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How Much Does the Stock Market Risk Decline with the Investment Horizon? A Cross-Country Comparison

CARLO A. FAVERO* – FEDERICO NUCERA†

We perform a cross-country comparison of stock market risk. Stock market risk is defined as the standard deviation of cumulative stock market returns. We model stock market returns in a VAR(1) system jointly with bond returns and a set of predictive variables. Our results provide evidence of a strong negative horizon effect for US stock market returns and a weak negative horizon effect for Germany and France. When an open economy VAR(1) is considered, we find that stock market risk increases for the United States and Germany, while the evidence for France is mixed.

(*J.E.L.*: *G10*, *G11*, *G15*, *G22*, *G28*).

1. Introduction

Starting from the seminal works by Samuelson (1969) and Merton (1969, 1973) on portfolio choice, financial economists have devoted increasing attention to the problem of asset allocation. A well-established point in this strand of literature is that asset return predictability may produce significant differences in the allocation strategies of short- and long-term investors. More recently, an important contribution in this field is provided by Barberis (2000), which focuses on the implications that the predictability of US asset returns has for the investment decisions of long horizon investors. Notably, by assuming that asset returns follow the dynamic of a first-order vector autoregression, VAR(1), process with dividend yield used as predictor, this work finds that the implied standard deviation of US stocks' returns at 10-year horizon is much lower (23.7 per cent) than the one which arises from the usual assumption of i.i.d. returns (45.2 per cent). The influential studies by Campbell and Viceira (2002, 2005) confirm these findings. Preserving the simple VAR(1) framework used by Barberis (2000), they provide strong evidence of mean-reversion for US stock returns since the standard deviation of annualized returns

*Department of Finance, Bocconi University, Milan, Italy
†Corresponding author: Federico Nucera, Department of Economics and Finance, Luiss Guido Carli, Rome, Italy

decreases from 18 per cent at 1-year horizon to 14 per cent at 25-year horizon, thereby showing a strong negative dependence on the investment horizon.

The negative relationship between asset returns volatility and investment horizon, evidenced by Campbell and Viceira (2002, 2005), may result in a *wedge* between asset allocation strategies of investors with different time horizons. In other words, long horizon investors may find stocks more attractive than short horizon investors as stock returns volatility decreases with the investment horizon.

It is quite surprising that, despite the results provided by Campbell and Viceira (2002, 2005) and Barberis (2000) having deep implications in terms of asset allocation, few studies have tried to extend their analysis by taking the European case into consideration. Hence, this paper aims to fill this gap in the literature also in light of the new regulation about the solvency of insurance companies, the so-called *Solvency II* that is currently near to implementation in the European Union. According to this new regulatory framework, the capital requirements of insurance companies should be computed according to the asset and liability risks measured on a 12-month basis. Clearly, to evaluate the efficiency of this requirement, it is crucial to examine the relationship between asset risk and investment horizon and, hence, to investigate the degree of *mean-reversion* of European asset returns. In fact, a regulation that does not take asset returns predictability into consideration may fail to recognize that volatility decreases with the investment horizon, thereby forcing insurers to allocate wealth towards assets traditionally considered less risky, such as bonds.

A work very related to ours is Bec and Gollier (2009), where the relationship between the asset returns volatility and the investment horizon is investigated for the French case. However, our approach differs in at least two important aspects. First, we extend the set of countries taken into consideration by also applying our analysis to Germany. Second, we use an open-economy VAR to pick up the effects of international linkages and omitted variables on asset return risks. This allows us, on the one hand, to investigate important spill-over effects on the standard deviation of asset returns while preserving the appealing structure used by Campbell and Viceira (2002, 2005) and, on the other, to study the role of foreign assets as an alternative asset class for domestic investors. Indeed, the literature on this topic is scarce as few papers provide an empirical assessment of the horizon profile of risk for investments in foreign assets. A notable exception is the work by Campbell et al. (2003) which, by focusing on short-term debt only, demonstrates that foreign currency (i.e. foreign bills) may offer a hedge against interest rate risk for long-term investors. However, in our open-economy VAR formulation, we take into consideration a larger set of assets than Campbell et al. (2003).

As a starting point, we follow Campbell and Viceira (2002, 2005) and estimate a closed-economy VAR of real asset returns for the German, French and US financial markets over the period of 1973Q4–2008Q2. Our basic system includes short-term ex post real interest rates, excess stock market returns, excess bond returns and variables that are traditionally recognized as return predictors, i.e. the short-term nominal interest rate, the dividend–price ratio and the spread between long- and short-term bonds. For each country, we use the VAR estimates to extract the annualized standard deviation of asset returns and compare them over the investment horizon.

Interestingly, while for the US case we obtain results very close to Campbell and Viceira (2002, 2005), i.e. strong evidence of *mean-reversion* of stock returns, the *mean-reversion* of German and French stocks' returns is weaker, thereby enlightening important differences in terms of risk. Putting it differently, the annualized standard deviation of cumulative US stock returns seems to be much more sensitive to time horizon.

Afterwards, we evaluate the effects of financial contagion and exchange rates risk on asset returns volatility. For this purpose, we extract the annualized standard deviation of asset returns from an open-economy VAR(1) estimated over the period of 1975Q4–2008Q2. In this specification, asset returns of two different countries and exchange rates are inserted in the same system. The main results of this further analysis can be summarized as follows. First, once linkages amongst financial markets are considered, we find that US stock returns volatility still decreases with the time horizon but shifts upwards, implying an overall increase in risk w.r.t. the closed-economy case. Volatility of stock returns also shifts upwards for German stock returns, while it shifts downwards for French stock returns. Second, we find that the annualized standard deviation of US stock returns denominated in dollars is considerably lower than the standard deviation of US stock return denominated in foreign currency. Furthermore, French and German investors that invest in the US stock market suffer levels of volatility not lower than the ones that they would have suffered by investing in their domestic stock markets once exchange rate risk is taken into consideration. Although our results are relevant just to long-term investors adopting a buy-and-hold strategy to investments in stock markets, they might provide an explanation for the well-known *home-bias* effect in stock market investments at least as far as risk is concerned.

