

DOES EQUITY RISK DECREASE IN THE LONG RUN? SOME EVIDENCE FROM FRENCH SECULAR DATA

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ABSTRACT:

A recent debate has sparked controversy on the relevance of accounting for market inefficiencies in the context of Solvency II (Lukassen and Pröpper 2007, Gollier 2007). The present article confirms long term mean reversion of French stock returns and shows the variation of asset relative risk which should induce a rational investor to own more stocks on the long run. Therefore the optimal asset allocation depends on the time horizon of the investor as the relative risk of stocks over bonds or bills progressively declines. One possible interpretation of this result is that equity is a better hedge against inflation risk, however empirical evidence of this latter assertion remains a matter of debate. Finally we highlight the issue of including this empirical evidence in the appraisal of insurer's market risk.

1. INTRODUCTION: THE ISSUE OF EQUITY RISK IN SOLVENCY II

The revision of the current European insurance directives (Solvency I) has crossed a decisive stage on the 10th of July 2007. The European Commission (EC) has issued a directive proposal (Solvency II) that reasserted the aims of the reform: improve consumer protection, modernise supervision, deepen market integration and increase the international competitiveness of European insurers. The new Solvency II (SII) system introduces a risk based prudential regime that require companies investing in risky assets to hold capital in order to be able to face their liabilities. This solvency capital requirement (SCR) will take into account all types of risk exposition (market risk, credit risk, operational risk...). The directive supports a Value at Risk (VaR) measure with a one year time horizon to determine the solvency capital requirement.

The issue of market risk, especially equity risk, remains a matter of debate among SII stakeholders. Some of them criticized the relevance of the equity charge of the standard formula as specified in the quantitative impact studies¹ (QIS). This criticism led to an

¹ All technical information about quantitative impact studies is available on CEIOPS website : <http://www.ceiops.org/content/view/118/124/>

alternative “duration approach” of equity risk in the third quantitative impact study (QIS3) and to an alternative “dampener approach” in QIS4. The rationale for these new approaches to equity risk is, according to QIS4 technical specifications¹, that it introduces “*distortion in the relative prices of assets*” which “*would result in a decrease of the insurers’ share in the funding of the economy*”. In other words, the short time horizon implied by a one year VaR measure biases insurers’ asset allocation towards safer assets as the capital requirement for more risky assets (such as stocks) does not take into account insurers’ investment horizon. However these alternative approaches have many flaws: the calibration of the volatility decrease is arbitrary, it is not consistent with the VaR one year measure and the arguments underlying the decrease of equity risk in the long run do not reach a consensus among SII stakeholders.

In this paper we clarify the arguments in favour of reducing the equity capital requirement when the time horizon of the company is long and show some evidence of stock mean reversion from French secular data. We partially confirm the mean reversion effect in line with the results of Bec and Gollier (2007). Section 2 summarizes the main results of financial theory and empirical research on market efficiency. Section 3 gives an insight of the stock mean reversion from French historical data over 200 years. Section 4 presents the results of fitting a GARCH model on stock returns to estimate the mean reversion effect and the results of fitting a multivariate (VAR) model on asset returns (stock, bonds and bills). Finally, Section 5 discusses the equity hedge against inflation risk.

2. LIMITS OF MARKET EFFICIENCY IN THE LONG RUN

Huber and Verall (1999) emphasise both the need for theory and empirical testing in developing actuarial economic models, and the need for judgment in their application. As a consequence, the current debate on fair value spills over into questions of market efficiency and mean reversion.

The standard financial economic theory asserts that time horizon should not impact optimal asset allocation if financial markets are efficient (Samuelson, 1969). According to this theory, stock market is completely unpredictable and the best guess of the market tomorrow may be represented by a geometric Brownian motion:

$$\frac{dS_t}{S_t} = \mu dt + \sigma dW_t^P$$

¹ EUROPEAN COMMISSION (2008) : QIS4 Technical Specifications (ARKT/2505/08). Annex SCR 8, 282-284.

In this model the continuously compounded return of asset price follows a normal distribution of mean μdt and variance $\sigma^2 dt$. The variance and mean of equity returns grows linear in time and the standard deviation with the square root of time. Then estimating the risk in the long term comes down to compute:

$$\sigma_T = \sigma\sqrt{T}$$

However, empirical evidence of mean-reversion in the behaviour of stock price (Campbell Viceira, 2002, Dimson, Marsh and Staunton 2002, Asher 2006, Bec and Gollier, 2007) put into question the standard approach for risk of equity returns. According to these studies, the annualised volatility of stock return decrease with time.

