US Stocks and the US Dollar

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Abstract

The purpose of this paper is to study the relation between US stock prices, as exemplified by the S&P 500 stock index, and the change in eleven foreign exchange rates against the US dollar. The null hypothesis of no-cointegration fails to be rejected for all dual specifications. Granger-causality tests on the log returns reveals no effect of the exchange rates on stock prices, but there is Granger causality of US stock prices upon three foreign exchange rates. The model developed requires the inclusion in the regressions of the change in the cost of equity. The latter is substituted for by the baa or the aaa corporate bond yield. All regressions are estimated with a GARCH(1,1) model of the conditional variance. The regressions of stock log returns on the log returns of each foreign exchange rate uncover significant impacts for five different rates. However when the 'fundamental variable' is added to the regressions, which is the change in the cost of equity, replaced by the change in the baa corporate bond yield, the above impacts reduce to only one with an additional impact that is marginally significant. If the change in the aaa corporate bond yield replaces the change in the cost of equity two significant impacts out of the eleven are found, with one additional marginal result. The evidence is therefore rather strong that the US stock market and the US dollar are effectively independent of each other once fundamentals are accounted for.

Keywords: S&P 500 stock returns, US dollar, eleven foreign currencies, Gordon constant growth dividend model, fundamental and non-fundamental variables, corporate bond yields, dividend yield, cointegration, Granger-causality

1. Introduction

The purpose of this paper is to find out whether US domestic and international financial markets are statistically significantly integrated. In other terms the paper studies whether there is a link between the US stock market and the foreign price of the US dollar. In the abstract the link could be unidirectional, bidirectional, or could show a lead-lag behavior. For this purpose Granger-causality tests are undertaken. These tests depend on the statistical process followed by the variables, especially if these are variance and covariance stationary or not. That is why stationarity tests are conducted before Granger-causality tests are applied. Another hypothesis that is tested in this study is whether US stock prices move in the long run together with the US dollar or whether there is only a short run co-movement. For this sake cointegration procedures are employed.

The theory behind a relation between stock markets and foreign exchange rates derives from two different origins. The first is termed the flow approach and the second is the stock approach. The flow approach is concerned about the current account of the balance of payments (Dornbusch and Fischer, 1980). A depreciation of the foreign exchange rate makes export-oriented firms more competitive internationally. Hence they sell more and have more profits generated from international trade. Since stock prices are equal to discounted future cash flows, and since higher earnings mean higher cash flows, then stock prices are positively impacted. Nonetheless such a relation breaks down, and changes signs, if firms are import-oriented, relying on foreign inputs into their production process. A depreciation of the foreign exchange rate raises the cost of inputs and squeezes profits, lowering stock prices. In both cases the causality runs from the foreign exchange rate to the stock market.

The stock approach is oftentimes named the portfolio balance theory (Frankel, 1983). If stock prices are higher this makes people believe that they are now wealthier. Higher perceived wealth increases the domestic and foreign demand for the US dollar which thereby appreciates. Higher wealth increases also the domestic demand for money, raising interest rates which attract more foreign capital inflows. In this case again the US dollar appreciates. However if central banks react by countering the rise in interest rates by stimulating the economy with more money supply, interest rates may either regain their initial level, fall below that level, or remain higher than originally. As a result the US dollar either stays the same, or depreciates, or may still appreciate. However, there is an inherent problem with such a transmission mechanism. The changes in stock prices are considered exogenous. But in fact they are not. Stock prices depend on two factors: future earnings and the discount rate. If future earnings are higher, or if the discount rate is lower, then stock prices will surge. Stock prices cannot surge in a vacuum. There is a need to know which of the two factors has changed because stock prices will change only if one or both of these two factors change. If the change comes from earnings then this approach becomes similar to the flow approach whereby product exports or input imports affect earnings, and consequently stock prices. If the change comes from the discount rate the underlying theory need to clearly and explicitly specify this connection in the model.

In the next section the literature is surveyed. In section 3, a simple theoretical model is derived which incorporates all of the above determinants of stock prices. In section 4, the source of the data is stated and the statistical behavior of the variables is studied. In this same section the empirical estimations are carried out. One of the major themes and findings of this paper is that the data are unable to isolate any significant relation between US stock prices and the US dollar. This applies for most of the eleven currencies against the US dollar that are part of the research herein. Consequently, and maybe unfortunately, this removes one policy instrument, and one financial indicator, from the hold of the domestic US monetary authorities, but generates substantial opportunities in international portfolio diversification of total risk. The last section concludes.

2. The Literature

The start in the literature is with the empirical determinants of stock prices. For example the negative relation between inflation and stock returns is well established. For a rather recent survey see Azar (2010). Higher inflation increases the required discount rate and affects detrimentally stock prices, especially if there is money illusion. However Azar (2010) presents empirical evidence that such a negative relation is spurious and that it fades away when a fundamental variable is added to the regressions. This is true in whatever form the inflation variable is measured: actual inflation, expected inflation, unexpected inflation, or separate positive and negative inflation. This fundamental variable is defined in the next section.

Some authors consider that, since inflation and inflation uncertainty move positively together, the appropriate relation is between inflation uncertainty, and not inflation, with stock returns. The rationale is twofold. Higher inflation uncertainty increases the required risk premium, leads to a higher discount rate, and lowers the discounted present value of expected future cash flows, thus resulting in a fall in stock prices (Malkiel, 1979). The other reason is that economic activity is adversely affected by inflation uncertainty (Friedman, 1977) and, since stock returns lead economic activity, there is a negative relation between stock returns and inflation uncertainty. There is no one theoretical basis for how to measure inflation uncertainty. In this respect all measures of inflation uncertainty are ad hoc. Usually in the literature inflation uncertainty is measured by a GARCH process of the conditional variance (Engle, 1982; Bollerslev, 1986). The earliest study that uses the GARCH methodology is Buono (1989). He finds little evidence for a negative relation between conditional variance and stock returns. However Alexakis et al. (1996) find a significant negative relation for a sample of emerging economies which are characterized by high inflation rates. Lee (1999), Hu and Willett (2000), and Bhar (2010) all find significant negative relations. Lee (1999) uses contemporaneous data and is mainly concerned with unexpected inflation and conditional variance, while Hu and Willett (2000) and Bahr (2010) include in their regressions lagged variables of inflation uncertainty. The problem with the latter two papers is that the Efficient Markets Hypothesis, (Fama, 1965, 1970, 1991), is presumed wrong by allowing stock returns to be a function of lagged variables, known in advance, and hence making stock returns essentially predictable. Another drawback is that, in some sample periods, GARCH estimation fails dramatically because of the inexistence of a significant relation for the conditional variance. This necessitates considering other measures of inflation uncertainty than conditional variance within a GARCH model. Azar (2012) singles out two other and different proxies for inflation uncertainty: absolute inflation, and the square of inflation. Although inflation uncertainty supplants in significance inflation in the stock regressions, Azar (2012) finds that inflation uncertainty has an insignificant effect on stock prices when the same fundamental variable as before is included in the regressions. The conclusion is strong that inflation uncertainty does not affect stock prices. A possible theoretical explanation for such a result is that inflation uncertainty affects both the discount rate of expected future cash flows, and the magnitude of these expected future cash flows, raising both, and keeping the present value and stock prices unchanged. Since inflation uncertainty and inflation are positively related higher inflation uncertainty coincides with a higher discount rate and with higher nominal expected future cash flows.