The paper is organized as follows. Section 2 describes the model specification along with the methodology we use to extract standard deviations from a simple VAR(1) system. Section 3 describes the dataset and provides sample statistics of French, German and US asset returns. Sections 4 and 5 compare asset conditional volatility arising from the closed economy and the open economy, respectively, while Section 6 concludes.

2. Empirical Analysis

Following Barberis (2000) and Campbell and Viceira (2002, 2005), we describe asset return dynamics by means of a first-order vector autoregressive or VAR(1) model. We choose a VAR(1) as the inclusion of additional lags, even if easily implementable, would reduce the precision of the estimates. In the specification, we also add a set of variables that can be used by the investor for forecasting returns. Hence, we have

$$z_t = \Phi_0 + \Phi_1 z_{t-1} + \nu_t \tag{1}$$

where

$$z_t = \begin{bmatrix} r_{0t} \\ x_t \\ s_t \end{bmatrix} \tag{2}$$

is a $m \times 1$ vector with r_{0t} being the real short-term rate, x_t being the $n \times 1$ vector of log excess returns and s_t being the $(m - n - 1) \times 1$ vector of returns predictors.

In the VAR(1) specification, Φ_0 is a $m \times 1$ vector of intercepts and Φ_1 is a $m \times m$ matrix of slope coefficients. Finally, ν_t is a $m \times 1$ vector of innovations in asset returns and returns' predictors for which standard assumptions apply, i.e.

$$\nu_t \sim \mathcal{N}(0, \Sigma_\nu), \tag{3}$$

where Σ_ν is the $m \times m$ variance-covariance matrix.

To extract the k-period conditional variance of asset returns, we first estimate the closed-economy/open-economy VAR model and use the estimation to simulate the model K-periods ahead with $K = 100$ quarters, i.e. 25 years. Then, we allow for errors in the forecasting equations by inserting a stochastic term into them. Finally, we compute cumulative asset returns as $(z_{T+1} + \cdots + z_{T+K})$ and, then, we compute their variance. More formally, as in Campbell and Viceira (2002, 2005), we calculate the variance of the cumulative returns as:

$$\begin{aligned} &\mathrm{Var}_t(z_{T+1} + \cdots + z_{T+K}) \\ &\quad = \Sigma_\nu + (I + \Phi_1)\Sigma_\nu(I + \Phi_1)' \\ &\qquad + \left(I + \Phi_1 + \Phi_1^2\right)\Sigma_\nu\left(I + \Phi_1 + \Phi_1^2\right)' + \cdots \\ &\qquad + \left(I + \Phi_1 + \cdots + \Phi_1^{K-1}\right)\Sigma_\nu\left(I + \Phi_1 + \cdots + \Phi_1^{K-1}\right)'. \end{aligned} \tag{4}$$

Using this procedure, we get the value of the variance of the real cumulative returns and, as a by-product, the annualized standard deviation. The latter is computed by multiplying the square root of the quarterly variance by 200.

3. Dataset Description

In this section, we describe our dataset and provide descriptive statistics for asset returns over the period of 1973Q4–2008Q2. In order to construct our quarterly dataset, we take end of quarter values from monthly time-series. Following Campbell and Viceira (2002), we define r_{0t} as the real ex post short-term rate, e.g. the difference between the log return on the 3-month short-term rate and the log inflation rate. The log return on the 3-month short-term rate is also used to measure the log short-term nominal interest rates, denoted as r_{0t}^{nom}.

The short-term rate is the 3-month interbank rate, i.e. US LIBOR for the United States, FIBOR for Germany and PIBOR for France. All these series are taken from Datastream.

The log inflation rate is computed as $\log(cpi_t) - \log(cpi_{t-1})$, where *cpi* is the Consumer Price Index series (for the United States, this series is obtained from the FRED database; while for Germany and France, the CPI series is downloadable from Datastream). Data for equity prices and returns are taken from the Morgan Stanley Capital International (MSCI) database and are available starting from January 1973. In particular, for each country, quarterly stock market data are retrieved from the MSCI Total Return Index and from the MSCI National Price, all in local currency. Applying to these series the procedure described in Campbell (1999), we derive quarterly stock returns. The quarterly dividends series, instead, is obtained simply as the MSCI Total Return Index multiplied by the MSCI dividend yield.

It is worth noting that we move slightly from Campbell (1999) as we do not include tax credits on dividends. In fact, as pointed out by Bec and Gollier (2009), it is likely that both the taxation rate and the way dividends are taxed have not remained fixed over the sample period considered. Thus, it might not be a sensitive choice to apply a unique tax rate to all the samples, as in Campbell (1999). Hence, we choose not to incorporate tax credits on dividends since the application of a fixed coefficient to all the observations would not affect volatility.

In our analysis, we denote by r_{et} the quarterly log real return on the stock index, defined as difference between the log returns on equities and the log inflation rate. The log excess return on equities is defined as $x_{\text{et}} = r_{\text{et}} - r_{0t}$ and the log dividend–price ratio, ldp_t, is defined as the log difference between dividends and price index. As far as the bond market is concerned, for each country in the sample we calculate bond yields on the basis of long-term (10-year) government bonds (source: Datastream). We calculate the log excess return on bonds as $x_{\text{bt}} = r_{\text{bt}} - r_{0t}$, where r_{bt} is the log real return on bonds, i.e. the difference between $r_{\text{bt}}^{\text{nom}}$ and the log inflation. $r_{\text{bt}}^{\text{nom}}$ is the long-term government bond return and is computed using the log-linear approximation technique described in Campbell et al. (1997), chapter 14. Namely:

$$(5) \qquad r_{b,n,t+1}^{\text{nom}} \approx D_{nt} y_{nt} - (D_{nt} - 1) y_{n-1,t+1},$$

where n is the bond maturity (here 10 years), y_{nt} is the log bond return [i.e. $y_{nt} = \log(1 + Y_{nt})$] and D_{nt} is the bond duration computed as:

$$(6) \qquad D_{nt} \approx \frac{1 - (1 + Y_{nt})^{-n}}{1 - (1 + Y_{nt})^{-1}}.$$

Note that, following Campbell and Viceira (2002), we approximate $y_{n-1,t+1}$ as $y_{n,t+1}$.

For each country, the yield spread, spr_t, is defined as the difference between the long-term bond yield and the 3-month interbank rate.