Using other measures of risk, Fedor and Morel showed in 2006 that the daily Value at Risk on an internationally diversified equity portfolio was systematically more pessimistic when using the square root approach than when randomly simulating daily equity returns. Albrecht et al., 2001 argue that *“under a worst-case perspective [...] an investment in stocks exhibits an increasing and substantial risk and that this characteristic is the true danger of a long-term investment”*. Their analysis of the German DAX stock index for different time horizons concludes that the mean excess loss (Tail-VaR) increases over time whereas the probability of a shortfall (VaR) decreases. The irrelevance of the time horizon for the level of stock in an investment would be verified if *“the growing improbability of a loss was offset by the increasing magnitude of potential losses”* (Kritzman, 1994). However Albrecht et al. recognize that *“the balance of these two effects is not compensatory. The shortfall probability over-compensates the mean excess loss to a certain extent”*.

A direct consequence of the decline of equity risk in the long run is the asset reallocation in favour of stocks for long term investors. If time diversification does exist, a buy-and-hold strategy is sub-optimal. Exley Mehta and Smith (2004) show that it is possible to propose a mean reverting model which is consistent with the weak form of market efficiency and with the hypothesis of no arbitrage opportunities.

These remarks make a strong case for the decay of equity risk in the long run and its implementation into insurance risk models. In the following parts, we investigate the evidence of mean reversion in French asset returns over 200 years.

3. EVIDENCE OF TIME DIVERSIFICATION FROM FRENCH SECULAR DATA

The notion of time diversification is equivalent to mean reversion. It underlines that investment opportunities are not constant over time which mean that an investor does not face the same risk-return arbitrage for different time horizons.

The first investigation of time diversification simply consists of a close look at the historical data. Following Dimson, Staunton and Marsh 2002, we compute the average annual real return on equity, bonds and short term bills and draw the historical distribution for different time horizons. The data set used for this study is publicly available and was built by CGPC¹. The data span ranges from 1802 to 2005 (204 annual observations). The variables are defined as follows:

For $t \in [1802, 2005]$, Q_t is the French consumer price index² and P_{it} is the price index for asset i :

Bonds: Value of an investment in bonds, interest reinvested, derived from the long term interest rate series³ on the French market, assuming the investor purchases a 10 year bond at the year's interest rate, keeps it for one year then sells it and purchases an new 10 year bond at the following year's interest rate.

Bills: Value of an investment on the money market, interest reinvested, derived from the short term interest rate series⁴ on the French market.

Stocks: Value of an investment in French stocks, dividend reinvested⁵

From these data we compute:

$$I_{t,k} = \ln\left(\frac{Q_t}{Q_{t-k}}\right) \text{ the inflation rate between } t-k \text{ and } t$$

$$R_{it,k} = \ln\left(\frac{P_{it}}{P_{it-k}}\right) \text{ the nominal return on asset } i \text{ between } t-k \text{ and } t$$

$$r_{it,k} = R_{it,k} - I_{t,k} \text{ The real return on asset } i \text{ between } t-k \text{ and } t$$

¹Source: J.Friggit (CGPC) series available at <http://www.edef.org/statistiques/index.htm>

²Source J.Friggit (CGPC) adapted from Chabert (1949), Lévy-Leboyer and Bourguignon (1985), INSEE

³Source : J.Friggit (CGPC) adapted from Vaslin (1999), Loutchitch (1930), INSEE and CDC-IXIS

⁴Source : J.Friggit (CGPC) adapted from Chabert (1949), INSEE and CDC IXIS

⁵Source : J.Friggit (CGPC) adapted from Arbulu (2000) and SBF250.

$r^a_{it,k} = \frac{R_{it,k} - I_{t,k}}{k} = \frac{r_{it,k}}{k}$ the average annual real return on asset i on the period $[t-k, t]$

If the returns are independent and identically distributed then:

$$r_{it,k} \sim L(k\mu, k\sigma^2) \text{ and } r^a_{it,k} \sim L(\mu, \sigma^2)$$

We first look at the distribution of average annual return. We can see from figure 1 that the average real return on stock is 4.5% and is constant over different time horizons. The quantiles of the distribution declines quicker than the square root of time, which gives us an insight of mean reversion. By comparing this result to the distribution of average annual return on bonds (figure 2) and bills (figure 3), it is obvious that in the long run, equities are less volatile than bills and bonds but it does not mean that equity risk decays over time.