Instead of including inflation, or inflation uncertainty, as determinants of stock returns some parts of the literature have included exchange rates. If inflation is imported from abroad then inflation and exchange rate changes move together closely, and the two variables represent the same source of variation. Ratner (1993) runs cointegration tests between the S&P 500 stock index and the dollar exchange rates for Canada, France, Italy, Japan, the United Kingdom and West Germany. He uses monthly data from March 1973 to December 1989. He generally fails to reject no-cointegration, and shows that the relation is unstable and period or regime specific. He concludes that, contrary to the popular financial press, there is no long run relation between exchange rates and stock prices.

Yang and Doong (2004) explore the transmission mechanism between the mean and volatility of exchange rates and stock prices. They use weekly data. The stock indexes and exchange rates considered are for the G-7 group of countries. Cointegration tests are negative, i.e. no long run relation exists between stock prices and exchange rates. Their evidence shows that stock markets exert a significant impact on future foreign exchange rates, but that the reverse is only weakly true.

Phylaktis and Ravazzolo (2005) study five Pacific Basin countries with monthly data. They conduct cointegration tests and Granger-causality tests to examine the short run and the long run dynamics between stock prices and exchange rates. Their models include the real domestic stock price as a function of the real foreign (US) stock price and the real exchange rate. Their results show that the presence of cointegration depends on the period studied, but that there is in general a close association between stocks and exchange rates. The US stock market is found to be an important causing variable for the other two variables.

Piccillo (2008) uses daily data on three economies: the British market, the Japanese market, and the pre-Euro German market. Like Phylaktis and Ravazzolo (2005) Piccillo (2008) considers three variables together: the US and the domestic stock markets with the foreign exchange rate. Although all variables have unit roots the hypothesis of no-cointegration between the three variables fails to be rejected. Granger causality tests find that the exchange rate appears to be independent of any causality, while the domestic stock market is always Granger-caused by the other two variables. The analysis carries out non-linear Markov VAR switching processes in addition to linear VAR processes. The former uncovers a time-varying non-linear relation with the presence of three different regimes.

Ahmad et al. (2010) study the relation between the Pakistani stock prices, the Pakistani exchange rate and the change in the Pakistani interest rates. They unveil a significant effect for the exchange rate on the stock market, and a marginally significant effect of the change in interest rates on the stock market. The model of Ahmad et al. (2010) is similar to the model derived in this paper in the next section.

Tian and Ma (2010) use a monthly data set and test for a particular kind of cointegration, known as ARDL, between the Shanghai stock market and the Chinese renminbi real exchange rates against the US dollar and the Hong Kong dollar, money supply, consumer price index, and industrial production index. They find support to the flow approach to the equity markets. A disturbing feature of their results is that a 1% change in the renminbi against the US dollar causes a 32% long run change in the Shanghai stock market index, while a 1% change in the renminbi against the Hong Kong dollar causes a 38% change in the stock market. These reaction magnitudes are too high to be plausible

Inci and Lee (2011) examine the relation between stock returns and exchange rate changes for eight developed nations. Lagged exchange rates are found to have a significant impact on stock returns. However Granger causality is bidirectional in the two markets. The dynamic relation is more significant and stronger in recent years of recessionary experience relative to previous years of expansion.

Parsva and Lean (2011) study the relation between exchange rates and the stock market for six Middle Eastern countries. Their data set is monthly from January 2004 to September 2010. They include in their regressions the interest rate, the inflation rate, and oil prices. They test for cointegration among the variables and they undertake Granger causality tests. Their results support cointegration, which may result in predictability of asset prices. Three countries have bidirectional relation between exchange rates and stock prices in both the short run and in the long run. In one country the exchange rate Granger causes the stock market in both the short run and in the long run. A two-way long run linkage for the remaining two countries exists for the same relation.

Anlas (2012) carries out a test between stock prices and exchange rates from the perspective of Turkey. The regressions in first-differences include a model for the conditional variance. In this paper the same procedure for the conditional variance is adpted. The conditional mean equation includes other variables like money supply, inflation, and oil prices. The traditional approach is supported for two currencies, and the portfolio balance approach is supported for the third currency.

Kollias et al. (2012) use daily data and consider the linkage between the euro-dollar rate and two European stock market indexes. They undertake rolling cointegration tests and rolling Granger-causality tests. No-cointegration fails to be rejected. They find that, under normal conditions, the exchange rate drives the stock market, while, in stressful circumstances, the reverse causality holds.

Lee (2012) rejects the null hypothesis of no-cointegration between the euro rate against the Hong Kong dollar and the Hang Seng stock index using daily data from January 2009 onward. This long run relation implies a short run error-correction model which is also supported by the evidence. Granger-causality is unidirectional and runs from the euro rate to the stock index.

Tudor and Popescu-Dutaa (2012) investigate the issue of Granger causality between stock prices and exchange rates for 13 developed and emerging financial markets. Most of the causality tests fail to reject the null of no causality. However they uncover evidence that the Brazilian stock market Granger causes the US dollar rate against the Brazilian currency, that the Korean exchange rate against the US dollar and the Korean stock market have a bidirectional association, that the US dollar rate against the Russian currency Granger causes the Russian stock market, and that the UK stock market Granger causes the US dollar rate against the British pound.

3. The Model

The model in this paper borrows from a relation developed by Williams (1938) and Gordon (1962) and which is:

$$P_0 = \frac{D_1}{(k-g)} = \frac{(1+g)D_0}{(k-g)} \tag{1}$$

where P_0 is this period's stock price, D_1 is next period's dividend, D_0 is the current dividend, k is the cost of equity, and g is the constant growth rate in dividends, and measures also the percentage capital gain yield. Although this model is simple, and literally unrealistic for individual stocks, the findings in the literature show that it is still a valid approximation for a market equity index. As an example the same model has been used by Fama and French (2002) to derive statistics on the equity premium.

In the financial literature around three factors explaining the cross section of stock returns are identified (Roll and Ross, 1980). Fama and French (1992, 1993) single out three variables that explain the cross-section of stock returns: a market factor, size, and leverage. The model in equation (1) is already a market model. Size is proxied by the underlying structure of the stock market index (the S&P 500), which includes only large firms, and leverage is proxied by the cost of equity k. Higher leverage leads to a higher financial risk and consequently a higher cost of equity (Modigliani and Miller, 1958, 1963; Ross et al., 2010). Therefore this simple model is consistent with the financial literature.

Taking the derivative in equation (1) with respect to k one gets:

$$d(P) = \frac{\partial P}{\partial k} d(k) \Rightarrow d(P) = -\frac{D_1}{(k-g)^2} d(k) \Rightarrow \frac{d(P)}{P} = -\frac{1}{(k-g)} d(k) \tag{2}$$

The fundamental variable in Azar (2010, 2012) is k, and it enters in first-difference, i.e. $(d(k))$, in explaining the relative change in stock prices. In this paper a more general specification is derived. Taking the total derivative in equation (1) with respect to k and to D_0 one finds:

$$d(P) = \frac{\partial P}{\partial k} d(k) + \frac{\partial P}{\partial D} d(D) = -\frac{D_1}{(k-g)^2} d(k) + \frac{(1+g)}{(k-g)} d(D) \tag{3}$$

Dividing both sides of equation (3) by P one obtains:

$$\frac{d(P)}{P} = -\frac{1}{(k-g)} d(k) + \frac{1}{D} d(D) = -\frac{1}{(k-g)} d(k) + \frac{d(D)}{D} = -\frac{1}{D/P} d(k) + \frac{d(D)}{D} \tag{4}$$

Equation (4) identifies two fundamental variables that explain the relative change in stock prices. The first is the change in k, and the second is the relative change in the dividend D. The first variable should produce a coefficient equal to the negative of the inverse of the dividend yield, and the second has a unitary coefficient. Equation (4) summarizes all factors that explain the relative price change of the market stock index.

