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THE DYNAMICS OF VOLATILITY AND CORRELATION DURING PERIODS OF CRISIS: IMPLICATIONS FOR ACTIVE ASSET MANAGEMENT

Marcello Esposito[*]

During the 2007-2008 financial crisis, idiosyncratic and market volatilities across the world increased to level never seen before. The financial econometrics literature focussed on the spectacular increase in aggregate idiosyncratic volatility. Bekaert, Hodrick, and Zhang (2012) showed the high correlation across countries, documenting how most of the time variation in idiosyncratic volatility can be attributed, among others, to variation in U.S. market volatility and a business cycle sensitive risk indicator.

However, what worried most asset managers and commentators was not so much the increase in volatility per se but the dramatic increase in correlation between and within stock markets. A phenomenon interpreted by the financial press as a sort of structural break in stock market dynamics. Sandoval and De Paula (2011) studied the phenomenon of the increase in correlation during period of crisis. They found that markets tend to behave as one in time of crisis.

I will show that it is possible to calibrate a simple dynamic CAPM model over the last 20 years that fits very well the observed dynamic of stock markets' volatility and correlation. I use the model to investigate if the 2007-8 environment should have been detrimental to bottom-up managers and favourable for top-down manager, as far as "alpha" creation is concerned. There is in fact a sort of consensus view about the fact that the increase in correlation observed during the 2007-2008 should have impaired the capabilities of bottom-up managers to produce alpha. As there is good and bad cholesterol, there is good and bad volatility for bottom-up alpha generators.

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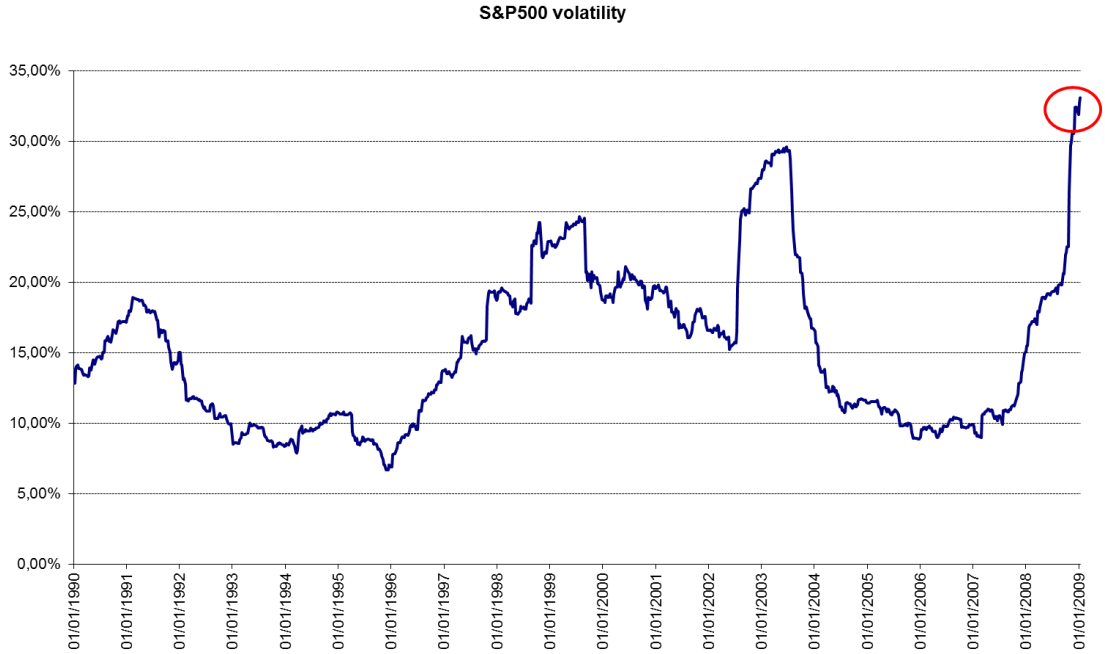
1. The facts

The 2007-2008 financial crisis will be remembered for many exceptional facts. Among them, financial analysts and econometricians will not forget the spectacular increase in stock markets' volatility and in correlation between markets, sectors and single stocks. The fact that, when a crisis erupts, markets tend to move closely together has been empirically investigated by Sandoval and De Paula (2011). The authors found that, using the eigenvalues and eigenvectors of correlations matrices of some of the main financial market indices in the world, high volatility of markets is directly linked with strong correlations between them.

