A Second look at the movements of currency exchange rate

-- A Multi-Factor Model to Forecast the Movements of Currency Exchange Rate

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Introduction and Background:

As the trend of economic globalization and financial regulation relaxation picks up steam during the last few years, the role played by exchange rate is growing rapidly. As Harald Hau and Helene Rey remarked in 2005:

"The last 25 years have been characterized by a remarkable increase in international capital mobility. While gross cross-border transactions in bond and equity for the United States were equivalent to only 4% of GDP in 1975, this share increased to 100% in the early 1990s and has grown to 245% by 2000. Furthermore, a growing proportion of these capital flows consists of equity as opposed to bank loans or government bonds…"

Many countries use exchange rate as a tool to achieve the balance of international payments, adjust the circulation of currencies, and stimulate the local economy. Given the enormous impact of exchange rate on so many areas, study of exchange rate movements and the reasons behind these movements has received tons of attention in academia and industry.

Basically, there are two mainstream in the studies of the exchange rate—one explores the various factors which may exert an influence on the exchange rate dynamics, and one focuses on exchange rate movements forecasting.

Scores of studies have been done to identify factors which could drive the movements of exchange rates. Yet the extant studies about exchange rate movements have been far from reaching a consensus. For example, Hali J. Edison and Dianne Pauls, 1991, find no short-term impact of interest rate on exchange rate, while the long-term impact is ambiguous. On the other hand, however, the paper by Dong, 2006 systematically analyzed the impact of macroeconomic variables, especially interest rates, on the movement of exchange rate between US and German. While Obstfeld and Rogoff, 2000, failed in explaining exchange market movement when they focused exclusively on goods market, the Goldman Sachs GSDEER model, on the other hand, shows that the fluctuations in trade and real exchange rate movements are highly correlated. It is conventionally thought that a strong domestic equity market will attract international investment flow, thus pushing up the local currency. Surprisingly, Harauld and Helene, 2006, find the opposite result, that is, the well-performing local equity market will result in local currency depreciation. Colvo, Leiderman and Reinhart 1993, find that the fund flows into Latin American area are accompanied by an appreciation of the local currency. David O. Cushman 1985 reveals a significant reduction of bilateral direct investment flows is accompanied with expected appreciation of real foreign currency.

Among all these debates, the relationship between real exchange rate and real interest rate differentials receives lion's share of attention in the literature and is probably the most controversial issue. Hali J. and B. Dianne 1991 don't find cointegration between real exchange rate and real interest rate differential in the short term. Robert and Mark 2006, by employing a nonlinear bivariate model, prove the existence of a long-run relationship between real exchange rate and real interest rate differentials. However, Georgios and Rebeca 2001 find that such a cointegration only exists in small open economies, while there is little evidence to support the relationship in G7 countries.

There are improportionally fewer studies concerning the impact of short term momentum and long term value on the foreign exchange market movements. It is ambiguous whether the foreign exchange market will exhibit the similar pattern as other financial markets, such as equity market, of the short term momentum effect and long term reversion.

Overall, the factors can fall into two categories. The first category consists of a variety of fundamental factors. There are macroeconomic policy variables, which capture changes in currency values affected by economic policies. Another group of variables captures the effect of a country's economic growth on its currency. One could argue a strongly growing domestic economy could be bullish for the currency because a robust economy should attract significant inflows of capital from abroad. The third indicator which could be used to forecast currency movements is fund flows. Many studies have been conducted to study the correlation between a country's equity market trends and its currency exchange rates. The argument is a country's strong financial market could boost the demand for its currency.

Other than fundamental factors mentioned above, there are technically-based factors. Technical factors forecast the future trend in exchange rate based on past sequences of exchange –rate movements. One such factor is short-term momentum, which captures the tendency of the exchange rate to maintain its current uptrend or downtrend over relatively short horizons. The other term is long term value, which predicts the currencies to revert to a long term equilibrium value.