The effect of the foreign exchange rate on stock prices comes about from the indirect effect of this rate on dividends. If the change in the foreign exchange rate induces higher profits then the impact is positive on dividends. If the change in the foreign exchange rate induces lower profits than the impact on dividends is negative. This is true because dividends are set by firms according to the extent of permanent profits or earnings generated (Pan, 2001). If X denotes the foreign exchange rate then it is reasonable to state that:

$$\frac{d(D)}{D} = \theta \frac{d(X)}{X} \tag{5}$$

where θ is a constant that can be either positive or negative, or may be insignificant. Replacing equation (5) in equation (4) produces the model of this paper:

$$\frac{d(P)}{P} = -\frac{1}{(k-g)} d(k) + \theta \frac{d(X)}{X} \tag{6}$$

Using the following approximations which are close to equality with monthly data:

$$\frac{d(P)}{P} \approx \frac{\Delta(P)}{P} \approx \Delta(log_e(P)) \quad \text{and} \quad \frac{d(X)}{X} \approx \frac{\Delta(X)}{X} \approx \Delta(log_e(X)) \tag{7}$$

where log_e is the natural logarithm, and Δ is the first-difference operator, then equation (6) becomes:

$$\Delta(log_e(P)) \approx -\frac{1}{(k-g)}\Delta(k) + \theta\Delta(log_e(X)) \approx \alpha + \beta\Delta(k) + \theta\Delta(log_e(X)) + \varepsilon \tag{8}$$

where α and β are constants, and ε is the regression residual. Equation (8) is the model regression of this paper. Equation (8) is a relation between the difference in the natural logs of a stock price, as proxied by a stock market index, and (1) the change in k, where the proportionality factor is the negative inverse of the dividend yield, $(k-g) = D_1/P_0$, which happens also to be the (modified) duration (Baz and Chacko, 2004), and (2) the relative change in the foreign exchange rate. Equation (8) is the equation of what is here called the fundamentals. It does not include any other additional variable.

4. The Empirical Results

The data series for the end-of-period US monthly S&P 500 stock market index, the eleven end-of-period monthly foreign currencies against the US dollar, and the two monthly US corporate bond yields, the baa and the aaa corporate yields, are retrieved from the web site of the Federal Reserve Bank of Saint Louis. The eleven currencies are: the Australian dollar (AUD), the Canadian dollar (CAD), the Swiss franc (CHF), the Danish kronor (DKK), the British pound (GBP), the Japanese yen (JPY), the Norwegian kroner (NOK), the New Zealand dollar (NZD), the Swedish kronor (SEK), the trade-weighted US dollar rate (TW), and the trade-weighted US dollar rate for major currencies (TWM). All rates are against the US dollar. The samples are monthly from January 1, 1973 to April 1, 2013. The sample sizes are 484 observations per variable. Log returns for the S&P 500 index and the eleven foreign currencies are calculated by taking the first difference of the natural logs. The first differences of the two corporate bond yields, divided by 1200 to get monthly decimal figures, are utilized (separately) in the regressions.

In Table 1 unit root tests are applied on all logged series, except for the two corporate yields which are taken as is. The test selected is the Elliott-Rothenberg-Stock point-optimal unit root test with a constant and a linear trend (Elliott et al., 1996). The maximum lag is set to 6 because the data is monthly. The null hypothesis is a unit root. All series are non-stationary and need first-differencing to become stationary. The null hypotheses of non-stationarity on the log level variables fail to be rejected at marginal significance levels much higher than 10%. The null hypotheses of non-stationarity, on the variables in first-differences of the logs, are rejected at marginal significance levels much lower than 1%. The changes in the two corporate bond yields are found to be stationary.

Table 1. Elliott-Rothenberg-Stock point-optimal unit root tests with a constant and a linear trend (Elliott et al., 1996): The maximum lag is set to 6. The null hypothesis is a unit root.

Variable X	Test statistic on $log_e(X)$	Test statistic on $\Delta(log_e(X))$
AUD	20.72450	1.123228
CAD	33.38300	0.421168
CHF	15.14776	1.217279
DKK	9.179102	0.884637
GBP	9.080167	0.633328
JPY	8.570376	1.193313
NOK	7.808524	1.006545
NZD	26.02632	1.075714
SEK	12.77375	0.547778
Trade-weighted (TW)	46.13297	1.856907
Trade-weighted, major currencies (TWM)	8.176712	1.025021
S&P 500	21.60824	0.456136
Variable X	Test statistic on X	Test statistic on $\Delta(X)$
baa corporate bond yield	34.78811	0.323900
aaa corporate bond yield	35.97455	0.252577

Notes: The critical values for the test are 3.96 (1%), 5.62 (5%), and 6.89 (10%). AUD is the Australian dollar. CAD is the Canadian dollar. CHF is the Swiss franc. DKK is the Danish kronor. GBP is the British pound. JPY is the Japanese yen. NOK is the Norwegian kroner. NZD is the New Zealand dollar. SEK is the Swedish kronor. All rates are against the US dollar. S&P 500 is the S&P 500 stock market index. The samples are monthly from January 1, 1973 to April 1, 2013. The sample sizes are 484 observations per variable.

Since the stock and the currencies series are all non-stationary in log levels, and following the tradition in the literature, cointegration tests (Johansen, 1988, 1991, 1995; Johansen and Juselius, 1990) are run on the relation between log stock prices and each logged currency separately. If there is a long run cointegration relation then the residuals of these cointegration regressions should be stationary, but can be auto-correlated. Two cointegration tests are computed: the trace statistic and the maximum Eigen value statistic. The null hypothesis of no-cointegration fails to be rejected for all eleven currencies, and for the two cointegration tests, except for the regression with the trade-weighted exchange rate of the US dollar (TW). See Table 2. However when the Engle-Granger, (Engle and Granger, 1987), and the Phillips-Ouliaris, (Phillips and Ouliaris, 1990), residual tests are carried out on the residuals of the regression with the TW exchange rate the null hypothesis of non-stationarity fails to be rejected, meaning that the null hypothesis of no-cointegration fails also to be rejected. The actual p-value for the Engle-Granger tau test is 0.3706 and that for the Phillips-Ouliaris tau test it is 0.3630. The conclusion is therefore very strong that there is no long run cointegration relation between the logged S&P 500 stock market index and each of the eleven logged foreign currencies. This is in conformity to the results in the US (Ratner, 1993; Yang and Doong, 2004) but not to the results in emerging countries (Parsva and Lean, 2011; Lee, 2012).

