations 1 and 2, relative to pair co-movements between the USA and Japan.

Table 15: Descriptive statistics for Japan

Test	Statistics	p-value
Normality test	$\chi^2_2 = 367.84$	0.000
ARCH test	$F(2,3417) = 1.0499$	0.3501
Portmanteau statistics	$\chi^2_{57} = 66.304$	0.1868

Comments: The null hypothesis of normality of residuals is rejected at any conventional level of significance. The null hypotheses of homoskedasticity and absence of serial correlation are instead accepted at any conventional level of significance.

Not surprisingly, the coefficient of R_{t-1}^{USA} is significantly positive and quite high, suggesting that the Japanese market at opening time quickly implements information arising from the American market which has closed few hours before. Therefore, we can argue that the behavior of Tokyo stock exchange is strongly explained by events occurred in the US stock market the

day before.
As for the asymmetric effect, instead, the evidence we obtain is different as the coefficient of $D1^{JAP}R^{USA}_{t-1}$ is not significant at any conventional level of significance. From graphical evidence, we recall that the Nikkei225 and the Dow Jones start moving together only after the 1997 crash. Therefore, full evidence for asymmetry might be recovered estimating the model for the period 1997-2003. Table 16 reports estimated results relative to this sub-period.

Table 16: ESTIMATED RESULTS FOR JAPAN - 1997-2003

Variable	Coefficient	SE	t-statistics	p-value
constant	0.008	0.040	0.204	0.838
R^{JAP}_{t-1}	-0.096	0.0264	-3.64	0.000
R^{USA}_{t-1}	0.319	0.039	8.25	0.000
$D1^{JAP}R^{USA}_{t-1}$	0.159	0.093	1.72	0.086
a	0.088	0.038	2.3	0.022
b	0.070	0.019	3.68	0.000
c	0.889	0.031	27.9	0.000

Comments: The table reports estimated coefficients, robust standard errors, t-statistics and p-values of equations 1 and 2, relative to pair co-movements between the USA and Japan. The estimate covers the period 1997 through 2003.

Table 17: Descriptive statistics for Japan - 1997-2003

Test	Statistics	p-value
Normality test	$\chi^2_2 = 74.768$	0.000
ARCH test	$F(2, 1592) = 1.9136$	0.1479
Portmanteau statistics	$\chi^2_{39} = 26.075$	0.9439

Comments: The null hypothesis of normality of residuals is rejected at any conventional level of significance. The null hypotheses of homoskedasticity and absence of serial correlation are instead accepted at any conventional level of significance.

In this case, the evidence for asymmetry is not contradicted. Having a priori expectations that the coefficient is positive, we can use a one-sided test. The critical value at 5% level of significance is 1.645 (the sample is big enough to appeal to the asymptotic theory and use the critical values for the Normal distribution). Consequently, as the t-value relative to the estimated coefficient of $D1^{JAP}R^{USA}_{t-1}$ is 1.72, the null hypothesis of an insignificant coefficient, tested against the alternative of a positive coefficient, is rejected at

5% level of significance[16]. Ultimately, this result suggests that there is a rise in return co-movements across Japan and America in periods of combined poor performance after 1997.

3.4 Some final remarks

Our idea that the behavior of major stock markets in the world is partly explained by co-movements with the US stock exchange has been widely proved through the empirical analysis. Indeed, our results confirm that both European markets and the Japanese market tend to implement news arising from the New York exchange and that the transmission of information is quite quick and efficient. This transmission starts on the same day, for European markets, and is mostly completed within few days.
In a short-run perspective, these results are consistent with the idea of informationally efficient stock markets.

Additionally, the results confirm what discussed in section 1, namely that over the last decade there has been a general tendency of other world's stock markets to mirror the behavior of America's exchange. Estimated coefficients suggest indeed that changes in US stock returns have, on average, impacted on the expected value of stock returns of the other countries.
More importantly, for European markets, and in part also for Japan, we have also obtained evidence for the hypothesis that pair co-movements with America tend to be asymmetric, namely tend to be higher in periods of joint poor performance. Consequently, estimated results strengthen the idea that, over the last 15 years, European stock markets have, on average, shared in America's downturn and their performance has not been sustained by economic fundamentals as much as the performance of the USA exchange.