Despite hundreds of academic studies focusing on explaining the exchange rate movements, there are frustratingly fewer works predicting exchange rate dynamics, much less reaching a unified framework, which leaves the field much room for further research. The role of even one of the longest-existing and most solid theories of exchange rate, the purchasing power parity (PPP), have long been under consistent debate among scholars. Though it is well known that it has little predicting power in short term, its power to predict over long horizon is also ambiguous in even latest published academic literature. Some argue that there is no favorable evidence to support the PPP in long-run term (David, 2008), while the others maintain that it is still the most robust predictor of exchange rate movements in long term, and the deviations from long-run PPP will automatically vanish over time, say, with half-life of 2-5 years (Kenneth, 2009).

The majority of extant works are about real exchange rate forecasting rather than nominal exchange rate. According to Joseph Plasmans, William Verkooijen and Hennie Daniels (1998), the primary tools used by extant researchers are structural models, which include monetary models and portfolio balance models, while the authors innovatively propose an artificial neutral network models to predict exchange rate movements.

The monetary exchange rate model can further be divided into two types: there are the Flexible-Price Monetary Model (FPMM) and the Sticky-Price Monetary Model (SPMM). Due to the strict constraint that the PPP must hold in FPMM, which violates the economic reality, the SPMM is much more preferred in practice. There is not much work about monetary work. Christopher J. Neerly and Lucio Sarno (2002) argue that such type of model does not perform very well on predicting. Among these models, the most promising ones are those based on purchasing power parity or the current account (Kenneth Rogoff, 2009).

As to the Portfolio Balance Model (PBM), the central assumption is that foreign and domestic assets are not perfect substitute to each other. In the case of floating exchange rate, the exchange rate is determined by currency account imbalance. One of the works was by David O. Cushman (2007). In this paper, the empirical portfolio model presented is consistent with theoretical expectations and its out-of-sample forecasting performance is better than other fundamentals-based models.

Significance:

As noted earlier, previous studies tended to focus on the impact on the movement of exchange rate from one factor and seldom investigated all the possible factors jointly. In this paper, by constructing several variables to proxy for the fundamental factors discussed above, I would like to establish a new multi-factor foreign exchange model combining the fundamental factors and technical, which the author hope can help inspire a new financial market paradigm, shed a light on the puzzles mentioned above concerning the exchange market movements, and make more specific predictions about expected foreign exchange rate movements, despite its generally acknowledged difficulties.

Besides, this paper tests one of the most promising exchange rate forecasting model in existed literature by extending the data sample period which may exert significant impacts on its predictive power. Moreover, this paper also has some implications of asset pricing aspect, which current literature seldom set foot in.

Data Source:

To test the stock market return, I use the data from CRSP NYSE-AMEX market-returns indexes, spanning from January 1972 to December 2008. The data before the year 1972 are excluded from the sample because of the crash of Bretton Woods System in August, 1971. Since the main focus of this study is on the reaction of floating exchange rate to various market factors, the fixed foreign exchange rate system before Bretton Woods System will not be considered.

Data on real GDP is seasonally adjusted, from the FRED database (GDPC1). Following conventional practice, the annualized log real GDP growth from t to t+k is denoted as:

$$g = 4/k(\log GDP_{t+k} - \log GDP_t)$$

The daily and monthly interest rates are used as a proxy for short-term interest rate, respectively. Data on daily and one month interest rates are obtained from CRSP.

Exchange rate market represented by the HKD/USD, CNY/USD, SGD/USD, KRW/USD, JPY/USD,TWD/USD, CAD/USD, AUD/USD, NYZ/USD, SWF/USD, GBP/USD, and ERC/USD, where HKD represents Hong Kong Dollar, CNY represents Chinese Renminbi, SGD represents Singapore Dollar, KRW represents Korea Won, JPY represents Japanese Yen, TWD represents Taiwan Dollar, CAD represents Canada Dollar, AUD represents Australia Dollar, NYZ represents New Zealand Dollar, SWF represents Swiss Franc, GBP represents the Great Britain Pound, and ERC represents Euro. The reasons for studying these data are not only for increasing the data sample size, but also for the fact that the global economy seldom focuses only on a few currencies. The data for the euro-dollar exchange rates are obtained from the I/B/E/S (measured as USD per euro).

Data on bond market were gathered from CRSP.