Table 2. Johansen cointegration tests: The lag length is 6 for all regressions and these include a constant but not a trend. See notes under Table 1 for the definition of the variables

$log_e(SP500)$ *with* $log_e(AUD)$

Cointegration equations	Eigen value	Trace statistic	5% critical value	Probability	Maximum Eigen value	5% critical value	Probability
None	0.009677	6.495731	15.49471	0.6369	4.638395	14.26460	0.7866
At most 1	0.003886	1.857336	3.841466	0.1729	1.857336	3.841466	0.1729

$log_e(SP500)$ *with* $log_e(CAD)$

Cointegration equations	Eigen value	Trace statistic	5% critical value	Probability	Maximum Eigen value	5% critical value	Probability
None	0.007490	6.156152	15.49471	0.6771	3.585985	14.26460	0.9003
At most 1	0.005374	2.570167	3.841466	0.1089	2.570167	3.841466	0.1089

$log_e(SP500)$ *with* $log_e(CHF)$

Cointegration equations	Eigen value	Trace statistic	5% critical value	Probability	Maximum Eigen value	5% critical value	Probability
None	0.014976	7.641128	15.49471	0.5045	7.197820	14.26460	0.4660
At most 1	0.000929	0.443308	3.841466	0.5055	0.443308	3.841466	0.5055

$log_e(SP500)$ *with* $log_e(DKK)$

Cointegration equations	Eigen value	Trace statistic	5% critical value	Probability	Maximum Eigen value	5% critical value	Probability
None	0.011202	5.822883	15.49471	0.7163	5.373341	14.26460	0.6942
At most 1	0.000942	0.449542	3.841466	0.5026	0.449542	3.841466	0.5026

$log_e(SP500)$ *with* $log_e(GBP)$

Cointegration equations	Eigen value	Trace statistic	5% critical value	Probability	Maximum Eigen value	5% critical value	Probability
None	0.025366	13.10750	15.49471	0.1109	12.25545	14.26460	0.1014
At most 1	0.001785	0.852044	3.841466	0.3560	0.852044	3.841466	0.3560

$log_e(SP500)$ with $log_e(JPY)$

Cointegration equations	Eigen value	Trace statistic	5% critical value	Probability	Maximum Eigen value	5% critical value	Probability
None	0.013148	6.970554	15.49471	0.5811	6.313366	14.26460	0.5733
At most 1	0.001377	0.657188	3.841466	0.4176	0.657188	3.841466	0.4176

$log_e(SP500)$ with $log_e(NOK)$

Cointegration equations	Eigen value	Trace statistic	5% critical value	Probability	Maximum Eigen value	5% critical value	Probability
None	0.011372	6.023242	15.49471	0.6928	5.455666	14.26460	0.6836
At most 1	0.001189	0.567576	3.841466	0.4512	0.567576	3.841466	0.4512

$log_e(SP500)$ with $log_e(NZD)$

Cointegration equations	Eigen value	Trace statistic	5% critical value	Probability	Maximum Eigen value	5% critical value	Probability
None	0.013786	8.313227	15.49471	0.4325	6.621706	14.26460	0.5348
At most 1	0.003540	1.691521	3.841466	0.1934	1.691521	3.841466	0.1934

$log_e(SP500)$ with $log_e(SEK)$

Cointegration equations	Eigen value	Trace statistic	5% critical value	Probability	Maximum Eigen value	5% critical value	Probability
None	0.014055	7.723167	15.49471	0.4955	6.751569	14.26460	0.5189
At most 1	0.002035	0.971598	3.841466	0.3243	0.971598	3.841466	0.3243

$log_e(SP500)$ with $log_e(TW)$

Cointegration equations	Eigen value	Trace statistic	5% critical value	Probability	Maximum Eigen value	5% critical value	Probability
None	0.024094	16.83806	15.49471	0.0312	11.63332	14.26460	0.1252
At most 1	0.010852	5.204737	3.841466	0.0225	5.204737	3.841466	0.0225

$log_e(SP500)$ with $log_e(TWM)$

Cointegration equations	Eigen value	Trace statistic	5% critical value	Probability	Maximum Eigen value	5% critical value	Probability
None	0.008546	4.444581	15.49471	0.8646	4.093820	14.26460	0.8493
At most 1	0.000735	0.350761	3.841466	0.5537	0.350761	3.841466	0.5537

Table 3 presents descriptive statistics on the S&P 500 log returns and the log returns of the eleven foreign exchange rates. The maximum of the monthly log returns for the 11 currencies hovers between 6.42% (for the TW rate), and 13.17% (for the NOK rate). These are substantial returns. The minimum of the monthly log returns is also substantial and ranges between -17.31% (for the AUD rate), and -5.39% (for the TWM rate). The monthly standard deviations are between 1.31% (for the TW rate) and 2.97% (for the CHF rate). The annualized standard deviations are between 4.55% and 10.27% respectively. These standard deviations compare with an annualized standard deviation for the S&P 500 log returns of 15.77%. As expected the former are lower than the latter. Moreover an annualized standard deviation for the S&P 500 log returns of 15.77% is almost equivalent to the one reported in Ross et al. (2010) of 14.69%. The S&P 500 log returns have a maximum return of 15.10% and a minimum return of -24.54% both of which are higher in absolute values than their counterparts for the foreign exchange rates.

Table 3. Descriptive statistics on $\Delta(log_e(X))$

Variable X	mean	median	maximum	minimum	standard deviation	annualized standard deviation	t-test on the mean
AUD	-0.000420	0.001229	0.071211	-0.173060	0.026004	0.090080	-0.35483
CAD	0.0000414	-0.000152	0.112920	-0.060094	0.014171	0.049090	0.06326
CHF	-0.002860	-0.001490	0.116871	-0.087458	0.029654	0.102724	-2.11966
DKK	-0.000379	0.001015	0.083068	-0.070719	0.026188	0.090718	-0.31806
GBP	-0.000895	-0.000549	0.095205	-0.110761	0.024459	0.084729	-0.80418
JPY	-0.002334	-0.000282	0.080657	-0.105227	0.027369	0.094809	-1.87418
NOK	-0.000273	-0.000323	0.131658	-0.057584	0.024577	0.085137	-0.24412
NZD	-0.000713	-0.000361	0.081063	-0.143436	0.027432	0.095023	-0.57122
SEK	0.000648	-0.000318	0.138113	-0.071200	0.026007	0.090091	0.54769
TW	0.002244	0.002391	0.064238	-0.041750	0.013128	0.045477	3.75617
TWM	-0.000725	0.000404	0.064691	-0.053901	0.017218	0.059645	-0.92520
S&P 500	0.005429	0.009320	0.151043	-0.245428	0.045532	0.157728	2.62065

Notes: See notes under Table 1 for the definition of the variables. All figures are monthly except the annualized standard deviation. The latter is calculated by multiplying the monthly standard deviation by the square root of 12.

In Table 3 the monthly mean and median log returns are all small. However t-tests on whether the mean returns are different from zero reveals that the mean returns of the TW and CHF rates are indeed statistically significantly different from zero with t-statistics of 3.756, and -2.119 respectively, while the mean return of the JPY rate is marginally significant (t-statistic: -1.874). As expected the continuously compounded mean return of the S&P 500 log returns is statistically positive with a t-statistic of +2.621 and yields an annual continuously compounded mean log return of 6.73%, a value close to the estimates in the financial literature.