Finally, we compute the log difference of the exchange rate (defined as the amount of domestic—i.e. German or French—currency needed for obtaining one unit of foreign—i.e. US—currency) as

$$(7) \qquad de_{t,k/\text{US}} = (k/\text{usd})_t - (k/\text{usd})_{t-1}$$

where $(k/\text{usd})_t$ is the log of the exchange rate, measured at time t, between the currency of country k—e.g. Germany (dm) or France (ff)—and the US dollar (usd). Data for exchange rates are taken from the Bank of England database and start from 1975Q1.

In Table 1, we provide descriptive statistics of asset returns (including exchange rate returns vis-à-vis the usd) and forecasting variables for Germany, France and the United States. Note that for each variable except for the dividend–price ratio, means and standard deviations are reported in annualized percentage points. Note also that, as stock returns do not include tax credits, their mean could be downwards biased. In order to annualize quarterly data, we multiply means by 400 and standard deviations by 200. As expected, standard deviation is much higher for stocks than for bonds for all the countries in our sample. Compared to the German financial markets, French stock and bond excess returns exhibit lower means and higher standard deviations. Interestingly, the standard deviation of the US real log return on stocks is lower than the standard deviation of real log returns on stocks of Germany and France.

Table 1: Descriptive Statistics for Asset Log Returns and Forecasting Variables (the United States, France and Germany)

	GER Mean	Std. dev.	FR Mean	Std. dev.	United States Mean	Std. dev.
r_0	2.64	1.06	2.44	1.48	2.16	1.50
x_e	5.16	20.30	4.76	22.94	6.48	17.10
x_b	1.88	6.74	1.68	7.10	0.92	9.32
r_0^{nom}	5.32	1.24	7.24	1.78	6.68	1.70
ldp	−4.56	0.22	−4.73	0.35	−4.26	0.30
spr	1.04	0.74	0.88	0.62	0.52	0.86
de	−1.56	11.93	0.30	11.57	–	–

4. European and US Asset Risk across Investment Horizons

In this section, we compare the conditional annualized standard deviations of asset returns—extracted from three closed-economy VARs—across investment horizons. For each country (USA, Germany and France), we adopt the same specification as in Campbell and Viceira (2002, 2005) and Bec and Gollier (2009), i.e. z_t in Equation (1) is a (6×1) vector such that $z_t = (r_{0t}\ x_{\text{et}}\ \ x_{\text{bt}}\ r_{0t}^{\text{nom}}\ ldp_t\ spr_t)'$. If returns were not predictable, i.e. i.i.d., the annualized standard deviation of the cumulative returns would not depend on the investment horizon. Conversely, if returns were predictable, we should observe at least some degree of dependence. More specifically, to get more insights about asset returns predictability, we plot for each country the annualized standard deviations of the cumulative real returns implied by the estimated closed-economy VAR model. We consider the cumulative returns obtained by investing in four classes of financial assets or investment strategies, namely: (i) investing in equities; (ii) investing in the short-term rate (i.e. the interbank rate, which is assumed to be the *risk-free* asset); (iii) investing in a bond-rolled strategy, in which the investor keeps the maturity of a government bond constant by buying a 10-year bond each period and selling it next period in order to buy a new 10-year bond;[1] and (iv) investing in a buy and hold strategy (also called bond held), in which the investor buys a government bond and holds it until maturity K.[2]

In Figure 1, we plot annualized standard deviation of US, German and French real returns across investment horizons up to 100 quarters, i.e. 25 years. Our benchmark is the US financial market, panel A in Figure 1, since previous literature (e.g. Campbell and Viceira, 2002, 2005) finds evidence of strong *mean-reversion* of equities and—even if less remarkable—*mean-*

[1]Note that this strategy is the one implicitly assumed in the long-term bond returns time series.

[2]The risk associated to this strategy is essentially inflation risk, since the nominal value of the bond is guaranteed and the standard deviation of real returns is equal to the standard deviation of cumulative inflation from T to time $T + K$.

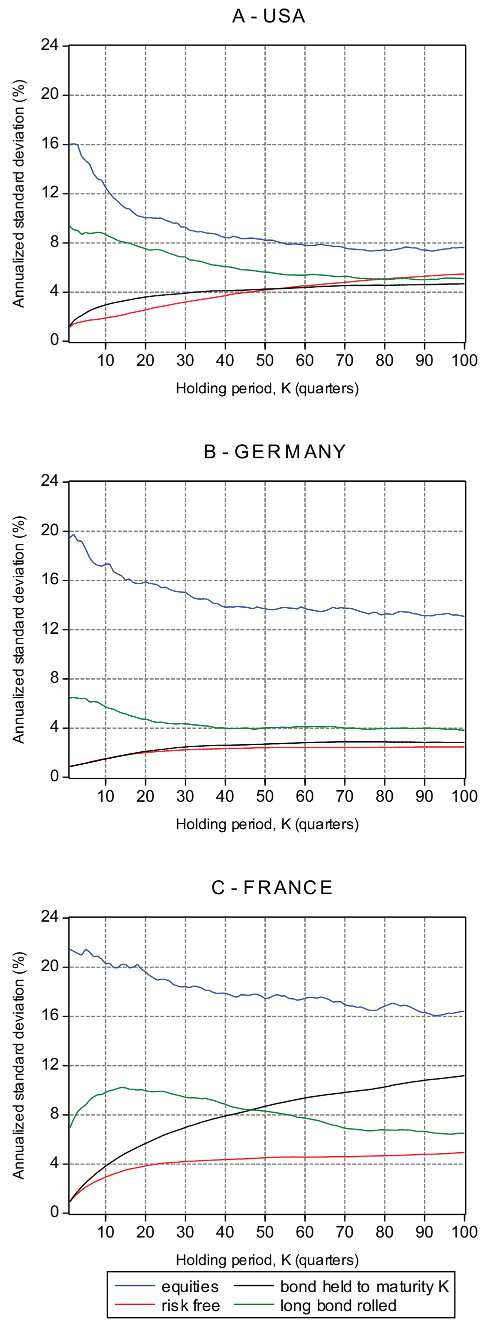

Figure 1: Annualized standard deviations (per cent) of real excess returns (US, GER, FR, closed-economy VAR)

reversion of bonds (bond-rolled strategy). It is worth noting that, although our sample is different, our findings support the theory that the US stock returns and the US bond-rolled strategy are *mean-reverting*. Specifically, US annualized standard deviation for equities declines sharply: from 16 per cent to 8.2 per cent in the first 50 quarters, and further to 7.6 per cent at $K = 100$. This is exactly the same as in Campbell and Viceira (2002, 2005). Similarly, the annualized standard deviations of the bond-rolled strategy is almost one third less—9 per cent vs. 5.6 per cent—after 50 quarters and then it declines up to 5 per cent. The short-term asset (US LIBOR) and the bond held strategy are *mean-averting*, and again this is consistent with Campbell and Viceira (2002, 2005). Thus, in terms of asset allocation, we can infer that, for the US case, stocks are still the riskiest assets even at the long horizon but the relative riskiness of bearing stocks rather than other assets decreases with the time horizon.