Following earlier studies (Ilker, Ghiath, 1999), I will calculate real exchange rate as:

$$R_{it} = \frac{E_{it} WPIUS}{CPI_{it}},$$

Where WPIUS is the U.S price index, as a proxy for P_T*(the foreign currency price of tradables), domestic CPI is as a proxy for P_N (the domestic currency price of non-tradables), E is the official nominal foreign exchange rate, which is measured as the amount of domestic currency of per unit of U.S. dollar.

The data of analysts' prediction and updated revisions for EPS of each share will be collected from I/B/E/S database. However, IBES does not provide an aggregate market index. Therefore the author will construct an index following Stefano, Vincenzo, Alessandro and Fabrizio 2007 method (see for detail in their paper of "The Effect of Analysts' Forecasts on Stock Market Returns: A Composite Multifactor Approach" 2007).

Methodology:

<u>Assumptions:</u>

1. The author assumes a hedge-free foreign exchange market. Previous studies find that complete foreign exchange rate hedge makes the domestic and international investors easily eliminate the exchange risks, thus bringing about a "counterfactual benchmark" (Harauld Hau and Helene Rey, 2006). Levich, Hayt, and Ripston, 1999, implied that the majority of the institutional investors such as funds, who play a more significant role than individual investors, are not allowed to trade in derivatives or have to trade under certain constraints.

2. The exchange rate between any two countries represents the relative productivity of the two countries.
3. The process of asset pricing and exchange rate is endogenous, compared to the conventional exogenous pricing assumption. In other words, the short term foreign exchange rate movements are determined by equity market (Harauld Hau and Helene Rey, 2006).
4. The economy is composed of two players, international investor (i) and domestic investor (j), who are both risk-averse investors and maximize their profits from equity market, bond market, and foreign exchange market investments.

<u>Independent variables:</u>

1. *<u>Long-term value:</u>*

a. Neg-FX-13-60: currencies that have performed well over the past five years, but for the last 12 months, look less attractive.

•Hypothesis:

Similar with other financial markets, foreign exchange returns display mean-reversion over long horizons. In other words, countries whose currencies have performed well over the past several years look less attractive.

2. *<u>Short term momentum:</u>*

I use currencies that have performed well over the past twelve or twenty four months to capture the tendency for currencies to display trends over relatively short horizons.

FX12

FX12-1

If two currencies with the same positive momentum over the past twelve months, I will use the one with the strongest performance over the last month.

I will construct a wide variety of factors, using windows of different length to measure performance, and using different starting points (lags) to construct the windows. The predictability of daily, monthly, and quarterly data will be explored respectively.

•Hypothesis:

Similar with other financial markets, foreign exchange returns display short-term momentum. In other words, countries whose currencies have performed well over the past short period will continue their strength.

3. *Fund flows:*

a. ER- 12: 12-month equity return
b. VWERMQ: Analysts' revisions of equity earnings. The author is thinking about two methods. One is a market-weighted average of (#analysts up-# analysts down)/#analysts). The other is to follow the Stefano, Vincenzo, Alessandro and Fabrizio 2007 method. Basically, I will obtain the IBES constituents for each revision period as the weight, collect data of weekly EPS forecast and weekly market capitalization for each company, and form a weighted consensus indicator from these data:

$$Cons_t = \sum_{i=1}^{30} k_{ti} Const_i / \sum_{i=1}^{30} k_{ti}$$

where $Const_i$ (t=1,…T, i=1,…30) is the week t EPS consensus value for each IBES company, when t is the current period index composite for each week t; kti (t=1,…T, i=1,…30) indicates the week (data will come from DataStream) market capitalization for the company i.

•Hypothesis:

Currencies of countries with attractive financial markets tend to become weaker. This is because the inflow of those currencies increases, making them relatively less expensive.

4. *Macroeconomic policy:*

Since the forecasting ability of the model is one important aspect that needs to be studied in this paper, the author would consider macro factors, which turn out to play a crucial way in predicting exchange-rate change (Cappiello and DeSantis, 2005, Kari Heimonen, 2009). I will consider the variables that are directly affected by economic policy, which play a role in driving the changes in currency values.

a. Short-term interest rates: DSR (adjusted by inflation)
b. Negative slope of the yield curve: Neg-Term

•Hypotheses:

1. When short-term interest rates increase, funds flow into the country thus pushing up the value of the local currency;
2. If the yield curve is flat in equilibrium, a negative slope indicates that short-term bonds are likely to appreciate through a reduction in yield. This may attract funds from international short-term speculators and therefore, push up the value of the currency.