Since it is already established that all logged series are integrated of order 1, and since no-cointegration fails to be rejected for all 11 currencies against the S&P 500, Granger-causality tests must be conducted on the differenced logged series, or on the log returns. The number of lags is selected to be 6 because the data is monthly. Table 4 presents the results. For the eleven exchange rates none of these exchange rates Granger-causes the S&P 500 log returns, with a minimum p-value of 0.3894. By contrast the S&P 500 log returns Granger-cause three foreign rates: the AUD, the CAD, and the NZD. The relation is that a positive shock in the S&P 500 appreciates these three rates. There is no reason why these three currency rates behave in such a way, especially since Granger-causality implies predictability of returns and this is against the Efficient Market Hypothesis (Fama, 1965, 1970, 1991). Therefore an appropriate conclusion is that these 3 significant causality relations are due to sampling error, and that generally speaking there is no unidirectional or bidirectional Granger-causality. This is true because the data is monthly. If the data were daily, or weekly, predictability may be more acceptable (Yang and Doong, 2004).

Table 4. Granger causality tests: The number of lags is set to 6

Null hypothesis	p-value
$\Delta(log_e(AUD))$ does not Granger cause $\Delta(log_e(S\&P500))$	0.6126
$\Delta(log_e(S\&P500))$ does not Granger cause $\Delta(log_e(AUD))$	0.0034
$\Delta(log_e(CAD))$ does not Granger cause $\Delta(log_e(S\&P500))$	0.3894
$\Delta(log_e(S\&P500))$ does not Granger cause $\Delta(log_e(CAD))$	0.00005
$\Delta(log_e(CHF))$ does not Granger cause $\Delta(log_e(S\&P500))$	0.8041
$\Delta(log_e(S\&P500))$ does not Granger cause $\Delta(log_e(CHF))$	0.2701
$\Delta(log_e(DKK))$ does not Granger cause $\Delta(log_e(S\&P500))$	0.5281
$\Delta(log_e(S\&P500))$ does not Granger cause $\Delta(log_e(DKK))$	0.4417
$\Delta(log_e(GBP))$ does not Granger cause $\Delta(log_e(S\&P500))$	0.6719
$\Delta(log_e(S\&P500))$ does not Granger cause $\Delta(log_e(GBP))$	0.9025
$\Delta(log_e(JPY))$ does not Granger cause $\Delta(log_e(S\&P500))$	0.5754
$\Delta(log_e(S\&P500))$ does not Granger cause $\Delta(log_e(JPY))$	0.6294
$\Delta(log_e(NOK))$ does not Granger cause $\Delta(log_e(S\&P500))$	0.9629
$\Delta(log_e(S\&P500))$ does not Granger cause $\Delta(log_e(NOK))$	0.9643
$\Delta(log_e(NZD))$ does not Granger cause $\Delta(log_e(S\&P500))$	0.9655
$\Delta(log_e(S\&P500))$ does not Granger cause $\Delta(log_e(NZD))$	0.0167
$\Delta(log_e(SEK))$ does not Granger cause $\Delta(log_e(S\&P500))$	0.8635
$\Delta(log_e(S\&P500))$ does not Granger cause $\Delta(log_e(SEK))$	0.6714
$\Delta(log_e(TW))$ does not Granger cause $\Delta(log_e(S\&P500))$	0.6203
$\Delta(log_e(S\&P500))$ does not Granger cause $\Delta(log_e(TW))$	0.2581
$\Delta(log_e(TWM))$ does not Granger cause $\Delta(log_e(S\&P500))$	0.5765
$\Delta(log_e(S\&P500))$ does not Granger cause $\Delta(log_e(TWM))$	0.8525

As argued in Azar (2010) the proper model specification is a regression of *nominal* stock returns upon the inflation, and not *real* stock returns upon inflation. Azar (2010) shows that in the regressions of *real* stock returns on inflation the coefficient on the inflation variable is statistically insignificantly different from -1, since inflation appears on both sides of the regression with the same coefficient of -1. This implies that *nominal* stock returns are independent of inflation. That is why in the regressions estimated in this paper the dependent variable is nominal stock returns, and not real stock returns.

In Azar (2010) the inflation variable becomes insignificant whence a "fundamental variable" is included in the regressions. This fundamental variable, as argued in the preceding section, is a proxy for the change in the time-variable equity return $\Delta(k)$. It is estimated by two different series: the change in the baa and the change in the aaa corporate bond yields, granted that the first series should be more appropriate because it has a higher default risk premium, and is therefore closer to the cost of equity.

Does the same apply to regressions with the foreign exchange rates? In other terms, in equation (8) , is the coefficient θ statistically insignificant? Before em

barking on such a test regressions without the 'fundamental' variable are run. There is a conditional mean equation which includes the log returns of each one of the eleven exchange rates, and a conditional variance GARCH(1,1) model. Table 5 presents the results.

Table 5. OLS regressions with a GARCH(1,1) model of the conditional variance: The dependent variable is $\Delta(log_e(S\,\&\,P500))$. The independent variable is $\Delta(log_e(X))$.

	Conditional mean equation		Conditional variance equation			Econometric diagnostics		
Variable X	constant	slope	constant	ARCH(-1)	GARCH(-1)	Q-statistic	Q^2-statistic	Adjusted R-square
AUD	0.006200	0.200273	8.19E-05	0.105857	0.859718	0.335	0.987	0.020422
	(3.156587)	(2.055283)	(1.985462)	(3.348409)	(19.55393)	0.567	0.891	
						0.924	0.985	
CAD	0.006104	-0.549777	0.000101	0.094871	0.858260	0.208	0.996	0.047782
	(3.061720)	(3.363517)	(1.919797)	(3.138365)	(16.26882)	0.403	0.954	
						0.854	0.996	
CHF	0.005887	-0.066843	9.01E-05	0.113776	0.850309	0.313	0.994	0.001462
	(2.932852)	(0.962219)	(2.031081)	(3.123419)	(17.13343)	0.634	0.949	
						0.933	0.993	
DKK	0.005950	-0.144473	9.35E-05	0.111017	0.850443	0.295	0.991	0.011238
	(2.992572)	(1.763736)	(2.162791)	(3.225133)	(18.08904)	0.643	0.957	
						0.943	0.994	
GBP	0.006068	0.083248	9.30E-05	0.112093	0.850281	0.315	0.994	0.003368
	(3.059592)	(1.080805)	(2.039114)	(3.052411)	(16.84676)	0.650	0.957	
						0.936	0.996	
JPY	0.006000	-0.014666	8.83E-05	0.116437	0.849377	0.315	0.994	-0.00217
	(2.974249)	(0.193100)	(1.956808)	(3.101638)	(16.62298)	0.606	0.932	
						0.903	0.992	
NOK	0.006005	-0.119357	9.32E-05	0.109116	0.852250	0.284	0.994	0.008266
	(3.009320)	(1.397270)	(2.070950)	(3.207027)	(17.59701)	0.597	0.946	
						0.930	0.993	
NZD	0.006108	0.080208	4.32E-05	0.112453	0.852263	0.301	0.991	0.005947
	(3.059620)	(0.960716)	(2.051230)	(3.199006)	(17.84139)	0.582	0.930	
						0.894	0.995	
SEK	0.006112	-0.224807	0.000104	0.108913	0.846124	0.346	0.995	0.027388
	(3.104079)	(2.752596)	(2.149055)	(3.260218)	(17.16687)	0.687	0.958	
						0.959	0.992	
TW	0.007056	-0.457903	9.54E-05	0.106577	0.851714	0.302	0.995	0.025539
	(3.600465)	(2.593257)	(2.213348)	(3.332148)	(19.25625)	0.532	0.967	
						0.941	0.994	
TWM	0.005822	-0.301609	0.000102	0.106772	0.848740	0.334	0.995	0.020291
	(2.922887)	(2.357351)	(2.208078)	(3.145320)	(17.73408)	0.633	0.969	
						0.951	0.994	