In panel B of Figure 1, we plot the annualized standard deviation of German real returns. Comparisons with the US case are very interesting. As for the United States, German stock returns are less volatile at longer horizons rather than at the short horizon. The annualized standard deviation of German real stock returns declines from about 19.4 per cent to 13.7 per cent after 50 quarters and then it stays almost constant. However, the decline in volatility is not as steep as for the United States. In fact, the end of period (i.e. for $K = 100$) annualized standard deviations of German stock returns are much higher than the end of period annualized standard deviations of US stock returns (13 per cent vs. 7.6 per cent), implying that German stocks are much riskier even at the very long horizon. As for the US case, also for Germany, the annualized standard deviation of the bond-rolled strategy is *mean-reverting*, declining from 6.45 per cent to 3.83 per cent along the investment horizon. The German risk-free asset (FIBOR) and the bond held strategy are *mean-averting*, but they appear less risky than their US counterparts. For instance, the annualized standard deviation of the German bond held strategy is always lower than that of the US bond held strategy. This should not be a surprise; in fact, the bond held strategy is a proxy for inflation risk and the German Bundesbank has always devoted a lot of effort to keeping inflation low.

The annualized standard deviation of French real stock returns for investment horizons up to 100 quarters is shown in panel C of Figure 1. In this case, the volatility of stock returns decreases from 21.4 per cent to 16.4 per cent: in other words, French stock returns exhibit a lower degree of *mean-reversion* than US and German stock returns. The annualized standard deviation of the bond-rolled strategy first jumps from 7 per cent to 10 per cent after 15 periods and then declines up to 6.5 per cent. The *mean-aversion* of real returns on the short-term asset (PIBOR) and of the bond held strategy is also confirmed for France. Note that, with respect to Germany, investing in the French short-term asset is riskier, as the annualized standard volatility of real returns on PIBOR goes from 0.9 per cent to 4.9 per cent, while for Germany it goes from 0.85 per cent to 2.7 per cent. Overall, our analysis may have relevant indications for asset allocation for at least two reasons.

First, it points out that for the United States, Germany and France, stock returns have a certain degree of predictability. The easiest way to explain this predictability is to look at VAR estimates[3] for these countries and notice that—at least at the 10 per cent level—the log dividend–price ratio is a forecasting variable for stock returns. In all the cases, there is a strong negative correlation between stock returns shocks and dividend–price ratio shocks. As a consequence, a positive shock on excess stock returns results in a negative shock on the dividend–price ratio and bad news about the dividend–price ratio produces a downward revision of expectations about *future* stock returns.

Second, from our analysis, it emerges that the degree of *mean-reversion* of real excess stock returns is very strong for the United States and much weaker for the two European countries that we take into consideration. This implies that while for the United States the relative magnitude of asset returns risks changes with the investment horizon, being the relative riskiness of stocks w.r.t. other assets lower at the long end, for Germany and France the relative riskiness of stocks (especially w.r.t. the bond-rolled strategy) is almost unchanged. In fact, the annualized standard deviation of stocks' returns is much higher than the annualized standard deviation of bond-rolled strategy at the long horizon. However, with respect to Germany, France is also characterized by a strong inflation risk (this is evidenced by the volatility of the French bond held strategy), which in turn may increase the appeal of French stocks to long horizon investors even if the standard deviation of the bond held strategy is still lower (16.4 per cent vs. 11.2 per cent).

5. Implications from the Open-Economy VAR(1)

In this section, we discuss the implications of enlarging our original closed-economy VAR(1) specification by including omitted variables and exchange rates in the system. In the last few years, linkages and contagions amongst financial markets have increased and this provides the rationale to consider in the same model US excess returns and predictors jointly with excess returns and predictors from a country k, where k stands, alternatively, for Germany or France. In addition, we argue that it is also worth including exchange rates in the system. In fact, the inclusion of exchange rates allows us to consider an *additional* class of financial asset returns, i.e. the returns, expressed in domestic currency, that an investor from Germany or France

[3] For brevity we have chosen not to insert closed-economy VAR estimates in the paper but they could be obtained upon request.

gets by investing in the US financial markets. Putting it differently, the inclusion of exchange rates in the system allows us also to consider exchange rate risk.

The vector z_t in Equation (1) becomes a (13×1) vector since we model jointly six US variables ($r_{0t,\mathrm{US}}\ x_{\mathrm{et,US}}\ x_{\mathrm{bt,US}} r^{\mathrm{nom}}_{0t,\mathrm{US}}\ ldp_{t,\mathrm{US}}\ spr_{t,\mathrm{US}}$), six country k variables ($r_{0t,k}\ x_{\mathrm{et},k}\ x_{\mathrm{bt},k}\ r^{\mathrm{nom}}_{0t,k}\ ldp_{t,k}$) and the exchange rate $de_{t,k/\mathrm{US}}$. We allow for two different specifications (US–Germany and US–France) and estimate two open-economy VAR(1) models in order to get insights about the stock market risk faced by German and French investors. The open-economy VARs are estimated using quarterly data from 1975Q4 to 2008Q2 since exchange rates series are available from 1975Q1. For each open-economy VAR specification, risk is again measured as the annualized standard deviation of real returns. We consider the same classes of assets/investment strategies as before (i.e. equities, risk-free, bond-rolled and bond held). Open-economy VAR(1) estimates are shown in Tables 2 and 3.