We then look at the cumulated volatility of assets over different time horizons. We compute the annualised volatility as follows:

$$V^a(r_{it,k}) = \frac{V(r_{it,k})}{\sqrt{k}}$$

With $V(r_{it,k})$ the standard deviation of the total real return on asset i over the period $[t-k, t]$. If the returns are independent and identically distributed (i.i.d) then $V^a(r_{it,k})$ is a constant. If the returns mean revert then $V^a(r_{it,k})$ must be decreasing. Figure 4 shows that the annualised volatility of equity is increasing on the first three years, then slowly decreasing on the next 10 years and finally stabilizes around 17%. On the contrary, fixed income annualised volatilities show a strong mean aversion as they are increasing with the time horizon. Therefore, an investment in bonds (resp. bills) is more risky than an investment in stocks if the investor has a buy and hold strategy for more than 4 years (resp. 7 years). These results rely essentially on the inflation risk. Indeed, if we look at figure 5 which displays nominal annualised volatilities, we observe that volatilities are almost constant over time.

Overall, studies relying on a purely descriptive approach may be deceiving as the results may differ whether the risk measure is the total return at the horizon or the average annual return. Moreover the appraisal of risk differs if we take a worst case scenario point of view. For instance, if we draw the historical probability of facing a negative total real return and the average loss for different investment horizons (up to 30 years, figure 6) we

observe that the probability of losing money decreases whereas the average loss relatively increase for the 10 first years. However after this period, the average loss slowly decreases. This result confirms the idea that the increase in the average loss does not compensate the decrease in the probability of a loss which favours the hypothesis of a mean-reversion behaviour in stock returns.

4. MEASURE OF THE MEAN-REVERSION EFFECT ON ASSET RETURNS

The descriptive approach allows us to conclude that real asset risk is not constant over time and that fixed income risk overcome equity risk for long term horizons, presumably due to inflation risk. However this does not allows us to conclude that equity risk time diversifies. Indeed, the relative risk of stocks compared to bonds and bills decline, but the absolute risk of stock may increase. We now look at the specific question of mean reversion in equity returns. An in depth analysis of the concept of mean reversion has been presented by Exley, Mehta and Smith 2004. They propose two statistical definitions of mean reversion:

Definition 1: “An asset model is mean reverting if returns are negatively autocorrelated”.

The most common definition of mean reversion is the tendency of a given process to return to its trend path. This implies that returns are negatively autocorrelated which is a mathematical representation of the fact that below average returns tend to be followed by above average returns. The simplest model to account for mean reversion is an Autoregressive discrete time process:

$$R_t = \alpha + \beta R_{t-k} + \varepsilon_t$$

$$\varepsilon_t \sim N(0, \sigma)$$

k is the holding period, α is the trend. If $\beta = 1$ the process is a random walk if $-1 < \beta < 1$ the process is mean reverting: an above average return is followed by a below average return. The evidence of the mean reversion effect in stock price is mixed (see for example Howie and Davies, 2002 or Asher 2006). This analysis is subject to an important number of biases especially on the distribution of residuals and outliers. They should not be removed because mean reversion depends relatively on extreme values, even though they are likely to cause measurement error. We estimated autoregression for French equity return using a GARCH(1,1) framework to take into account the heteroscedasticity of the variance of residuals.

$$\begin{aligned}
R_t &= \alpha + \beta R_{t-k} + \sigma_t \varepsilon_t \\
\sigma_t^2 &= w + c\varepsilon_{t-1}^2 + d\sigma_{t-1}^2 \\
\varepsilon_t &\sim N(0,1)
\end{aligned}$$

The results for non-overlapping¹ time period are presented in table 1. The autocorrelation coefficient β is significant for holding periods of one and two years. Therefore yearly return exhibits a tendency to revert to the mean. However the autocorrelation coefficient is not significant for holding periods superior to three years. This is partly due to the drastic reduction in the sample but it also highlights the difficulty to forecast stock returns with an autoregressive specification.