Notes: See the notes under Table 1 for the definition of the variables. Absolute t-statistics are in parenthesis. The Ljung-Box Q-statistics and the Ljung-Box Q^2-statistics are applied to the standardized residuals and the squares of the standardized residuals respectively (Ljung and Box, 1979). For these tests actual p-values are reported. The lag lengths for these tests are 6 (1st row), 12 (2nd row), and 24 (3rd row). Bollerslev-Wooldridge robust standard errors are reported (Bollerslev and Wooldridge, 1992).

In Table 5 the slope coefficients on five currency log returns are statistically significantly different from zero with t-statistics ranging between 2.0553 and 3.3635, one slope coefficient is marginally significant statistically, with a t-statistic of 1.7637, and the remaining five coefficients are statistically insignificant. Therefore more than half of the regressions show a significant relation between exchange rates and US stock prices. Of course the sign of the impact depends on the way the foreign currency is quoted. An appreciation of the US dollar against the AUD, the CAD, the SEK, the TW, and the TWM leads to a fall in stock prices. This is in support to the goods market or flow approach. This means that the causality runs from the exchange rate to equity prices and that the exchange rate should indeed be the independent variable. The significant impacts range between 0.2003 for the AUD and 0.5498 for the CAD. The intercepts are all statistically significantly different from zero with t-statistics ranging between 2.9229 and 3.6005. The range of the intercepts is between 0.005822 and 0.007056. With continuous compounding the annualized range is from 7.236% to 8.836%. These are plausible coefficient estimates for the mean S&P 500 log return.

The conditional variance in Table 5 is modeled as a GARCH(1,1). The coefficients on the ARCH(-1) variable range between 0.09487 and 0.11644, which is a tight range. The coefficients on the GARCH(-1) variable range between 0.84874 and 0.85972, which is also a tight range. These estimates are comparable with the estimates in Hafner (1998) who applied the parametric GARCH model on very high frequency data. Hafner (1998) estimates the coefficients on the ARCH(-1) variable to be between 0.0845 and 0.1405, and the estimates of the coefficient on the GARCH(-1) variable to be between 0.8382 and 0.8862.

In what concerns the econometric diagnostics, the adjusted R-squares of the regressions range between -0.00217 and 0.04778. Three lag lengths are selected for the Ljung-Box Q-statistic on the standardized residuals: 6, 12, and 24. The p-values of the Ljung-Box Q-statistics on the standardized residuals vary between 0.284 and 0.959, failing to reject the nulls of no high-order serial correlation. The p-values of the Ljung-Box Q-statistics on the standardized residuals squared lie between 0.891 and 0.996, failing to reject the nulls of no further high-order conditional heteroscedasticity. Therefore the standardized residuals are well-behaved. Finally one can invoke the Central Limit Theorem for asymptotic normality of the residuals because the samples are large. This means that hypothesis testing can be conducted and is valid.

Table 6 presents the results of the regressions of the S&P 500 log returns on each of one of the eleven changes in the exchange rates and on a proxy for k, which is the baa corporate bond yield, which enters the regression in first-differences, i.e. $\Delta(k)$. The number of statistically significant coefficients on each of the eleven currencies falls from 5 to one, the latter corresponding to the CAD exchange rate. And there is one coefficient which is marginally significant as before, corresponding to the SEK exchange rate. Hence including the 'fundamental variable' $\Delta(k)$ in the regressions has forced four coefficients to become statistically insignificantly different from zero. There is no reason why the CAD and marginally the SEK have statistically significant coefficients. That is why this feature can be due to simply the existence of sampling errors. Therefore the conclusion is strong that once the fundamental variable is included in the regressions the impact of foreign exchange rates becomes insignificant, and hence the evidence is strong that US equity prices and the US dollar are disconnected and are unrelated.

The intercepts in Table 6 are all statistically significantly different from zero with t-statistics ranging between 2.5343 and 2.8313. The range of the intercepts is between 0.005225 and 0.005906. With continuous compounding the annualized range is from 6.471% to 7.344%. These are plausible coefficient estimates for the mean S&P 500 log return.

The conditional variance in Table 6 is modeled again as a GARCH(1,1). The coefficients on the ARCH(-1) variable range between 0.11319 and 0.12416, which is a tight range. The coefficients on the GARCH(-1) variable range between 0.8497 and 0.8545, which is also a tight range. These estimates are comparable with the estimates in Table 5 and with Hafner (1998) who applied the parametric GARCH model on very high frequency data. Hafner (1998) estimates the coefficients on the ARCH(-1) variable to be between 0.0845 and 0.1405, and the estimates of the coefficient on the GARCH(-1) variable to be between 0.8382 and 0.8862.

In what concerns the econometric diagnostics, the adjusted R-squares of the regressions are now higher and range between 0.05061 and 0.07723. Three lag lengths are selected for the Ljung-Box Q-statistic: 6, 12, and 24. The p-values of the Ljung-Box Q-statistics on the standardized residuals vary between 0.271 and 0.962, failing to reject the nulls of no high-order serial correlation. The p-values of the Ljung-Box Q-statistics on the standardized residuals squared lie between 0.923 and 0.992, failing to reject the nulls of no further high-order conditional heteroscedasticity. Therefore the standardized residuals are well-behaved. Finally one can invoke the Central Limit Theorem for asymptotic normality of the residuals because the samples are large. This means that the hypothesis tests that are conducted are valid.

Table 6. OLS regressions with a GARCH(1,1) model of the conditional variance. The dependent variable is $\Delta(log_e(S\,\&\,P500))$. The independent variables are $\Delta(log_e(X))$ and $\Delta(k)$. The baa corporate bond yield replaces k.