In Figure 2, we plot the annualized standard deviations of US stock market real returns implied by four VAR specifications: the closed-economy VAR plus two open-economy VARs (US–Germany and US–France). The annualized standard deviation of stock returns implied by the open-economy VARs still decreases across the investment horizons but is shifted upwards w.r.t. the standard deviation implied by the closed-economy VAR. Hence, financial contagion increases the risk of the US stock market even if the *mean-reversion* of US stock returns is preserved once the open-economy specification is considered.

Then, for each class of financial assets, we compare the annualized standard deviations of domestic—i.e. German and French—asset returns arising from both the closed-economy and the open-economy VAR to the annualized standard deviation of US asset returns, denominated in domestic currency. This allows to evaluate the effects of financial contagion and exchange rates oscillation on the risk faced by German and French investors. For instance, in Figure 3, we plot the annualized standard deviations of real asset returns for a German investor. In the upper-left panel of Figure 3, we compare the annualized standard deviations of German stock returns implied by the closed-economy VAR, the standard deviation of German stock returns implied by the open-economy VAR and the standard deviation of US stock returns expressed in Deutsche Marks/Euros. The interaction amongst German and US financial markets increases the risk faced by a German investor since—at almost all the horizons—the annualized standard deviation of stock returns from the open-economy model is shifted upwards w.r.t. the standard deviation arising from the closed-economy model. Moreover, once exchange rate risk is taken into consideration, US stocks look less appealing since, both at the short horizon and at the long horizon, their standard deviation is not lower than the standard deviation of German stock

[h]

Table 2: VAR US–Germany Estimation Results

	$r_{0,t,\text{US}}$	$x_{e,t,\text{US}}$	$x_{b,t,\text{US}}$	$r^{\text{nom}}_{0,t,\text{US}}$	$ldp_{t,US}$	$spr_{t,US}$	$r_{0,t,\text{GER}}$	$x_{e,t,\text{GER}}$	$x_{b,t,\text{GER}}$	$r^{\text{nom}}_{0,t,\text{GER}}$	$ldp_{t,GER}$	$spr_{t,GER}$	$de_{t,GER/US}$
$r_{0,t-1,\text{US}}$	0.209	1.441	1.028	−0.189	−0.022	0.128	0.103	2.877	0.332	−0.033	−0.030	0.024	1.857
	[2.02]	[1.00]	[1.15]	[−3.05]	[−1.56]	[2.72]	[1.40]	[1.49]	[0.54]	[−1.37]	[−1.40]	[0.94]	[1.87]
$x_{e,t-1,\text{US}}$	0.008	0.036	−0.068	0.007	−0.0003	−0.004	0.004	−0.010	−0.041	0.002	−0.0001	−0.0007	−0.032
	[0.94]	[0.30]	[−0.91]	[1.37]	[−0.28]	[−1.21]	[0.70]	[−0.06]	[−0.80]	[1.08]	[−0.09]	[−0.34]	[−0.38]
$x_{b,t-1,\text{US}}$	0.016	−0.024	0.041	−0.0007	0.0003	0.0001	0.019	0.034	0.167	−0.002	−0.0010	−0.002	−0.431
	[1.00]	[−0.10]	[0.29]	[−0.07]	[0.15]	[0.01]	[1.67]	[0.11]	[1.70]	[−0.60]	[−0.31]	[−0.60]	[−2.70]
$r^{\text{nom}}_{0,t-1,\text{US}}$	0.97	−4.87	0.350	1.276	0.047	−0.267	−0.080	−1.128	0.218	−0.039	−0.003	0.033	1.035
	[4.36]	[−1.57]	[0.18]	[9.51]	[1.49]	[−2.64]	[−0.50]	[−0.27]	[0.16]	[−0.75]	[−0.08]	[0.59]	[0.48]
$ldp_{t-1,US}$	−0.005	12.386	−0.414	−0.013	0.912	0.016	0.399	7.755	−2.135	0.048	−0.028	0.034	−9.040
	[−0.01]	[3.05]	[−0.16]	[−0.07]	[22.12]	[0.12]	[1.92]	[1.42]	[−1.23]	[0.69]	[−0.47]	[0.47]	[−3.21]
$spr_{t-1,US}$	1.037	−6.003	3.287	0.417	0.058	0.517	−0.105	−1.540	1.972	−0.205	−0.023	0.143	1.186
	[3.43]	[−1.43]	[1.26]	[2.30]	[1.37]	[3.77]	[−0.49]	[−0.27]	[1.10]	[−2.85]	[−0.37]	[1.90]	[0.41]
$r_{0,t-1,\text{GER}}$	−0.026	−1.620	−0.563	−0.0003	0.012	0.020	−0.023	−2.838	−1.120	0.004	0.022	−0.001	0.731
	[−0.18]	[−0.83]	[−0.46]	[−0.004]	[0.62]	[0.32]	[−0.24]	[−1.09]	[−1.35]	[0.15]	[0.78]	[−0.04]	[0.54]
$x_{e,t-1,\text{GER}}$	−0.005	−0.080	−0.038	0.001	0.0007	0.0001	−0.006	0.035	0.005	−0.0005	0.00002	0.0002	0.199
	[−0.75]	[−0.85]	[−0.65]	[0.28]	[0.72]	[0.05]	[−1.29]	[0.27]	[0.12]	[−0.36]	[−0.02]	[0.13]	[3.02]
$x_{b,t-1,\text{GER}}$	−0.023	0.266	−0.341	0.018	−0.002	−0.007	−0.022	0.316	−0.108	−0.007	−0.002	0.010	0.045
	[−1.07]	[0.88]	[−1.82]	[1.40]	[−0.91]	[−0.72]	[−1.43]	[0.78]	[−0.84]	[−1.38]	[−0.58]	[1.96]	[0.21]
$r^{\text{nom}}_{0,t-1,\text{GER}}$	−0.644	1.039	0.429	− 0.276	−0.019	0.257	0.346	−3.649	2.255	1.008	0.002	−0.086	3.278
	[−2.55]	[0.29]	[0.19]	[−1.82]	[−0.54]	[2.25]	[1.93]	[−0.77]	[1.71]	[16.80]	[0.03]	[−1.37]	[1.35]
$ldp_{t-1,GER}$	−0.850	−1.343	−0.384	−0.180	0.024	0.166	−0.768	5.133	1.019	−0.009	0.889	−0.058	5.934
	[−2.82]	[−0.32]	[−0.14]	[−1.00]	[0.58]	[1.21]	[−3.60]	[0.91]	[0.57]	[−0.13]	[14.32]	[−0.78]	[2.05]
$spr_{t-1,GER}$	−0.895	4.768	1.218	−0.392	−0.045	0.335	−0.212	−0.457	3.859	0.124	−0.016	0.762	2.293
	[−2.83]	[1.08]	[0.44]	[−2.06]	[−1.01]	[2.34]	[−0.94]	[−0.07]	[2.06]	[1.65]	[−0.25]	[9.62]	[0.75]
$de_{t-1,GER/US}$	0.005	−0.079	0.079	−0.006	0.007	0.003	−0.013	−0.099	0.023	−0.0005	0.0006	−0.0007	−0.040
	[0.63]	[−0.64]	[1.03]	[−1.12]	[0.58]	[0.85]	[−2.05]	[−0.59]	[0.44]	[−0.24]	[0.35]	[−0.35]	[−0.47]
c	−0.041	0.550	−0.050	−0.008	−0.003	0.008	−0.014	0.647	−0.083	0.002	−0.006	−0.0005	−0.202
	[−2.73]	[2.62]	[−0.38]	[−0.95]	[−1.41]	[1.23]	[−1.32]	[2.30]	[−0.93]	[0.65]	[−1.93]	[−0.13]	[−1.39]
R^2	0.54	0.14	0.12	0.87	0.94	0.67	0.50	0.11	0.16	0.95	0.78	0.86	0.31