4 Trading volumes and stock market comovements

In section 3.4, we have commented that estimated results not only confirm, on average, the existence of asymmetry in international stock market linkages, but also imply an efficient transmission of available information consistent with the notion of informationally efficient stock markets. This section represents an extension of this aspect and investigates whether there is a positive relationship between trading volumes and international stock market link-

[16] Note that the p-values we report are those provided by the econometric package and refer to the conventional two sided test.

ages. More trading implies a quicker transmission of available information and consequently higher informational efficiency of stock markets. Therefore, the existence of a positive relationship between trading volumes and international stock market co-movements confirms the idea that a rise in stock market linkages can be interpreted as a signal that efficiency is increasing, as we have indeed concluded in section 3.4. Obviously, this analysis should be considered as complementary, rather than alternative, to the economic motivations discussed above.

Relying on the assumption of risk aversion, we can argue that, when shares start to plunge, investors show a higher propensity to sell and to imitate the behavior of other investors. In particular, in section 1, we have suggested that in periods of boom European investors have benefited from free capital mobility investing in America more than in Europe, as America's growth potential has been generally higher over the last 15 years. However, when America' shares started to plunge, these investors started to suffer losses and plausibly to sell their share holdings, both in America and in Europe. In line with this explanation, it seems plausible to argue that, in periods of poor market performance, trading volumes in European markets rise as a result of herd behavior and increased contagion.

Generally, higher trading volumes are associated with higher volatility in stock markets. A paper by Neumark, Tinsley and Tosini (1991), for example, suggests that, assuming constant transaction costs, trading is more beneficial when stock markets are more volatile because transaction costs fall as a proportion of potential capital gains, which are obviously higher in volatile times. Indeed, only larger price changes pierce the transaction cost barrier between markets and consequently association between markets will appear to be stronger in periods of unusually large price volatility[17]. Obviously, correlations increase even more if transaction costs fall, ceteris paribus.

This explanation seems to suggest that when volatility increases trading volumes also increase and ultimately cross-border interdependence is higher. The reasoning is coherent but ignores some crucial considerations.

Firstly, the assumption that transaction costs are constant does not always hold. In fact, when considering stock markets, bid-ask spreads are commonly used as a proxy for transaction costs. We have looked at available data to recover series for bid-ask spreads and observe whether they have been constant or have changed over our sample period. Datastream only provides series for the highest and lowest intra-day price indexes. We have therefore used

[17]Neumark *et al.* (1991), p. 159, state indeed that "cross-market correlations are generally much larger in periods of extreme volatility and appear to subside to modest or even negligible association during periods of more normal trading activity".

these data as proxies for ask and bid prices then used to build series for bid-ask spreads, for each index included in our analysis. Plotting corresponding graphs, we have observed that spreads are not constant and in fact tend to increase over the twelve years observed. The rise is particularly intense during periods of high volatility, suggesting that dealers compensate themselves for the bigger risk of holding assets by augmenting spreads. Finance books show indeed that demand and supply curves for stocks are more sloped in volatile times and flatter when markets are steady, confirming that spreads are bigger in the former case.
Secondly, the explanation does not take into consideration that during high volatile periods the increase in potential gains might not be big enough to offset the higher risk of holding stocks and consequently investors might not actually trade more [18].
Finally, it seems more plausible that trading volumes, or at least fluctuations in trading volumes, affect volatility than viceversa.

For all these reasons, in our analysis we avoid relying upon the association higher volatility-higher trading and we rather associate higher trading with poor market performance. Even though not conclusive, results are quite interesting in terms of stock market efficiency and seem to confirm the idea of informationally efficient stock markets.
A general representation of our model is given by equations:

$$R_t^y = \alpha + \sum_{i=1}^{m} \gamma_i R_{t-i}^y + \sum_{j=0}^{n} \beta_j R_{t-j}^{USA} + \sum_{j=0}^{n} \theta_j R_{t-j}^{USA} * dummy^y \qquad (5)$$

$$h_{y,t} = a + b\epsilon_{t-1}^2 + ch_{y,t-1} \qquad (6)$$

where $dummy^y$ takes the value of 1 when returns in both the US and the other country are below average (down-down case) and simultaneously trading volumes in country y are above average, and 0 otherwise[19]. Finding a significantly positive θ indicates that trading volumes higher than average in the down-down case increase the change in the mean of country y returns, given a change in US stock returns by 1 unit, from β to $(\beta + \theta)$. In other words, with respect to equation 1, a significantly positive θ means that, ceteris paribus (i.e. given the down-down case), higher trading leads to higher cross-border linkages supporting our expectations.