How many times we heard sentences like "there is no place to hide"? A paper from Bartram S. and Bodnar G. (2009) describes well the feelings of that terrible period. There was a sense of betrayal with respect to the central tenets of Finance. Diversification provided little help to investors when needed most, as markets dropped in tandem. Volatility shot up on all major market indices, as one can see for example from the picture of the S&P500, where I represented the time series of the 1-year rolling weekly standard deviation of the log return (annualized).

Figure 1.

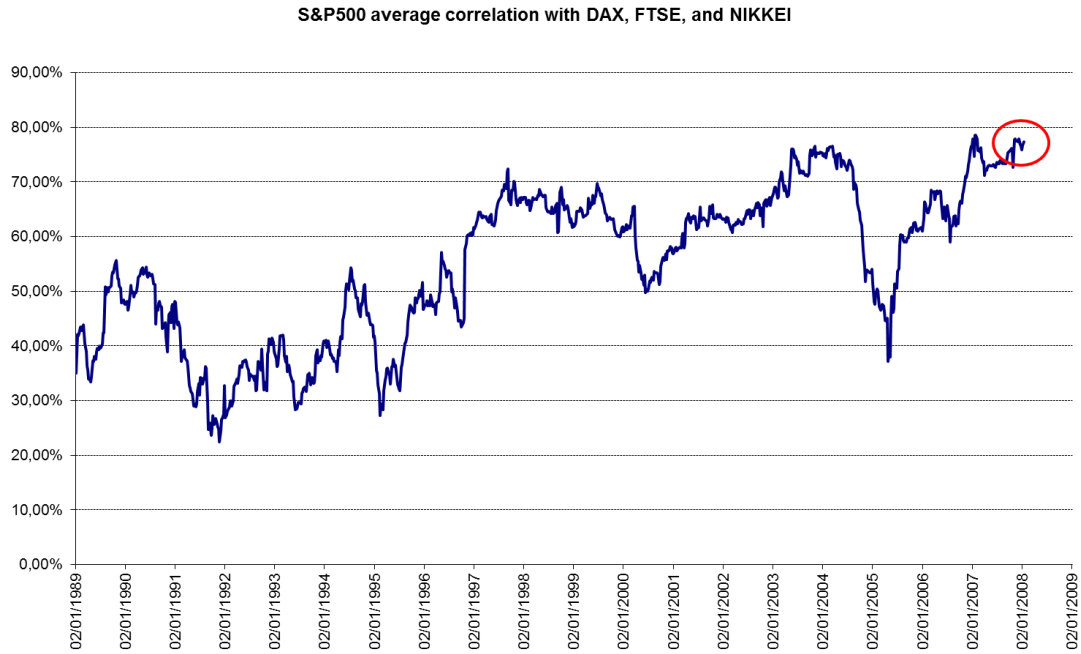


The volatility is calculated as the standard deviation of the weekly delta log of the S&P500 index over a 52-weeks rolling interval. It is annualized multiplying by the square root of 52.

The equity risk premium, measured from CFO surveys by Graham and Campbell (2009), sharply increased during the crisis. In the figures below, instead, I show the increase in

correlation observed between international markets (the average correlation of the S&P500 with the Nikkei, Ftse, and Dax).

Figure 2.



The correlation is calculated between the weekly delta log of the S&P500 index and the DAX Index over a 52-weeks rolling interval. The same procedure is used to calculate the correlation with the FTSE and the NIKKEI indices. The simple average of the three correlation is plotted.

These figures are a testimony to the degree of integration reached by world capital markets at the start of the century. It has to be noted that this topics has been deeply discussed in the economic literature. At the beginnings of the '90s a series of paper set out the model of a world CAPM and its variants[1]. A statistical rejection of these models can be interpreted as a rejection of the efficient market hypothesis and/or a rejection of world capital markets integration. Bekaert and Harvey (1995) tested the hypothesis of time-varying world market integration in order to take into account the possibility that the degree of integration can change through time because of a change in the institutional settings, in the monetary regime, in regulation, and in financial innovation. Their conclusion was that there was no evidence pointing to increased integration. Their conclusion is justified by the year in which the markets were analyzed. In Europe, for example, controls on the capital movements were still in place, there were national currencies, and many economies were dominated by big State-owned companies operating in the utilities, energy, telecom, and banking sectors. The biggest banks and insurance companies were still mostly organized on a national basis, and the separation between commercial and investment banking was still intact.