Definition 2: “An asset model is mean reverting if interest rates (and volatilities), yields or growth rates are stationary”

According to Exley Mehta and Smith, 2004 the best way to test for mean reversion is to test for stationarity of the return or volatility process. For instance the mean reversion of bonds is obvious when analysing the decay of volatility of forward rates. However the authors are more sceptical about the mean reversion of equity returns. We tested for stationarity of equity, bonds and bills real returns over the period 1802-2005. The results of the Augmented Dickey Fuller (ADF) test for unit root and of the KPSS test are presented in table 2. The tests conclude that the process of stocks, bonds and bills returns are stationary.

Stationary series are expected to have the same mean and variance regardless of the time period over which they are measured. If an observation is far from the long term average, the next observation will likely be nearer. This result is partially confirmed for the French data.

Campbell and Viceira (2002) developed a vectorial autoregressive methodology to measure the mean reversion of asset returns. This methodology was applied on French data by Bec and Gollier (2007). They conclude that equity risk decays over time as the annualized volatility of stock returns progressively decline with time horizon. They conclude that, in the long run, an investment in stocks is relatively less risky than an investment in fixed income. We developed the same methodology on our data.

¹ We use non-overlapping time period to avoid the multiple use of the same year return which introduce autocorrelation between the different periods. This method is better from a statistical point of view but drastically reduces the number of data available for the analysis

The estimated model can be written

$$Z_t = \underset{(m,1)}{\Phi_0} + \underset{(m,1)}{\Phi_1} Z_{t-1} + \underset{(m,1)}{v_t}$$

$Z_t = \begin{bmatrix} r_{0,t} \\ x_t \\ S_t \end{bmatrix}$ is a 5x1 vector of variables with:

$r_{0,t}$ the short term real interest rate (risk free asset).

$x_{a,t} = r_{a,t} - r_{o,t}$ is the excess return of an investment in stocks over an investment in the risk free asset $x_{b,t} = r_{b,t} - r_{o,t}$ is the excess return of an investment in long term bonds over an investment in the risk free asset

X_t is a (2,1) vector of excess returns and S_t is the (2,1) vector of predictor variables. In the study we used the short term and long term interest rate spread (SPR_t) and the nominal interest rate ($R_{0,t}^{nom}$).

Φ_0 is the vector of model constants and Φ_1 is the matrix of estimated coefficients v_t is the vector of residuals which must be iid to ensure the validity of the analysis. $v_t \sim N(0, \Sigma_v)$ with Σ_v the variance-covariance matrix of residuals.

Campbell and Viceira (2004) compute the variance-covariance matrix of asset returns after k-périods¹ :

$$\begin{aligned} Var(Z_{t+1} + \dots + Z_{t+k}) &= \Sigma_v + (Id + \Phi_1)\Sigma_v(Id + \Phi_1)' \\ &\quad + (Id + \Phi_1 + \Phi_1\Phi_1)\Sigma_v(Id + \Phi_1 + \Phi_1\Phi_1)' + \dots \\ &\quad + (Id + \Phi_1 + \dots + \Phi_1^{k-1})\Sigma_v(Id + \Phi_1 + \dots + \Phi_1^{k-1})' \end{aligned}$$

This model is slightly different from the model presented in Gollier (2007) as we do not integrate the dividend price ratio as predictor variable. Indeed our stock return data already include the dividend which is supposedly reinvested and tax free.

The results of the VAR estimation (table 5) show the relatively good fit of the model for the risk free asset and predictor variables. The mean reversion coefficients are positive and statistically significant for excess returns which reinforce the mean reversion behaviour of the series. However the process of stock and bond excess returns is relatively

¹ An in depth description of this methodology is available in Campbell and Viceira (2004) Long Horizon Mean Variance user guide.

poorly fitted (low R^2). The residuals of our model are not autocorrelated up to lag 8 but they are heteroscedastic and non-normally distributed. The mean reversion can be inferred from the autoregressive coefficient of the excess return which is below 1.

The annualised standard deviations are plotted in figure 8. If investment opportunities were constant, the lines on the diagram would be horizontal, reflecting a constant annualised standard deviation. This is almost the case for holding bonds and bills where the risk remains constant around 15% and 11%. However figure 8 exhibits a decreasing slope for holding stocks which corroborates that French stocks are mean-reverting. The annualised standard deviation for this strategy is about 25% for one year and decreases to 19% over 30 years.. Consequently stocks appear less risky for long term investors. This result is in line with the conclusions of Campbell Chan and Viceira (2000) who find a decreasing stock risk from 19% for short term investors to 14% for 25-year investors from US secular data (1890-1998). However these results are considerably smaller than those of Bec and Gollier (2007) who fit this model of French data from 1970 to 2006.