5. *Economic Growth:*

I will construct several forecasting variables to proxy for future expected growth:

a. GDP-3Mo: Past 3-month GDP growth;
b. GDP-6: Six-month change in average forecast of year-on-year real GDP growth;
c. GDP-12: Year-on-year change in seasonally adjusted nominal 12 month growth rate of nominal GDP, it captures improvement in economic performance, which may signal good investment opportunities that push up the value of a currency.

•Hypotheses:

The Economic growth can capture the effect of expected changes in productivity on currencies. The idea is that capital trends to flow in and out of countries as a function of productivity expectations. Positive expectations induce capital inflows and, as a consequence, currency appreciation.

Model:

(1) A proposed structural cross-sectional model:

$$R_i - R_j = \alpha + \beta_1 \mathrm{Neg{-}FX{-}13{-}60} + \beta_2 F4X12 + \beta_3 FX-12-1 + \beta_4 ER12 + \beta_{5i} r_i + \beta_{6j} r_j + \beta_7 GDP-12 + ei_j$$

Where R_i and R_j are the return from investing $1 in the currency of country i or j.

As previous papers have pointed out, in this case, the factors used as independent variables are interrelated and can influence each other in reaction to the market's behavior. Besides, there is also a concern that exchange rate movements cannot be completely exhausted by individual factors. Therefore it is possible that some potential factors with long-term influence on the exchange rate movement unexplained by the model, thus being correlated to different lags of independent variables. Linear regression requires their independent variables to be uncorrelated among themselves and with disturbance. To address this issue and obtain greater accuracy, the author will model the error term in an ARMA specification. (Need to be specified)

(Note: This model may work well, or in other case, fail to give sufficient predicting power. The author's preliminary thought is that, if, the model cannot provide significant predictability, it is probably necessary to make certain restrictions to the coefficients and exchange rate returns. May refer to more asset pricing paper for inspiration, including John and Thompson's 2008 paper.)

(2) A proposed time-series model:

Hypothesis: short-term interest rate and long-term interest rate can be used to predict the expected exchange rate.

$$R_{i,t+1} - R_{j,t+1} = \eta + \theta_{r_i,t} r_{i,t} + \theta_{r_j,t} r_{j,t} + \theta_{dl_i,t} dl_{i,t} + \theta_{dl_j,t} dl_{j,t} + \varepsilon i_{j,t}$$

R_i and R_j = return from investing $1 in the currency of country I or j

r_i and r_j = short-term interest rates in countries I and j

dl_i and dl_j = change in long-term rates in countries I and j

Recursive estimation for each currency pair:

a. At time t run each regression using 37 years of data (forecasting variables as of t-1)
b. Use estimated parameters from a) and time-t values of forecasting variables to build forecasted currency returns for t+1.

(3) The Pierre-Olivier and Helene model (POHM)

The first model is a new structural model built by the author, and the second one is derived from the purchasing power parity. The forecasting power of these two types of models is subjected to controversy in different extent, however (the very first early work of Meese and Rogoff, 1983, which lays the foundation of exchange rate theory, for example, criticize that the structural model was too simply specified to outperform the random walk model. Nevertheless, they did find one important positive result that the models appeared to outperform random walk under the case of a very long horizon).

However, among all these critiques against structural models, it does not mean, that such type of models has quite limited predictability. As Rogoff noted in 2009, recent works (Engel and West, 2005, 2006, Engel et al. (2007), Molodtsova and Papell (2008), and Gourinchas and Rey (2007) find somewhat more positive results.

Actually, the work on Pierre-Olivier and Helene have come up with a predicting model based on current account (see their paper International Financial Adjustment, 2007, for more details) that seem to perform surprisingly well at short, medium, and long horizon both in- and out-of sample—it is able to predict in sample 9% of the variance of the exchange rate one quarter ahead, 31% a year ahead, and 41% three years ahead.