t-statistics in [ ]

Table 3: VAR US–France Estimation Results

	$r_{0,t,\mathrm{US}}$	$x_{e,t,\mathrm{US}}$	$x_{b,t,\mathrm{US}}$	$r^{\mathrm{nom}}_{0,t,\mathrm{US}}$	$ldp_{t,US}$	$spr_{t,US}$	$r_{0,t,\mathrm{FR}}$	$x_{e,t,\mathrm{FR}}$	$x_{b,t,\mathrm{FR}}$	$r^{\mathrm{nom}}_{0,t,\mathrm{FR}}$	$ldp_{t,FR}$	$spr_{t,FR}$	$de_{t,FR/US}$
$r_{0,t-1,\mathrm{US}}$	0.074 [0.69]	−1.461 [−1.00]	−0.718 [−0.76]	−0.091 [−1.36]	0.006 [0.41]	0.088 [1.77]	0.198 [2.30]	−1.586 [−0.75]	0.836 [1.17]	−0.053 [−1.23]	0.0003 [0.01]	0.023 [0.64]	1.000 [0.97]
$x_{e,t-1,\mathrm{US}}$	0.010 [1.217]	−0.046 [−0.39]	−0.056 [−0.75]	0.005 [0.92]	0.0003 [0.25]	−0.002 [−0.60]	0.011 [1.62]	−0.052 [−0.31]	−0.027 [−0.48]	0.001 [0.46]	0.0003 [0.16]	0.00001 [0.004]	0.094 [1.14]
$x_{b,t-1,\mathrm{US}}$	0.027 [1.78]	0.212 [1.00]	0.054 [0.40]	0.008 [0.90]	−0.002 [−1.07]	− 0.009 [−1.37]	0.0006 [0.05]	0.195 [0.64]	0.072 [0.69]	0.006 [1.05]	0.00009 [−0.03]	−0.009 [−1.75]	−0.262 [−1.76]
$r^{\mathrm{nom}}_{0,t-1,\mathrm{US}}$	1.766 [4.23]	3.557 [0.62]	10.230 [2.80]	0.908 [3.47]	−0.050 [−0.86]	−0.237 [−1.21]	0.200 [0.59]	4.345 [0.53]	−0.435 [−0.15]	0.091 [0.54]	−0.017 [−0.19]	−0.062 [−0.43]	11.482 [2.88]
$ldp_{t-1,US}$	−0.463 [−1.57]	6.485 [1.61]	−2.612 [−1.01]	0.118 [0.64]	0.967 [23.60]	−0.047 [−0.34]	0.607 [2.57]	1.101 [0.19]	−0.273 [−0.13]	0.074 [0.62]	0.033 [0.52]	−0.049 [−0.49]	−10.274 [−3.65]
$spr_{t-1,US}$	1.621 [3.43]	0.741 [0.11]	12.836 [3.11]	0.067 [0.22]	−0.024 [−0.37]	0.536 [2.43]	0.683 [1.80]	−1.602 [−0.17]	1.043 [0.33]	0.022 [0.11]	0.041 [0.41]	−0.032 [−0.20]	12.847 [2.84]
$r_{0,t-1,\mathrm{FR}}$	0.340 [2.67]	5.301 [3.05]	1.250 [1.12]	−0.076 [−0.95]	−0.048 [−2.74]	0.041 [0.69]	0.234 [2.29]	7.100 [2.83]	0.504 [0.59]	−0.027 [−0.52]	−0.104 [−3.86]	−0.022 [−0.50]	−0.902 [−0.74]
$x_{e,t-1,\mathrm{FR}}$	0.0002 [0.03]	0.077 [0.84]	−0.001 [−0.02]	0.001 [0.23]	−0.0006 [−0.69]	−0.001 [−0.45]	−0.012 [−2.21]	0.170 [1.27]	0.001 [0.03]	−0.0004 [−0.17]	−0.001 [−0.78]	−0.0003 [−0.15]	0.047 [0.73]
$x_{b,t-1,\mathrm{FR}}$	−0.021 [−1.11]	−0.003 [−0.01]	−0.086 [−0.52]	−0.006 [−0.52]	−0.00001 [0.006]	0.008 [0.93]	−0.003 [−0.20]	0.080 [0.21]	0.006 [0.05]	−0.011 [−1.48]	−0.001 [−0.47]	0.012 [1.88]	0.015 [0.08]
$r^{\mathrm{nom}}_{0,t-1,\mathrm{FR}}$	−0.797 [−2.65]	−7.416 [−1.80]	−7.025 [−2.67]	0.150 [0.80]	0.070 [1.68]	0.091 [0.65]	0.102 [0.42]	−9.350 [−1.58]	0.243 [0.12]	0.967 [7.91]	0.098 [1.54]	0.028 [0.27]	−5.757 [−2.00]
$ldp_{t-1,FR}$	0.156 [0.49]	10.036 [2.30]	3.160 [1.13]	−0.218 [−1.09]	−0.075 [−1.70]	0.097 [0.65]	−1.069 [−4.17]	17.641 [2.81]	0.775 [0.36]	−0.156 [−1.20]	0.721 [10.68]	0.083 [0.76]	5.200 [1.70]
$spr_{t-1,FR}$	−0.429 [−1.07]	2.883 [0.52]	−6.467 [−1.84]	0.242 [0.96]	−0.016 [−0.29]	−0.009 [−0.05]	−0.460 [−1.43]	3.580 [0.45]	2.116 [0.79]	0.171 [1.04]	−0.039 [−0.46]	0.764 [5.59]	−10.907 [−2.84]
$de_{t-1,FR/US}$	0.0006 [0.07]	−0.097 [−0.74]	0.026 [0.32]	−0.005 [−0.92]	0.001 [0.82]	0.004 [1.09]	0.010 [1.40]	−0.286 [−1.52]	−0.019 [−0.31]	0.0006 [0.16]	0.002 [1.35]	0.0006 [0.18]	−0.116 [−1.27]
c	−0.026 [−1.54]	0.807 [3.53]	−0.010 [−0.07]	−0.006 [−0.60]	−0.005 [−2.12]	0.004 [0.63]	−0.026 [−1.93]	0.945 [2.86]	0.017 [0.16]	−0.005 [−0.75]	−0.012 [−3.52]	0.003 [0.51]	−0.273 [−1.70]
R^2	0.56	0.21	0.15	0.86	0.94	0.67	0.68	0.18	0.10	0.94	0.91	0.67	0.31