5. EQUITIES AS A HEDGE AGAINST INFLATION RISK

In this section, we applied the Fama and Schwert (1977) methodology to measure market efficiency through the correlation between stock market returns and anticipated inflation. In an efficient market, where each investor uses all the available information to elaborate the fair price in the market, inflation anticipations are integrated into the price of share so that an upward shock in inflation anticipations derives into a greater nominal return to compensate for the erosion of money. Therefore we can write the theoretical (Fisher) relationship between expected nominal returns and anticipated inflation:

$$E(\tilde{R}_j | \phi_{t-1}) = E(\tilde{r}_j | \phi_{t-1}) + E(\tilde{i}_t | \phi_{t-1})$$

If financial markets are efficient, they must integrate all the information available at $t-1, (\phi_{t-1})$ in order to set the price of asset j so that the expected nominal return of this asset: $E(\tilde{R}_j | \phi_{t-1})$, corresponds to the sum of expected real return $E(\tilde{r}_j | \phi_{t-1})$ and the best possible guess of future inflation: $E(\tilde{i}_t | \phi_{t-1})$.

The simplest empirical test elaborated by Fama and Schwert (1977) assumes that expected real returns are constant (α_j) and that short term interest rates (B_t) are a good proxy for expected inflation.

Hence we can write the estimated model:

$$\tilde{R}_{jt} = \alpha_j + \beta_j \times B_t + \gamma_j \times [i_t - B_t] + \tilde{\eta}_{jt}$$

With $\tilde{\eta}_{jt}$ the i.i.d residuals of the model and β_j and γ_j the estimated coefficients for anticipated and unanticipated inflation. If $\hat{\beta}_j = 1$, asset j gives a complete hedge against anticipated inflation and if $\hat{\gamma}_j = 1$, asset j gives a complete hedge against unanticipated inflation.

The results of the ordinary least square (OLS) estimation of Fama and Schwert (1977) relationship over 200 years are displayed in table 7. Three years have been tested for structural breaks; they correspond to major financial changes. 1913 is the last year of financial stability before the first world war, 1953 is the last year of deflation in France (-1,8%) and 1986 corresponds to the end of the high inflation period. Chow breakpoint test identifies one structural break in 1953. Whereas equities hedge against inflation risk before 1953 the hedge disappears after 1953. The negative relationship is in agreement with Fama and Schwert results on American data. This surprising negative correlation between inflation and stock return has triggered a debate in the economic literature to solve the so-called “stock-inflation puzzle”. Recent studies (Madsen 2005, Rouabah 2007) manage to exhibit a positive correlation when taking account of temporal instability of the relationship. Fama (1981) argued that the negative relationship was caused by a “proxy” bias. The level of inflation is negatively correlated with the level of economic growth whereas growth is positively correlated with stock returns. Other explanations put forward the irrational behaviour of investors in incomplete markets. All in all, the economic theory fails to give a clear answer to this problem.

6. CONCLUSION:

The aim of this paper was to investigate different methodologies to measure stock return mean reversion in order to check the pertinence of including risk mitigating procedures for long term investors who invest in stocks. The descriptive analysis puts forward that, over long periods of time, equities have produced returns about 4% higher than those on bonds. These higher returns are associated with a lower increase in risk when investing in equities.

The statistical analysis gives some evidence of mean reversion in the French stock return over the last two centuries but the effect is far less strong than previously measured by Bec and Gollier (2007). The decay of equity risk over time, relatively to an increasing risk on bonds and bills, may be a consequence of the investor inflation anticipations. Fixed income's returns are exposed to inflation risk whereas stock returns integrate investor's inflation expectations. The economic literature on the subject of the "stock-inflation puzzle" has considerably developed since the first work by Fama and Schwert (1977) and empirical results remain mitigated.