	Conditional mean equation			Conditional variance equation			Econometric diagnostics		
X	constant	Slope on $\Delta(log_e(X))$	Slope on $\Delta(k)$	constant	ARCH(-1)	GARCH(-1)	Q-statistic	Q^2-statistic	Adjusted R-square
AUD	0.005513	0.116266	-52.89836	7.01E-05	0.117084	0.854504	0.464	0.968	0.062572
	(2.684676)	(1.367373)	(5.301095)	(1.995326)	(3.846897)	(20.44704)	0.460	0.923	
							0.930	0.989	
CAD	0.005512	-0.375399	-49.08447	7.54E-05	0.113186	0.854564	0.271	0.974	0.077233
	(2.639563)	(2.686540)	(4.943386)	(1.976819)	(3.711218)	(18.77919)	0.318	0.950	
							0.869	0.990	
CHF	0.005331	0.011662	-55.61184	7.12E-05	0.122595	0.850102	0.445	0.982	0.050612
	(2.590107)	(0.180144)	(5.276837)	(1.984580)	(3.902228)	(19.50481)	0.491	0.950	
							0.926	0.988	
DKK	0.005262	-0.055372	-53.93157	7.31E-05	0.120290	0.850767	0.476	0.974	0.054323
	(2.556068)	(0.727520)	(5.138747)	(2.083695)	(3.934984)	(20.19604)	0.545	0.948	
							0.951	0.984	
GBP	0.005307	0.005547	-55.15209	7.81E-05	0.121762	0.850399	0.454	0.981	0.051183
	(2.561455)	(0.075555)	(5.287152)	(2.022814)	(3.849468)	(19.54688)	0.507	0.950	
							0.934	0.988	
JPY	0.005407	0.058903	-56.68761	6.97E-05	0.124160	0.849678	0.436	0.980	0.051429
	(2.603666)	(0.816502)	(5.372009)	(1.936728)	(3.951110)	(19.28171)	0.524	0.956	
							0.931	0.992	
NOK	0.005297	-0.045703	-54.49995	7.25E-05	0.119774	0.851522	0.459	0.977	0.053852
	(2.559814)	(0.588236	(5.266833)	(2.045558)	(3.911575)	(19.96464)	0.513	0.947	
							0.942	0.986	
NZD	0.005308	0.004838	-55.18296	7.17E-05	0.121728	0.850489	0.453	0.981	0.051388
	(2.555293)	(0.062300)	(5.293604)	(2.024572)	(3.889207)	(19.67868)	0.500	0.949	
							0.931	0.988	
SEK	0.005389	-0.144313	-52.43103	7.80E-05	0.116881	0.850334	0.491	0.967	0.067145
	(2.617349)	(1.990693)	(5.099546)	(2.106769)	(3.883968)	(17.16687)	0.563	0.943	
							0.962	0.978	
TW	0.005906	-0.239243	-51.56008	7.50E-05	0.116223	0.852465	0.455	0.973	0.062432
	(2.831343)	(1.485092)	(4.987838)	(2.113786)	(3.893018)	(20.56885)	0.472	0.945	
							0.944	0.979	
TWM	0.005225	-0.121682	-52.54694	7.45E-05	0.117883	0.851280	0.466	0.976	0.057421
	(2.534335)	(1.020704)	(5.004221)	(2.095472)	(3.849104)	(19.92641)	0.517	0.949	
							0.948	0.982	

Notes: See the notes under Table 5.

Table 7 presents the results of the regressions of the S&P 500 log returns on each of one of the eleven log changes in the exchange rates and on another proxy for k, which is the aaa corporate bond yield, which enters the regression in first-differences $\Delta(k)$. The number of statistically significant coefficients on each of the eleven currencies falls from 5 to two, the latter corresponding to the CAD and the SEK exchange rates. And there are two coefficients which are marginally significant, corresponding to the AUD and TW exchange rates. Hence including the 'fundamental variable' $\Delta(k)$ in the regressions has forced three coefficients to become statistically insignificantly different from zero. There is no reason why the CAD and the SEK have statistically significant coefficients. That is why this feature can be due to simply the existence of sampling errors. Therefore the conclusion is still strong that once the fundamental variable is included in the regressions the impact of foreign exchange rates becomes insignificant, and hence the evidence is rather strong that US equity prices and the US dollar are disconnected and are unrelated.

In Table 7 the intercepts are all statistically significantly different from zero with t-statistics ranging between 2.6134and 2.9945. The range of the intercepts is between 0.005385 and 0.006153. With continuous compounding the annualized range is from 6.675% to 7.663%. These are plausible coefficient estimates for the mean S&P 500 log return.

Table 7. OLS regressions with a GARCH(1,1) model of the conditional variance: The dependent variable is $\Delta(log_e(S\,\&\,P500))$. The independent variables are $\Delta(log_e(X))$ and $\Delta(k)$. The aaa corporate bond yield replaces k.

	Conditional mean equation			Conditional variance equation			Econometric diagnostics		
X	constant	Slope on $\Delta(log_e(X))$	Slope on $\Delta(k)$	constant	ARCH(-1)	GARCH(-1)	Q-statistic	Q^2-statistic	Adjusted R-square
AUD	0.005684	0.166430	-46.72903	7.35E-05	0.119079	0.851040	0.479	0.984	0.052242
	(2.813058)	(1.872862)	(4.964766)	(2.057604)	(3.727374)	(20.11820)	0.626	0.896	
							0.968	0.986	
CAD	0.005617	-0.452396	-49.08447	8.24E-05	0.113060	0.850887	0.257	0.989	0.070562
	(2.721757)	(2.686540)	(3.044181)	(2.041913)	(3.664051)	(18.25127)	0.406	0.946	
							0.909	0.988	
CHF	0.005452	0.001642	-47.62577	7.47E-05	0.126348	0.845815	0.465	0.994	0.031869
	(2.678468)	(0.024968)	(4.923287)	(2.030805)	(3.635512)	(18.60755)	0.672	0.947	
							0.961	0.988	
DKK	0.005385	-0.076268	-46.06795	7.71E-05	0.123443	0.846606	0.476	0.974	0.037656
	(2.649117)	(0.983874)	(4.795911)	(2.145618)	(3.687174)	(19.39422)	0.545	0.948	
							0.951	0.984	
GBP	0.005457	0.012875	-47.33092	7.54E-05	0.125422	0.846175	0.466	0.994	0.032762
	(2.671141)	(0.169237)	(4.924659)	(2.066399)	(3.574921)	(18.60732)	0.681	0.950	
							0.964	0.988	
JPY	0.005540	0.052291	-48.84626	7.33E-05	0.127517	0.845692	0.460	0.993	0.032599
	(2.705446)	(0.705998)	(4.936395)	(1.984296)	(3.718160)	(18.51600)	0.696	0.949	
							0.961	0.990	
NOK	0.005427	-0.075604	-46.92404	7.67E-05	0.121836	0.848075	0.452	0.992	0.038191
	(2.656749)	(0.958493	(4.897678)	(2.109644)	(3.693290)	(19.31462)	0.667	0.946	
							0.968	0.983	
NZD	0.005488	0.036392	-47.30030	7.57E-05	0.123811	0.847196	0.457	0.993	0.036048
	(2.671998)	(0.465257)	(4.953592)	(2.088040)	(3.634793)	(19.01640)	0.659	0.944	
							0.960	0.989	
SEK	0.005520	-0.160837	-45.18420	8.32E-05	0.119326	0.846069	0.488	0.990	0.052734
	(2.713923)	(2.140981)	(4.749122)	(2.167549)	(3.708034)	(19.17836)	0.714	0.951	
							0.981	0.977	
TW	0.006153	-0.295921	-43.99403	7.98E-05	0.119104	0.847812	0.437	0.992	0.048519
	(2.994531)	(1.786757)	(4.591387	(2.169005)	(3.711842)	(19.79346)	0.603	0.951	
							0.971	0.977	
TWM	0.005324	-0.162069	-44.58422	8.07E-05	0.120242	0.846965	0.458	0.993	0.042496
	(2.613419)	(1.321176)	(4.658224)	(2.161374)	(3.610973)	(19.08882)	0.663	0.956	
							0.973	0.981	

Notes: See the notes under Table 5.