[18] Ultimately increases in potential capital gains arising from larger fluctuations in prices might not pierce the 'risk premium' boundary.

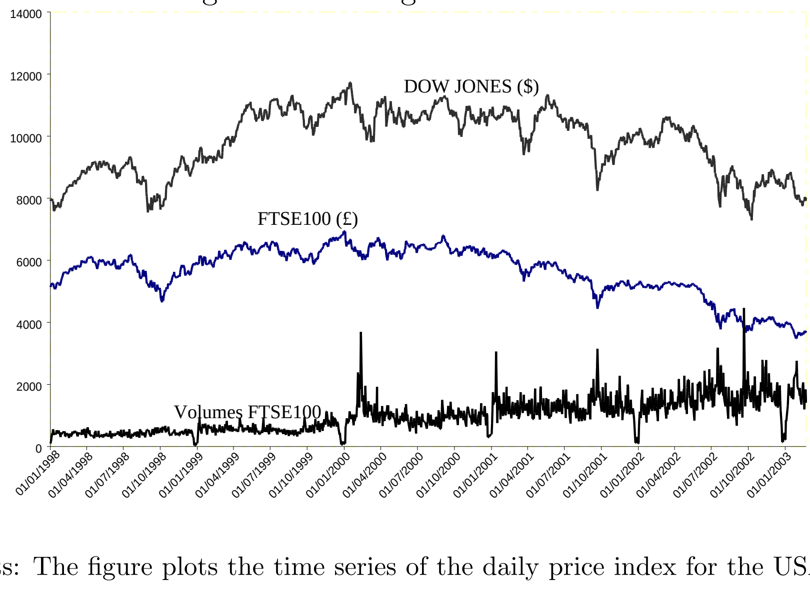
[19] Practically, to obtain $dummy^y$ we have multiplied $D1^y$ by another dummy called VOL^y, which takes the value of 1 when trading in country y is above average and 0 otherwise.

This analysis will be restricted to UK and France, as data on trading volumes are not available for the other countries.

4.1 Evidence for UK

As explained, we expect higher trading volumes in European markets in periods of poor market performance. To strengthen this view, in figure 9 we plot the Dow Jones and the FTSE100 from January 1, 1998. In addition, we plot daily trading volumes of the FTSE100, over the same period. The source for this latter series, called turnover by trading, is Datastream and the series shows the value of shares traded for an index on a particular day. Data are expressed in thousands of the domestic currency, but in our graph the series is scaled dividing by 1000 and is subsequently expressed in millions. The graph suggests two main observations. Firstly, both the Dow Jones and the FTSE100 show a downward trend from 2000 while trading volumes increase from 2000. Secondly, in most cases sharp rises in trading volumes coincide with troughs in both the Dow Jones and the FTSE100.

Figure 9: Trading volumes for UK



Comments: The figure plots the time series of the daily price index for the USA and the UK and of daily trading volumes of the FTSE100, over the period 1998-2003.

For our scope, it is however more revealing and interesting to observe estimated results of equations 5 and 6[20]. Results arising from the estimation of

[20]The estimate covers the whole sample period, from January 1, 1990, through February 21, 2003.

Table 18: ESTIMATED RESULTS FOR UK TRADING VOLUMES

Variable	Coefficient	SE	t-statistics	p-value
$constant$	0.030	0.0137	2.20	0.028
R_{t-1}^{UK}	-0.072	0.017	-4.26	0.000
R_t^{USA}	0.305	0.018	17.4	0.000
R_{t-1}^{USA}	0.265	0.018	14.6	0.000
$R_t^{USA} * dummy^{UK}$	0.413	0.052	7.92	0.000
$R_{t-1}^{USA} * dummy^{UK}$	0.025	0.057	0.442	0.659
a	0.0116	0.003	3.91	0.000
b	0.069	0.010	6.81	0.000
c	0.917	0.011	84.4	0.000

Comments: The table reports estimated coefficients, robust standard errors, t-statistics and p-values of equations 5 and 6, relative to the USA and the UK.