Overall, there is no clear cut answer on the issue of mean reversion and on the possible causes of this mean reversion. A risk modeller intending to take mean reversion into account in order to justify a greater amount of risky asset in its portfolio can rely on a batch of models available in the actuarial literature (see Asher (2006) for a recent review of these models). But the effort to fit the model to the data is relatively less important than the need for a better appraisal of model risk. Alternative modelling can considerably alter the final results and an actuarial economic model should take into account parameter uncertainty as well as model uncertainty. Empirical evidence of mean reversion remains, and will certainly remain, a matter of debate. In a context of validation of internal models the regulator should rather focus on the sensitivity of the final results to the model specifications.

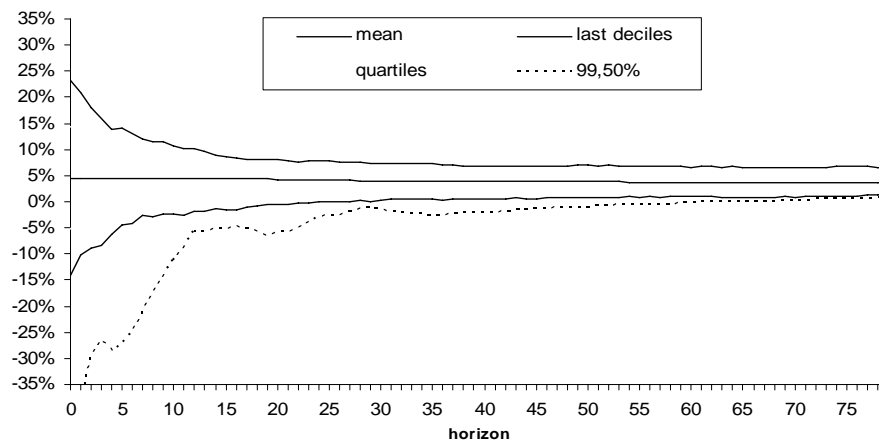


Figure 1: Development over time of the distribution of average real return on French stocks

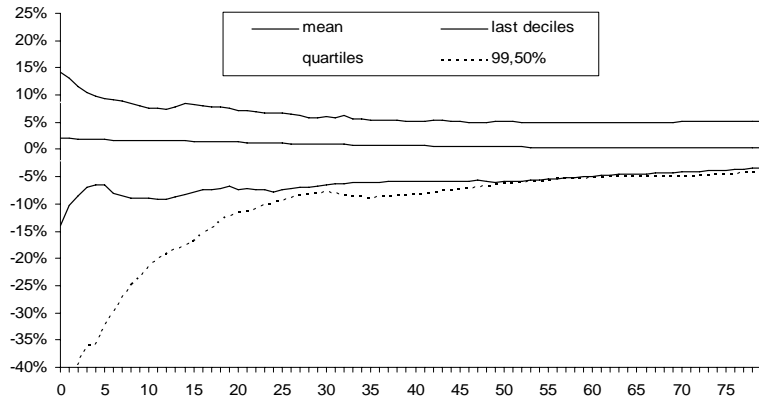


Figure 2: Development over time of the distribution of average real return on French long term bonds (10 years)

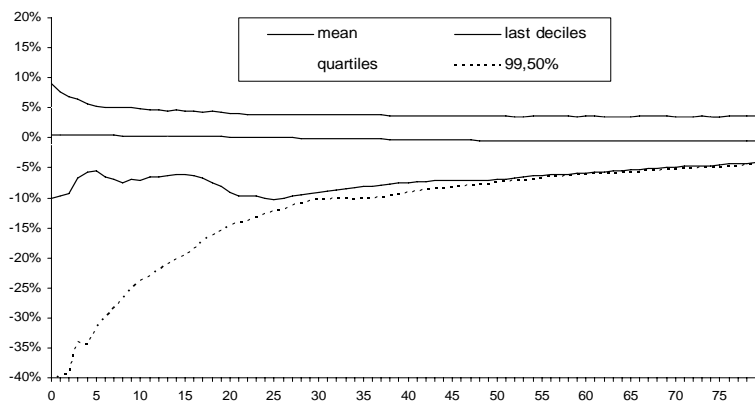


Figure 3: Development over time of the distribution of average real return on French short term bills (1 year)