For brevity, I will not illustrate this model step by step, but give a rather brief picture. Their methodology follows the work of Lettau and Ludvigson (2001) which uses the consumption wealth ratio as a predictor variable for equity premium. POHM covers both the "trade channel" effect and "valuation channel" effect, say, the effect of net exportation of one country and the net foreign asset of one country, respectively. This is somewhat in the same line of thoughts of my structural model discussed above, which include equity returns of domestic country as one of the control variables.

The accumulation identity for net foreign assets between period t and t+1 is given by:

$$NA_{t+1} \equiv R_{t+1}\left(NA_t + NX_t\right) \qquad (1)$$

The trend component μ_t^x is not assumed to be a constant but allows a possibly time-varying growth rate, i.e., $\mu_t^{zw} = \mu^{zw} . \mu_t$. In this case the first-order approximation of equation (1) will be:

$$na_{t+1} \approx \frac{1}{\rho_t} na_t + \left(\hat{r}_{t+1} - \Delta w_{t+1}\right) - \left(\frac{1}{\rho_t} - 1\right) nx_t \qquad (2)$$

Where,

$$
\begin{aligned}
nxa_t &\equiv |\mu^a| \cdot \epsilon_t^a - |\mu^l| \cdot \epsilon_t^l + |\mu^x| \cdot \epsilon_t^x - |\mu^m| \cdot \epsilon_t^m \\
\Delta nx_{t+1} &\equiv |\mu^x| \cdot \Delta\epsilon_{t+1}^x - |\mu^m| \cdot \Delta\epsilon_{t+1}^m - \Delta w_{t+1} \\
r_{t+1} &\equiv |\mu^a| r_{t+1}^a - |\mu^l| r_{t+1}^l
\end{aligned}
$$

nxa_t combines linearly the stationary components of exports, imports, assets and liabilities, and combines information both from the trade balance (the flow) and the foreign asset position (the stock). This is actually in accordance with my idea of constructing the structural model in section (2).

By assuming that nxa_t satisfies no-ponzi condition, they derive the following approximation from equation (2):

$$
nxa_t \approx -\sum_{j=1}^{+\infty} \rho^j E_t \left[r_{t+j} + \Delta nx_{t+j} \right] \qquad (3)
$$

It shows that movements in the trade balance and the net foreign asset position must forecast either future portfolio returns, or future net export growth, or both. The first one represents the so-called “valuation channel”, while the second one is the “trade channel”. Valuation channel, according to the authors, can take place by a depreciation of the domestic currency.

They run the regression of the form:

$$
\Delta e_t = \alpha + \beta nxa_t + \varepsilon_{t+1} \qquad (4)
$$

where y $_{t+1}$ denotes a quarterly return between t+1 and t and ε $_{t+1}$ is a residual. What they find exciting and surprising is that nxa_t is a strong predictor of Δe_t.

In the longer run (including 2,3,4,8,12,16,24 quarters respectively), they use both (4) and the other regression (5) to test the predictability of nxa_t on Δe_t :

$$
\Delta e_{t,k} = \alpha + \beta_1 \varepsilon_t^{\,x} + \beta_2 \varepsilon_t^{\,m} + \beta_3 \varepsilon_t^{\,a} + \beta_4 \varepsilon_t^{\,l} \qquad (5)
$$

$\bar{R}(1)$ is the adjusted R-squared of regression (4), and it shows the explanatory power of nxa_t. $\bar{R}(2)$ is the adjusted R-squared of the regression of regression (5).

At all horizons, the sign of the exchange rate effect is negative, which conforms to the hypothesis that an exchange rate depreciation increases the value of foreign assets held by the US and affects net exports positively. Moreover, the POHM beats the random walk model in out of sample predicting, exhibiting dramatic predictability.

Therefore, the POHM seems to be one of the most promising models predicting exchange rate dynamics hitherto. According to Rogoff and Stavrakeva (2008), however, forecasting models are very sensitive to the time period being examined; therefore it would be interesting to investigate whether their model still works well in recent periods, especially after the dramatic US dollar appreciation in 2008 despite the current account deficit. Thus I will follow the Olivier—Helene model, but extend the sample up until the very latest available data.