In 2007-2008, when the financial crisis exploded, the world capital markets were completely different with respect to 10 year before. National boundaries disappeared inside Europe, with many member states sharing a common currency, the euro. The biggest banks evolved into a new model, truly multinational and with a full integration of commercial and investment banking. The boundaries between insurance and banks were eliminated by the use of credit derivatives. The "globalization" of financial markets, generated by institutional reforms and innovations, increased the correlation between markets. But the very high correlation that we saw during the crisis of 2007 and 2008 was due to the nature of the financial turmoil: a liquidity crisis rapidly morphing into a systemic crisis.

2.1 the CAPM model for stocks' returns

The simplest way of modeling the return of the *i*-th stock is according to the well-known CAPM equation:

$$r_i = \beta_i * r_{mkt} + \varepsilon_i \tag{1}$$

The equation contains one parameter ("beta") and two independent random variables: the market return and an error term, ε. Both random variables are assumed to be Normally distributed:

$$r_{mkt} \sim N(\bar{r}, \sigma^2) \tag{2}$$

$$\varepsilon_i \sim N(0, \upsilon_i^2) \tag{3}$$

It derives that the return of the i-th stock is Normally distributed as:

$$r_i \sim N(\beta_i \bar{r}, \beta_i^2 \sigma^2 + \upsilon_i^2) \tag{4}$$

While the correlation between the return of the i-th and j-th stocks is equal to:

$$corr(r_i, r_j) = \frac{\beta_i \beta_j * \sigma^2}{\sqrt{\beta_i^2 \sigma^2 + \upsilon_i^2}\sqrt{\beta_j^2 \sigma^2 + \upsilon_j^2}} \tag{5}$$

2.2 A further simplification

The simplest assumption is that all securities are identically distributed. If this is the case, then the beta term is equal to 1 and equations (4) and (5) become:

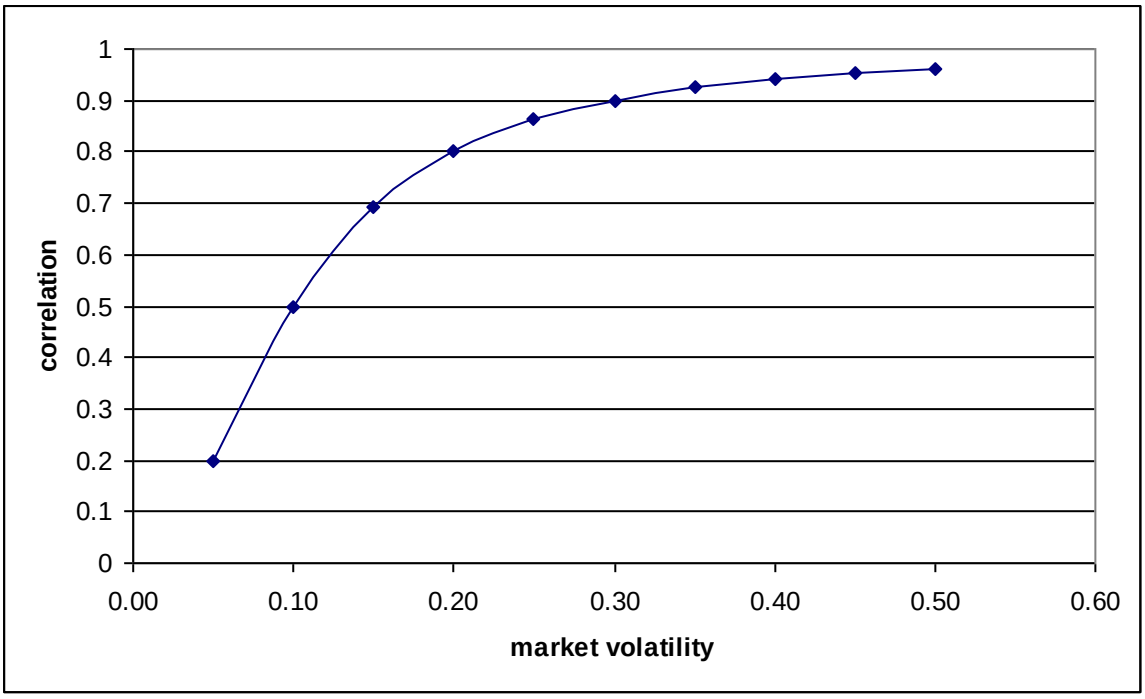
$$r_i \sim N(\bar{r}, \sigma^2 + \upsilon^2) \tag{4a}$$

$$\rho \equiv corr(r_i, r_j) = \frac{\sigma^2}{\sigma^2 + \upsilon^2} \tag{5a}$$

From (5a), it is quite easy to see the relationship between the volatility components and the correlation term. In particular, the higher the volatility of the market and the higher is the correlation between securities. The opposite holds true, if idiosyncratic volatility increases.