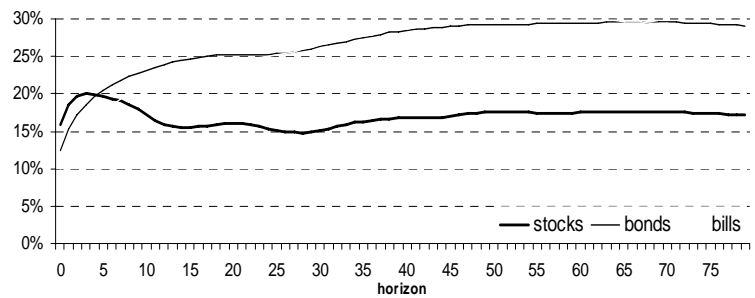


Figure 4: Development over time of the annualised total real return volatility

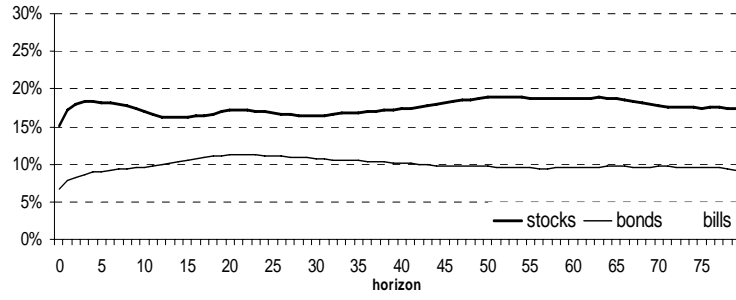


Figure 5: Development over time of the annualised total nominal return volatility

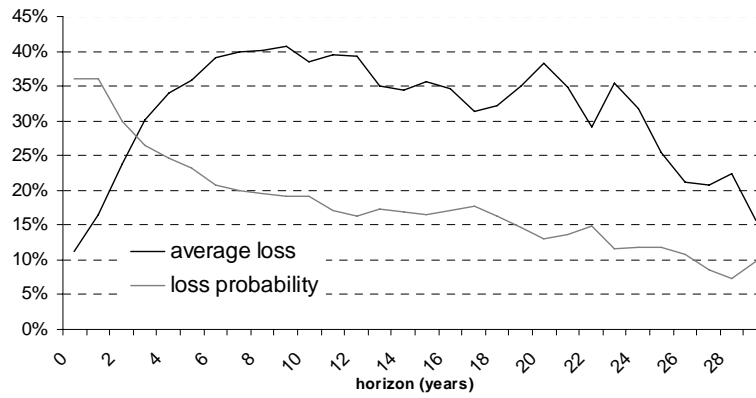


Figure 6: Probability of observing a negative return and average loss (% of investment) on the investment in stocks

horizon	1	2	3	4	5
sample	201	101	67	50	40
model	GARCH(1,1)	GARCH(1,1)	GARCH(1,1)	AR(1)	AR(1)
α	0,045**	0,089**	0,157**	0,236**	0,217**
β	0,335**	0,217**	-0,030	-0,151	-0,141

** : significant at the 1% level

Table I: autocorrelation of French equity returns

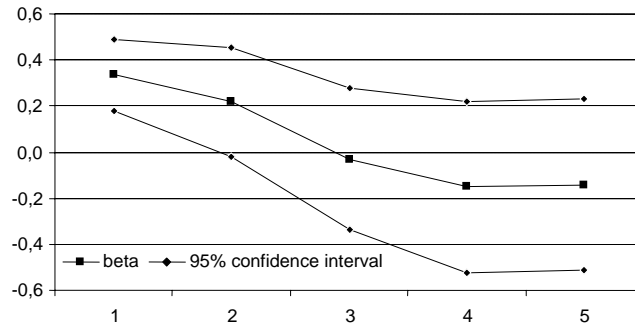


Figure 7: Autocorrelation of French equity returns over different holding period

	Stocks	Bonds	Bills
ADF-stat	-10,18 (0)	-7,82 (0)	-7,93 (0)
p-value	0,000	0,000	0,000
KPSS-stat	0,32 (0)	0,40 (9)	0,39 (9)
1%	0,74	0,74	0,74

Table 2: Unit root tests

(x) : number of lags in the ADF-test determined by Schwarz automatic selection criteria. Bandwidth in the KPSS test fixed with the Newey West automatic selection criteria. ADF test must reject H0 if the process is stationary whereas KPSS test must not reject H0 if the process is stationary.