The conditional variance in Table 7 is modeled again as a GARCH(1,1). The coefficients on the ARCH(-1) variable range between 0.11306 and 0.12752, which is a tight range. The coefficients on the GARCH(-1) variable range between 0.8460 and 0.8510, which is also a tight range. These estimates are comparable with the estimates in Tables 5 and 6 and with Hafner (1998) who applied the parametric GARCH model on very high frequency data. Hafner (1998) estimates the coefficients on the ARCH(-1) variable to be between 0.0845 and 0.1405, and the estimates of the coefficient on the GARCH(-1) variable to be between 0.8382 and 0.8862.

In what concerns the econometric diagnostics, the adjusted R-squares of the regressions range between 0.03187 and 0.07056. Three lag lengths are selected for the Ljung-Box Q-statistic: 6, 12, and 24. The p-values of the Ljung-Box Q-statistics on the standardized residuals vary between 0.257 and 0.981, failing to reject the nulls of no high-order serial correlation. The p-values of the Ljung-Box Q-statistics on the standardized residuals squared lie between 0.896 and 0.994, failing to reject the nulls of no further high-order conditional heteroscedasticity. Therefore the standardized residuals are well-behaved. Finally one can invoke the Central Limit Theorem for asymptotic normality of the residuals because the samples are large. This means that the hypothesis tests that are conducted are valid.

The issue of measurement error must be addressed. If the changes in the two corporate bond yields measure the change in the cost of equity with error, a classic case of measurement error, the coefficient on these bond yields should be biased towards zero (Verbeek, 2012). As mentioned in the previous section the absolute values of the slopes on these yields are estimates of the inverse of the average dividend yield. If the slopes are biased towards zero, then the dividend yields should be overstated in value. The dividend yield varies between 1.76% and 2.04%, when the change in the baa corporate bond yield is considered, and between 2.05% and 2.31%, when the aaa corporate bond yield is considered (Table 8). (Note 1) These estimates, while always statistically significantly different from zero, the minimum t-statistic being 4.591, cannot be considered overstated. Quite the opposite these estimates are on the low side of the actual average market dividend yield of 4.3256%, which is estimated over the monthly period from 1880m12 till 2012m3, with data retrieved from www.multpl.com/s-p-500-dividend-yield/table. Other estimates from the literature are 3.70% for the period 1951/2000 (Fama and French, 2002), 4.2437% for the period 1926/2001 (Jones et al., 2002), 4.098% for the period 1936/1999 (Wilson and Jones, 2002), 4.27% for the period 1926/2005 (Goetzmann and Ibbotson, 2006), and 3.1% (Ross et al., 2010). The average market dividend yield over the period 2000/2011 is much lower at 1.8296%, but the same average is 3.3546% over the period 1950 till 2012, which is the approximate sample range in the regressions in this paper. All this supports the assertion that the regressions do not seem to be affected by measurement errors. Quite to the contrary, instead of obtaining coefficients on the fundamental variable biased towards zero, these coefficients are biased away from zero.

Table 8. Estimates of the market dividend yield

Variable X	$\Delta(k)$ is the change in the baa corporate bond yield	$\Delta(k)$ is the change in the aaa corporate bond yield
AUD	0.018904 (5.301095)	0.021400 (4.964766)
CAD	0.020373 (4.943386)	0.023101 (4.636057)
CHF	0.017982 (5.276837)	0.020997 (4.923287)
DKK	0.018542 (5.138747)	0.021707 (4.795911)
GBP	0.018132 (5.287152)	0.021128 (4.924659)
JPY	0.017641 (5.372009)	0.020472 (4.936395)
NOK	0.018349 (5.266833)	0.021311 (4.897678)
NZD	0.018122 (5.293604)	0.021142 (4.953592)
SEK	0.019073 (5.099546)	0.022132 (4.749122)
TW	0.019395 (4.987838)	0.022730 (4.591387)
TWM	0.019031 (5.004221)	0.022429 (4.658224)

Notes: See notes under Table 1 for the definition of the variables. In parenthesis are t-statistics.

5. Conclusion

There are three determinants of stock returns in the literature. The first one is inflation. The second one is inflation uncertainty, and the last one is foreign exchange rates. Empirically stock returns are negatively related to actual inflation, and to expected and unexpected inflation. Theoretically there is a claim that higher inflation is caused by higher inflation uncertainty, with the direction of causality going from inflation uncertainty to inflation. Also empirically there is evidence that inflation uncertainty explains stock returns better than inflation but with the same negative impact.

Nonetheless more recent theoretical and empirical evidence challenges the existence of a negative relation between inflation and stock returns, and considers this relation to be non-fundamental once a “fundamental” variable is included in the regressions (Azar, 2010). Azar (2012) presents strong evidence that inflation uncertainty also fails to explain stock returns when the same “fundamental” variable is included in the regressions, although the effect of inflation uncertainty dominates the effect of inflation on stock returns. The fundamental variable is derived from the Gordon constant growth dividend model, and is approximated by the change in corporate bond yields.

The theoretical rationale behind the irrelevance of inflation and inflation uncertainty in explaining stock returns is as follows. Since higher inflation occurs with higher inflation uncertainty, inflation uncertainty increases the risk premium in the discount rate but at the same time the expected future cash flows are higher because inflation is also higher, leading to no change in the present value of these expected future cash flows, and consequently stock prices remain unchanged, and stock returns are not affected.

The purpose of this paper is to study the third relation, the one between stock prices and the change in eleven foreign exchange rates against the US dollar. Since inflation may be imported inflation and foreign exchange rate changes express the same source of variability.

All logged variables are integrated of order one. The null hypothesis of no-cointegration fails to be rejected for all dual specifications between stock prices and foreign exchange rates. Granger-causality tests on the log returns reveals no effect of the exchange rates on stock prices, but there is Granger causality of US stock prices on three foreign exchange rates. There is no plausible reason why this is so. The model developed requires the inclusion in the regressions of the change in the cost of equity, which is the 'fundamental' variable. The latter is substituted for by the change in the baa and in the aaa corporate bond yields. All regressions are estimated with a GARCH(1,1) model of the conditional variance. In all regressions the standardized residuals are well-behaved, and both heteroscedasticity and serial correlation are rejected. This implies that these regressions are well-specified in general.

The regressions of stock log returns on the log returns of the foreign exchange rate changes, each rate taken alone as the only independent variable, uncover significant impacts for five out of eleven slopes . However when the 'fundamental variable' is added to the regressions, which is the change in the baa corporate bond yield, replacing the change in the cost of equity, the above impacts reduce to only one with an additional one that is marginally significant. If the change in the aaa corporate bond yield replaces the change in the cost of equity, two significant impacts out of the eleven are found, with one additional marginal result. Hence the choice of the baa corporate bond yield, instead of the aaa corporate bond yield, provides better results, and this is reasonable and is as expected because the former includes a higher default risk premium, and is closer to the cost of equity. The evidence is therefore strong that the US stock market and the US dollar are effectively unrelated and independent when proper fundamentals are accounted for. This finding contradicts the assertion in the financial press.

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Note

Note 1. Azar (2007) finds a dividend yield of 1.74%. Azar (2010) finds a dividend yield between 1.69% and 2.12%. Finally, Azar (2012) finds a dividend yield between 1.56% and 2.26%.