Table 19: Descriptive statistics for UK

Test	Statistics	p-value
Normality test	χ_2^2 =203	0.000
ARCH test	$F(2,3415)$= 0.536	0.585
Portmanteau statistics	χ_{57}^2=66.282	0.187

Comments: The null hypothesis of normality of residuals is rejected at any conventional level of significance. The null hypotheses of homoskedasticity and absence of serial correlation are instead accepted at any conventional level of significance.

the model are reported in table 18, while descriptive statistics are reported in table 19. The model does not suffer of autocorrelation and heteroskedasticity. The null hypothesis of normality is instead rejected, but again we appeal to the asymptotic theory given the number of observations. The ARCH and GARCH parameters, namely b and c, are significant.
Estimated results are quite interesting. β is significantly positive and, ceteris paribus, this confirms what already observed estimating equation 1 for UK, namely that, on average, expected UK stock returns increase by 0.3% when US stock returns increase by 1%. In other words, the result confirms the fact that changes in US stock returns positively affect, on average, changes in the mean of UK stock returns. The effect is both contemporaneous and lagged. Additionally, we find a significantly positive θ, suggesting, ceteris paribus with respect to equation 1, that when trading volumes rise above average the change in expected UK stock returns rises by 0.413%. This re-

Table 20: Overall significance of R_t^{USA} and $(R_t^{USA} * dummy^{UK})$

Variable	χ^2	p-value
R_t^{USA} and R_{t-1}^{USA}	632.78	0.000
$(R_t^{USA} * dummy^{UK})$ and $(R_{t-1}^{USA} * dummy^{UK})$	93.14	0.000

Comments: The null hypothesis of overall insignificance is rejected for both of R_t^{USA} and $R_t USA * dummy^{UK}$ at any conventional level of significance.

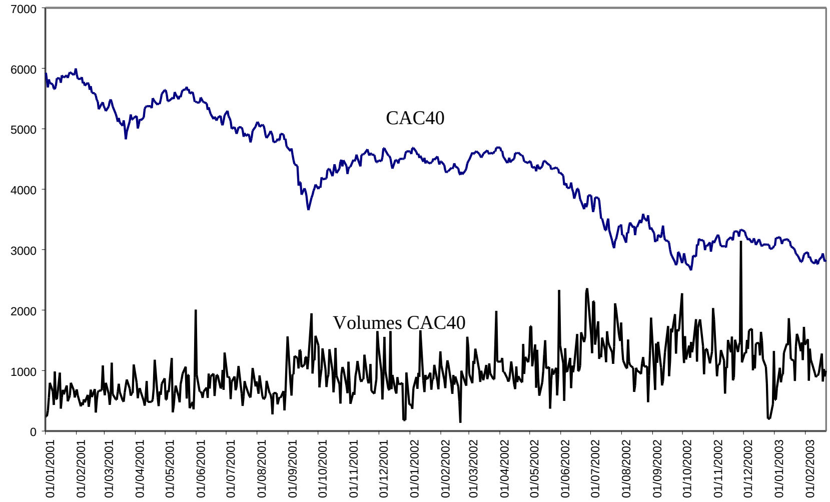
sult is coherent with the idea[21] of higher trading-higher interdependence and supports the notion of informationally efficient stock markets. Ultimately, it also confirms that we can interpret a rise in international stock market interdependence in favor of higher information efficiency, as we have indeed done in sections 3.3 and 3.4.

4.2 Evidence for France

A very similar analysis is carried out for France. Also in this case, we first observe the relationship existing between market performance and daily trading volumes. In figure 10, we plot the CAC40 and the series of daily trading volumes for the same stock index. Again, this series originally expressed in thousands is scaled dividing by 100. The graph is restricted to the period 2001-2003 because this is the most significant for our scope, while the econometric analysis is referred to the whole sample period, which in this case goes from January 2, 1992, through February 21, 2003, as the data on trading volumes are not available for the years 1990 and 1991. Also for France, we observe a downward trend for the CAC40 while the trend for trading volumes is positive. Moreover, troughs of the CAC40 index are mainly associated with sharp rises in daily trading volumes.
The interpretation of the model is analogous to the one provided for UK.
From a general point of view, the estimate provides appealing descriptive statistics, reported in table 22. Estimated results are instead reported in table 21. As for our hypothesis, also in this case we observe a significantly positive θ, equal to 0.584. This result indicates that, ceteris paribus with respect to equation 5, when trading volumes increase above average the change in expected French stock returns rises from 0.423% to 1.007%, given a change in US stock returns by 1%. Ultimately, the existence of increasing cross border linkages supports the idea of informationally efficient stock markets.

[21] This aspect is also consistent with the second part of the reasoning by Neumark, Tinsley and Tosini (1991) explained in section 4.