In figure 3, I show how correlation increases when market volatility increases from 5% to 50%. Note that I assume that idiosyncratic volatility is equal to 10% and remains constant.

Figure 3- Correlation between stocks and market volatility



3.1 Calibration

I use the weekly log returns on 4 major stock exchanges, as represented by their benchmark indices: S&P500, DAX, FTSE100, and NIKKEI. The period runs from 1/1/1987 to 1/1/2009. I measure the correlation among them on non-overlapping periods of 52 weeks.

On “average”, the S&P500 volatility is around 17%. During the so-called “great moderation” period of the 2004-2007 it was lower, whereas during the crisis periods it was much higher. During Autumn 2008, one observed volatility levels above 30%. Considering these indices, the average correlation is equal to 52% over the observed period.

Let's calibrate the model over "normal" times, so using:

$$\begin{cases} \sigma = 0.17 \\ \rho = 0.52 \end{cases} \tag{6}$$

Solving eq (5a) for the volatility of the single index and of the idiosyncratic term, I obtain:

$$\begin{cases} \sigma_i = \sigma / \sqrt{\rho} = 0.236 \\ \upsilon = 0.163 \end{cases} \tag{7}$$

I can then use this model to see how does it fits reality. In the figure 4, I show the result if one uses as a forecast for correlation our formula (5a) calibrated according to (7).

Figure 4. Estimating the relationship between correlation and volatility

The solid line represents the estimated correlation based on formula (5a), the dots represents the actual value.

Since correlation is used in many practical applications in financial and credit derivatives and in the calculation of regulatory capital, it is important to recognize that it is not constant and it is not exogenous with respect to volatility. As we have shown it is better to estimating the relationship between correlation and volatility via a non-linear (quadratic) function than with a simple linear regression.

3.2 Applications for the asset management industry

It is quite common to find comments on the (negative) impact of the 2008 crisis on the capabilities of asset managers to produce value added for their customers.[2] In fact, when correlation among assets increases, it is quite common to say that one has two negative effects for asset managers: a reduction in the beneficial impact of diversification on the risk-return characteristics of an investment portfolio and a lower "alpha" generation by active asset managers. Where "alpha" means, in the jargon of asset management, the extra-return with respect to the market performance generated by a skilled active manager. However, while the first effect is uncontroversial, one needs to better understand the causes of the increase in correlation, before saying that this is negative for active asset management.

I will show that, if the increase in correlation is due solely to an increase in market volatility, the only effect might be a reduced relevance of stock-picking as a source of "alpha" but not a reduction of the "alpha" that a stock-picker produces in absolute terms. On the contrary the importance of "alpha" deriving from market timing strategies increases in relevance.

4.1 A framework for active asset management

In the following I will loosely refer to Grinold-Kahn (1999). The simplest way of modeling the return of an actively managed portfolio is to represent it as a linear combination of the market ("benchmark" in asset management's jargon) return, according to the well-known equation:

$$r_p = \alpha + \beta * r_{mkt} + \varepsilon \tag{8}$$

The equation contains two parameters linked to the investment policy of the manager ("alpha" and "beta") and two independent random variables: the market return and an error term, ε.

The expected value and the variance of the portfolio's return can be easily derived:

$$E(r_p) \equiv \bar{r}_p = \alpha + \beta * E(r_{mkt}) \tag{8a}$$

$$Var(r_p) \equiv \sigma_p^2 = \beta^2 * \sigma^2 + \sigma_\varepsilon^2 \tag{8b}$$

The day to day excess-return of the portfolio wrt the benchmark is known as the tracking-error and it is equal to:

$$TE = (r_p - r_{bmk}) = \alpha + (\beta - 1) * r_{bmk} + \varepsilon \tag{9}$$

The term: $\beta_A = \beta - 1$ is sometimes called "active beta". The expected excess return is then equal to:

$$E(TE) = \alpha + \beta_A * E(r_{bmk}) \tag{10}$$

If the manager does not take "macro" directional bets (i.e. does not follow a "market timing" strategy), the beta of the portfolio is equal to 1. The excess return reduces to the well known "alpha" formula:

$$E(TE) = \alpha \tag{10a}$$

so that it is easy to understand why "alpha" is interpreted as the component of the portfolio excess return due to the capabilities of the manager to run a successful stock-picking activity. And it is easy to understand why I define "alpha" as the output of the industry: an active asset manager is paid in order to produce a performance which is higher than the one I could obtain by passive replication of the benchmark. The amount of money that the active manager can be paid depends on the "alpha" that he is able to produce.