	Mean	Standard deviation
$r_{o,t}$	4,34%	2,28%
$x_{a,t}$	4,07%	14,99%
$x_{b,t}$	1,51%	6,39%
$r_{0,t}^{nom}$	8,81%	11,38%
spr_t	1,26%	1,43%

Table 3: descriptive statistics

	$r_{o,t}$	$x_{a,t}$	$x_{b,t}$	$r_{0,t}^{nom}$	spr_t
ADF-stat	-4,83 (2)	-10,34 (0)	-11,08 (0)	-1,78(6)	-2,83 (4)
p-value	0,000	0,000	0,000	0,390	0,057

Table 4: Unit root test

We see that the nominal interest rate is non stationary which can bias the results of the analysis.

	$r_{o,t}$	$x_{a,t}$	$x_{b,t}$	spr_t	$r_{0,t}^{nom}$
$r_{o,t-1}$	0,3455 <i>0,0595</i>	0,0921 <i>0,1122</i>	0,1237 <i>0,0448</i>	-0,0143 <i>0,0069</i>	0,0008 <i>0,0078</i>
$x_{a,t-1}$	0,0372 <i>0,0392</i>	0,2500 <i>0,0739</i>	-0,0410 <i>0,0295</i>	-0,0127 <i>0,0046</i>	0,0137 <i>0,0051</i>
$x_{b,t-1}$	0,0703 <i>0,0896</i>	-0,0140 <i>0,1690</i>	0,1613 <i>0,0675</i>	0,0114 <i>0,0104</i>	-0,0251 <i>0,0117</i>
spr_{t-1}	-0,1932 <i>0,3998</i>	1,9065 <i>0,7539</i>	1,3511 <i>0,3011</i>	0,7724 <i>0,0464</i>	0,1490 <i>0,0523</i>
$r_{0,t-1}^{nom}$	0,0896 <i>0,2358</i>	0,4790 <i>0,4446</i>	0,3227 <i>0,1776</i>	0,0466 <i>0,0274</i>	0,9158 <i>0,0308</i>
Constante	0,0117 <i>0,0137</i>	-0,0174 <i>0,0258</i>	-0,0132 <i>0,0103</i>	0,0008 <i>0,0016</i>	0,0016 <i>0,0018</i>
R ²	63,45%	25,90%	41,41%	68,41%	84,52%

Standard deviations in italic

Table 5: estimation output of the VAR(1) process

	$r_{o,t}$	$x_{a,t}$	$x_{b,t}$	spr_t	$r_{0,t}^{nom}$
$r_{o,t}$	7,1%	-4,2%	2,1%	-0,3%	-0,1%
$x_{a,t}$		13,3%	37,7%	-1,4%	-3,1%
$x_{b,t}$			5,3%	3,1%	-69,7%
spr_t			3,1%	0,8%	-74,1%
$r_{0,t}^{nom}$					0,9%

Table 6: standard deviations and correlations of residuals of the VAR(1)

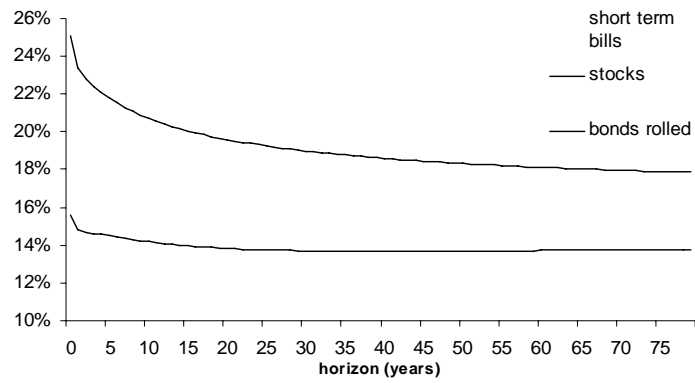


Figure 8: Annualised standard deviation of real returns

	1804-2005	1804-1953	1953-2005
observations	202	150	52
α	0,064	-0,003	0,141
β	0,521	2,219	-0,982
γ	0,255	0,309	-1,634
$P(\alpha)$	0,036	0,952	0,043
$P(\beta)$	0,396	0,052	0,273
$P(\gamma)$	0,008	0,001	0,102
R^2	0,270	0,388	0,139

Table 7: OLS estimate of Fama and Schwert model

Modèle	année	F stat	P()
1803-2005	1913	2,067	0,086
1803-2005	1953	2,834	0,039
1953-2005	1986	1,161	0,340

Chow breakpoint test

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