Figure 10: Trading volumes for France



Comments: The figure plots the daily price index for France and daily trading volumes of the CAC40, over over the period 2001-2003.

Table 21: ESTIMATED RESULTS FOR FRANCE TRADING VOLUMES

Variable	Coefficient	SE	t-statistics	p-value
$constant$	0.036	0.020	1.74	0.081
R_{t-1}^{FR}	-0.087	0.018	-4.72	0.000
R_t^{USA}	0.423	0.026	16.0	0.000
R_{t-1}^{USA}	0.363	0.027	13.4	0.000
$R_t^{USA} * dummy^{FR}$	0.584	0.066	8.85	0.000
$R_{t-1}^{USA} * dummy^{FR}$	-0.127	0.075	-1.70	0.090
a	0.023	0.007	3.11	0.002
b	0.053	0.010	5.12	0.000
c	0.930	0.014	67.9	0.000

Comments: The table reports estimated coefficients, robust standard errors, t-statistics and p-values of equations 5 and 6, relative to the USA and France.

Table 22: Descriptive statistics for France

Test	Statistics	p-value
Normality test	χ^2_2 =110.41	0.0000
ARCH test	$F(2, 2893)$= 0.356	0.700
Portmanteau statistics	χ^2_{52}=45.123	0.739

Comments: The null hypothesis of normality of residuals is rejected at any conventional level of significance. The null hypotheses of homoskedasticity and absence of serial correlation are instead accepted at any conventional level of significance.

Table 23: Overall significance of R_t^{USA} and $(R_t^{USA} * dummy^{FR})$

Variable	χ^2	p-value
R_t^{USA} and R_{t-1}^{USA}	559.15	0.000
$(R_t^{USA} * dummy^{FR})$ and $(R_{t-1}^{USA} * dummy^{FR})$	82.91	0.000

Comments: The null hypotheses of overall insignificance is rejected for both R_t^{USA} and $R_t^{USA} * dummy^{FR}$ at any conventional level of significance.

5 Implications for informational efficiency

Financial market efficiency is a central concern in financial economics and deservingly so. According to the Efficient Market Hypothesis (EMH)[22], equity markets are efficient when stock prices reflect all available information[23]. Following this theory, sudden price changes only happen because new and unanticipated information are made available[24].

The EMH has been tested and fundamental based models suggest that domestic stock markets are too volatile with respect to what would be suggested by economic fundamentals. For this reason, empirical literature has devoted great attention to understand whether the behavior of stock markets reflects the existence of co-movements with other markets and is consistent with the notion of 'informationally efficient international stock markets'[25].

Economists are especially concerned with financial market efficiency because of the implications it has on the real economy. It is well known that, despite the theory, stock markets are often driven by psychological factors, such as speculative attacks or price manipulation that may reveal information to investors that are not true. This ultimately leads to inefficient allocation of

[22]Pioneer works are those of Shiller (1981) and LeRoy and Porter (1981).

[23]Three different levels of efficiency can be distinguished, weak, semi-strong and strong.

[24]Shiller (2000).

[25]Eun and Shim (1989).

funds in investment projects. Economists are therefore concerned that information implied through changes in asset prices is fair and efficient.
Our econometric analysis suggests that a substantial amount of multilateral interaction exists between the US and major national stock markets in the world and that these interactions are positively affected by an increase in trading volumes. It should be obvious that higher trading volumes imply that available information are transmitted more quickly and subsequently that stock prices provide more precise indications about the performance of companies. Ultimately, this means that cross-border linkages between stock markets can be used as a measure of stock market efficiency and that observing high international pair co-movements indicates that information revealed in one market, the American one in our case, have a global impact on the performance of other markets. So, there is an international pattern of transmission of information which supports the notion of informational efficiency. Simply, we are suggesting that when international co-movements in stock markets are high information is well dispersed in the global market. There is therefore an implied consensus on asset prices that promotes real credibility and reduces risk associated with investment.
As well explained by previous work on the topic, higher correlation in the global market also implies a big cost. Indeed, national stock markets become exposed not only to domestic but also to international shocks and to the associated risk of contagion in case of financial crises. Moreover, high international interdependence erodes benefits arising from international diversification making it less convenient for investors to internationally diversify their portfolios[26].
Whether an integrated global market is desirable depends on whether benefits offset costs of international interdependence among equity markets.

[26] Adjaouté and Danthine (2002) suggest that sector diversification is more convenient in an integrated world.

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