If "alpha" is the output of the active manager, the TEV is the "input". The variance of the portfolio is easily derived:

$$\begin{aligned} \sigma_p^2 &= (1+\beta_A)^2 \sigma^2 + \sigma_\varepsilon^2 \\ &= \sigma^2 + 2\beta_A \sigma^2 + \beta_A^2 \sigma^2 + \sigma_\varepsilon^2 \\ &= \sigma^2 + 2\beta_A \sigma^2 + TEV^2 \end{aligned} \tag{11}$$

I used the term TEV in the equation above. TEV stands fro Tracking Error Volatility and it is equal to the standard-deviation of the TE, as one can see by taking the variance of the TE, so that:

$$TEV^2 = Var(TE) = \beta_A^2 \sigma^2 + \sigma^2{}_\varepsilon \tag{12}$$

The total "risk" of the portfolio return is then the sum of the TEV and the benchmark variance, plus a term that takes into account of the covariance existing between the tracking-error and the benchmark because of the active beta.

Summing up, the manager activity determines an excess return (wrt the benchmark) equal to the "alpha", but the "price" that he has to pay is an increase in the risk of the portfolio. The ratio

between the extra-return and the extra-risk is the "Information Ratio" and it measures the capability of the manager to produce alpha out of the available risk-budget:

$$IR = \frac{\alpha}{\sigma_\varepsilon} \tag{13}$$

One can easily understand why the IR has become such an important measure. It is in fact the simplest way to represent the production function of active asset management: the input is the TEV, the output is the alpha. For a given level of TEV, an high IR corresponds to an high capability of the active manager to produce alpha.

4.2 Correlation, stock-picking, and alpha generation

As one can see, the tracking error variance is caused by the stock selection activity and by the active beta. In case the beta is equal to 1:

$$TEV = \sigma_\varepsilon \tag{12a}$$

If active beta is zero, i.e. the active manager is a pure stock-picker, eq. (11) reduces to:

$$\begin{aligned} Var(r_P) &= \sigma^2 + TEV^2 \\ &= \sigma^2 + \sigma_\varepsilon^2 \end{aligned} \tag{11a}$$

A stock picker can generate TEV and, then, possibly alpha by taking a position in the underlying asset which is different from the one of the benchmark. Let's call "active weight" the difference between the weight of the security in the portfolio and its weight in the benchmark.

The relationship between the active weight and the TEV can be quite complicated to derive, but to give an intuition, consider the following simplified active strategy: overweight k% in N/2 stocks and underweight –k% in N/2 stocks, where N denotes the number of stocks in the benchmark.

Under the simplified assumptions generating the stock price dynamics described by eq. (4a), the portfolio's TE would be:

$$TE(stock - pic\ker) = k\sum_{i=1}^{N/2}\varepsilon_i - k\sum_{i=N/2+1}^{N}\varepsilon_i \tag{14a}$$

So that the TEV becomes:

$$TEV(stock - pic\ker) = k\upsilon\sqrt{N} \tag{14b}$$

As one can see, if the IR of the stock-picker does not change, the alpha is not affected by the increase in correlation caused by the increase in market volatility. Alpha is affected only by a variation in idiosyncratic volatility.

However, if it is not correct to say that an high correlation market environment is detrimental to stock-pickers, one has to recognize that the stock-picking strategies become less "relevant" with respect to "macro" strategies of so-called "market timing". Where by macro strategies I mean the choice to underweight the entire market and invest part of the portfolio in cash.

To show this point, one can compose a portfolio where one underweights the stock by -x%, and then one invests x% in cash, so that sum of the weights is still 100%. Under the hypothesis that cash is a deterministic variable, the TEV of the portfolio will be:

$$TE(macro) = -x \cdot r_{mkt} + x \cdot r_{riskfree} \tag{15a}$$

$$TEV^2(macro) = x^2\sigma_{mkt}^2 \tag{15b}$$

In this case, if the IR of the "macro" manager does not change, the alpha of the market timing strategy increases if the market volatility and then the correlation increases.