t-statistics in [ ]

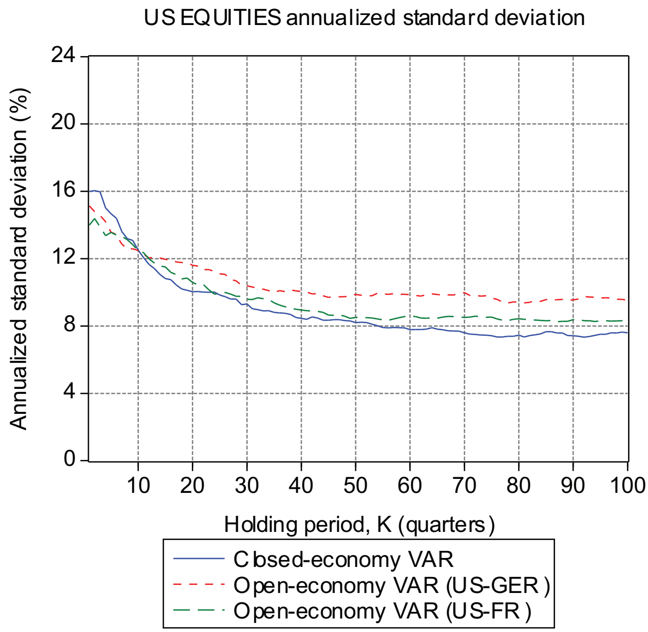

Figure 2: Annualized standard deviations (per cent) of US real stock returns

returns implied by the open-economy VAR. It is worth noting that the only class of asset for which we observe a clear difference between closed- and open-economy models is that of equities. Moving clockwise in Figure 3 and examining the other assets (i.e. the short-term rate plus the bond-rolled and the bond held strategies), it is possible to conclude that using an open-economy model produces no relevant differences in terms of risk arising from investing in the short-term asset and in the bond-rolled and bond held strategies, since there is no significant change in the correspondent volatility. However, investing in the United States and converting the proceeds into domestic currency is always the riskiest option for a German investor as the annualized standard deviation of the returns of this additional asset is always higher than the annualized standard deviation faced by investing in the domestic market. This confirms the findings obtained by Campbell et al. (2003), i.e. that dollars are riskier than Euros for German investors at all horizons, and extend them to a wider range of asset classes.

In Figure 4, we plot annualized standard deviations of real asset returns for a French investor. As for stock market risk, looking at the upper-left panel of Figure 4, it is clear that taking into account US–France linkages lowers the risk. In fact, the annualized standard deviation of real stock market returns extracted from the open-economy VAR(1) declines from 20.6 per cent to 14.7 per cent, while for the closed-economy case it just decreases

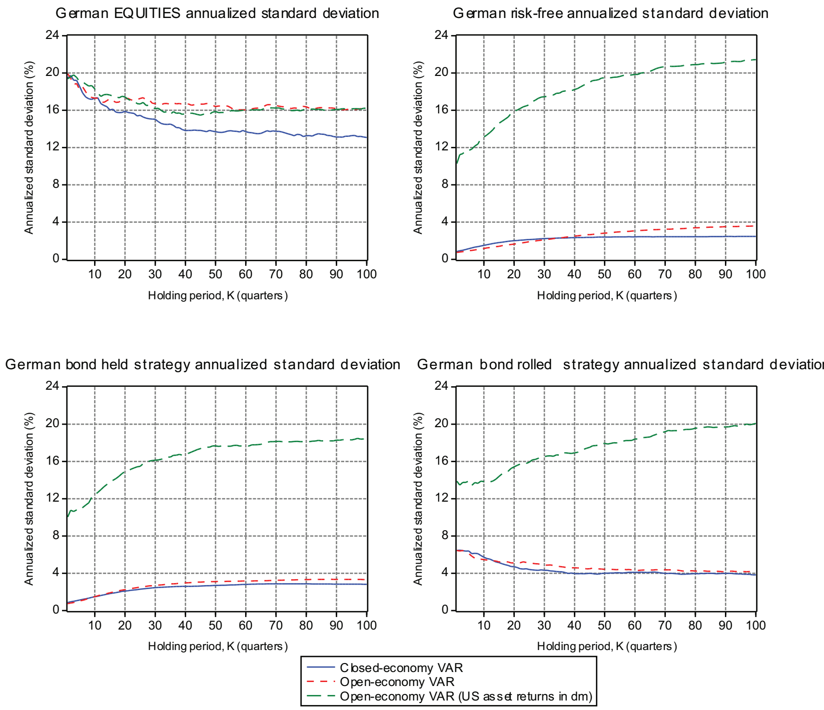

Figure 3: Annualized standard deviations (per cent) of real asset returns for a German investor