If, as in 2008, the correlation shot up because market volatility shot up (and not because idiosyncratic volatility collapsed), the stock-picker's alpha becomes almost irrelevant if compared with the alpha that a good "market timer" could produce.

5 Conclusions

During periods of crisis, the volatility of stock markets and single stocks increases. Contemporaneously, one observes an increase in the correlation, too. This happened during the 2007-2008 global financial crisis when we observed volatilities and correlations never seen before. Using a simple CAPM model I explain the functional relationship between volatility and correlation. This relationship is non linear and I show that it fits reasonably well the historical dynamics of the major international stock markets.

What is particularly worrisome from an asset management point of view is the increase in correlation because it threatens some of the few tenets of the industry: the benefits of diversification and of active asset management when mostly needed, i.e. during a crisis. Starting from the simple CAPM model and adding the algebra of active asset management, I show that active manager can still generate alpha for their clients if they switch from "stock-picking" to

"market-timing" strategies. The claim that during periods of crisis active asset managers cannot generate "alpha" is then inappropriate.

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Notes

[1] For the world CAPM see Harvey (1991), for world multibeta models see Ferson and Harvey (1993), for world latent factor models see Campbell and Hamao (1992)

[2] The problem of high correlation for stock pickers is well documented in a series of articles by J. Authers, columnist of the Financial Times

Sommario

La crisi finanziaria del 2007-2008 sarà ricordata per molti suoi aspetti eccezionali. Tra di essi, l'aumento spettacolare della volatilità dei mercati finanziari e in particolare modo della correlazione. Questo fenomeno è stato interpretato come una sorta di break strutturale nella dinamica del mercato azionario e come una dimostrazione del fallimento di uno dei pilastri della consulenza finanziaria: il valore della diversificazione. Si dimostrerà, al contrario, che l'aumento della correlazione non è sorprendente, dato l'aumento della volatilità del mercato e può essere ottenuto da un semplice modello CAPM dinamico. Nel paper, si calibrerà il modello sui 20 anni precedenti la crisi e si dimostrerà che esso spiega molto bene la dinamica della correlazione osservata. Infine, si utilizzerà il modello per verificare se il contesto del 2007-2008 avrebbe dovuto essere, ai fini della generazione di "alfa", sfavorevole per i gestori "bottom-up" e favorevole per i gestori "top-down".

Abstract

The 2007-2008 financial crisis will be remembered for many exceptional facts. Among them, the spectacular increase in stock market's volatility and correlation. This has been interpreted as a sort of structural break in stock market's dynamics and a proof of the fallacy of one of the central tenets of financial advisory services: the importance of portfolio diversification. I will show, on the contrary, that this phenomenon is not at all surprising, given the increase in market volatility, and it derives from a very simple dynamic CAPM model. I calibrate the model over the last 20 years and show that it fits very well the observed dynamic of stock markets' volatility and correlation. Finally, I use the model to investigate if the 2007-8 environment should have been detrimental to bottom-up managers and favourable for top-down manager, as far as "alpha" creation is concerned..

Nota biografica sugli autori

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Insegna International Financial Markets presso l'Università Cattaneo di Castellanza. Dal 1990 al 2000 è stato economista presso l'Ufficio Studi della Banca Commerciale Italiana (ora Intesa Sanpaolo), dove è stato responsabile della Financial Markets Research. Successivamente, ha svolto diversi incarichi nelle principali SGR italiane (Sanpaolo AM e Pioneer Investments), in Banca Patrimoni Sella e in UnipolSAI. Ha scritto articoli pubblicati su riviste internazionali. E' laureato in Università Bocconi (DES) e ha conseguito il MSc/MPhil in Economics presso la London School of Economics.

Biographical sketch

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Marcello Esposito teaches International Financial Markets at Università Cattaneo di Castellanza. From 1990 to 2000 he has been an economist at the Research department of the Banca Commerciale Italiana (now Intesa Sanpaolo), where he has been responsible for Financial Markets Research.

Therafter, he has worked in some of the major Italian asset management companies (Eurizon and Pioneer Investments), in Banca Patrimoni Sella and in UnipolSAI. He took his degree at Bocconi University and then earned the MSc/MPhil in Economics at the London School of Economics. He was born in Milan, 1963.