from 21.4 per cent to 16.4 per cent. However, the standard deviation of the domestic real stock returns extracted from the open-economy model is still considerably higher than the standard deviation of returns obtained by investing in the domestic short-term asset or by investing in the domestic bond market (this is true either for the bond held strategy or for the bond-rolled strategy). This means that the open-economy specification does not dramatically lower the relative riskiness of French stocks w.r.t. other French asset risks. The annualized standard deviation of US stock returns expressed in French Francs/Euros surges starting from quarter 40, implying that it is much riskier for a French investor to invest in US stocks rather than investing in the French stock markets (the long horizon standard deviation in the first case is 21 per cent, while it is 14.7 per cent in the second). Moreover, similarly to the German case, the standard deviations of US returns earned by investing in the short-term asset and in bonds explode, once exchange rate risk is incorporated. Summing up, our results confirm that stocks are always the riskier asset amongst all the assets considered. Due to exchange rates risk, investing in the US does not decrease the risk faced by German and French investors. Hence, our analysis points out some rationales—*at*

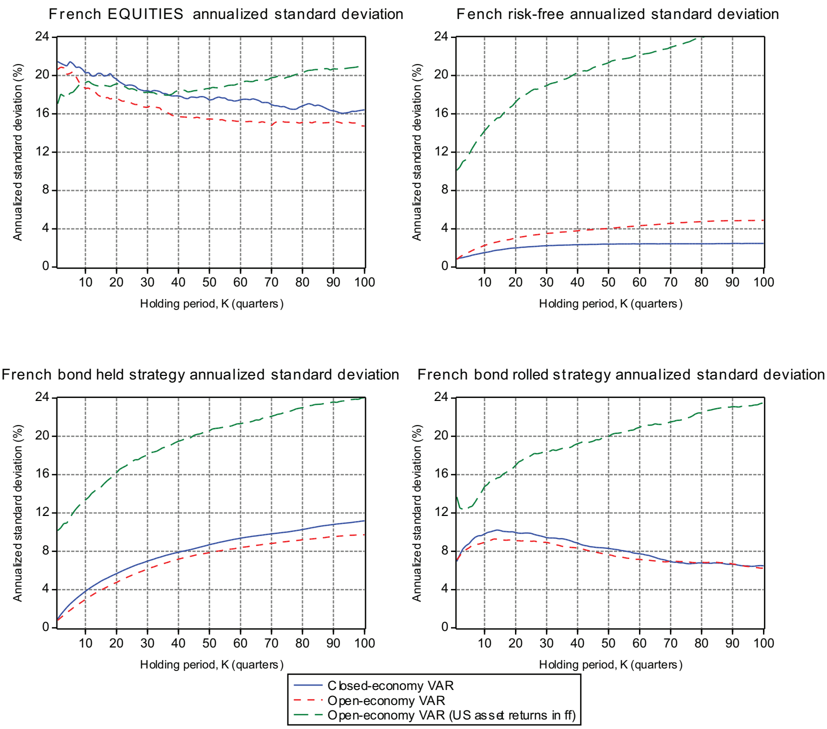

Figure 4: Annualized standard deviations (per cent) of real asset returns for a French investor

least as far as risk is concerned—to *home-bias* for the categories and the strategies of investments considered.

6. Conclusions

Our analysis investigates German and France asset returns volatility and compares it with US asset returns volatility. The main focus is stock market volatility. The standard deviations are those implied by a VAR(1) model estimated in two specifications. The first is the traditional closed-economy specification used, amongst others, by Campbell and Viceira (2002, 2005) and Bec and Gollier (2009). The second is an open-economy specification that aims to incorporate spill-over effects on international financial markets and exchange rates risk.

Results from the first specification show that German and French stock returns have a certain degree of predictability but not as strong as for US stock returns. In fact, the long horizon annualized standard deviation of real US stock returns is much lower than the standard deviations of German and

French stock returns (7.6 per cent vs., respectively, 13 per cent, 16.4 per cent and 18.5 per cent).

Furthermore, results from the open-economy VAR imply that international financial contagion increases stock market returns volatility. In fact, the annualized standard deviation of stock returns shifts upwards w.r.t. the closed-economy specification for the United States and Germany and shifts downwards only for France. Hence, even if with some *caveats*, the results of open-economy analysis provide support to *home-bias* in financial market investing, at least as far as risk is concerned. As for the stock markets, we find that the risk of investing in the US stock markets rather than in the domestic stock market is higher/not lower—once exchange rates risk is considered—for French and German investors.

Our results might have strong implications for asset allocation and regulation (e.g. Solvency II). In fact, our analysis implies that the extension of the time horizon over which risks are measured should not be a rationale for European insurers to prefer stocks to other asset classes in their asset allocation strategy.[4] A promising avenue for further research in this area would be to investigate if our results still hold when the uncertainties (e.g. parameter uncertainty) faced by European investors are directly addressed in the empirical analysis. Indeed, for the case of US investors, Pastor and Stambaugh (2012) show that mean reversion could be more than offset by different sources of uncertainties and, as a consequence, annualized volatility of stock returns might not be lower over long horizons than over short horizons.

[4]Note that this statement refers just to the risk profile of the assets considered. Taking into consideration the risk–return trade-off is indeed beyond the scope of our analysis.

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Non-technical Summary

This paper performs an empirical cross-country comparison of stock market risk. Indeed, previous literature (e.g. Campbell and Viceira, 2002, 2005) has often found a negative relationship between US stock market risk, i.e. volatility of stock returns, and the investment horizon. However, despite this evidence having deep implications in terms of asset allocation, few studies have tried to extend their analysis by taking the European case into consideration. We fill this gap in the literature by investigating the relationship between stock market risk and investment horizon for two European countries, namely France and Germany, and compare them with the United States. Our results provide further evidence of a strong negative horizon effect for US stock market returns, but only a weak negative horizon effect for

Germany and France. Finally, when interlinkages across financial markets and exchange rates risk are considered, we find that the rationale in terms of risk for a German or French investor to invest in the United States decreases as, for most of the time, the risk profile of the US assets denominated in the domestic (i.e. German or French) currency is higher than the risk profile of domestic assets.