Table I

U.S. Stock Market Return (S&P 500; partial): 1/2000-12/2008

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	-5.09%	-2.01%	9.67%	-3.08%	-2.19%	2.39%	-1.63%	6.07%	-5.35%	-0.50%	-8.01%	0.41%
2001	1.73%	-9.23%	-6.42%	7.68%	0.51%	-2.50%	-1.08%	-6.41%	-8.17%	1.81%	7.52%	0.76%
2002	-1.56%	-2.08%	3.67%	-6.14%	-0.91%	-7.25%	-7.90%	0.49%	-11.00%	8.64%	5.71%	-6.03%
2003	-2.74%	-1.70%	0.84%	8.10%	5.09%	1.13%	1.62%	1.79%	-1.19%	5.50%	0.71%	5.08%
2004	1.73%	1.22%	-1.64%	-1.68%	1.21%	1.80%	-3.43%	0.23%	0.94%	1.40%	3.86%	3.25%
2005	-2.53%	1.89%	-1.91%	-2.01%	3.00%	-0.01%	3.60%	-1.12%	0.69%	-1.77%	3.52%	-0.10%
2006	2.55%	0.05%	1.11%	0.59%	-3.09%	0.01%	0.52%	1.98%	2.46%	3.15%	1.66%	1.26%
2007	1.43%	-2.16%	1.00%	4.33%	3.25%	-1.78%	-3.28%	1.29%	3.58%	1.45%	-4.18%	-0.76%
2008	-6.09%	-3.48%	-0.58%	4.46%	1.04%	-8.55%	-0.73%	1.06%	-9.56%	-16.79%	-7.48%	1.65%

Figure I: U.S. Stock Market Return (S&P 500; partial): 1/2000-12/2008

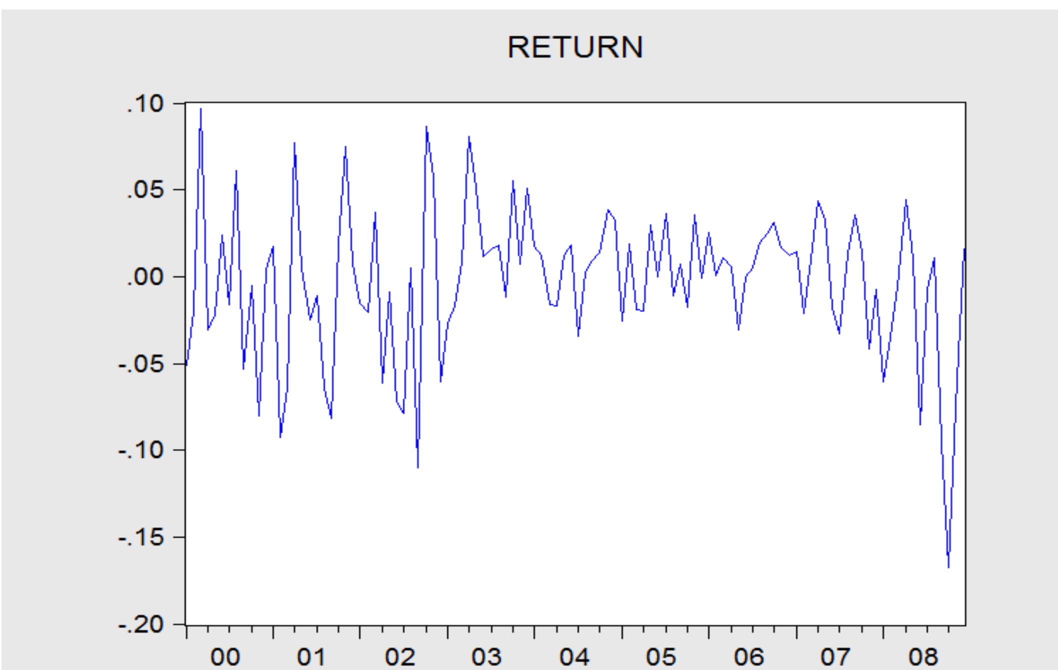

Table II

USD/EUR exchange rate (partial): 01/2000-12/2008

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	0.987	0.987	1.045	1.045	1.122	1.122	1.051	1.092	1.163	1.192	1.164	1.142
2001	1.075	1.089	1.097	1.146	1.131	1.174	1.148	1.098	1.112	1.103	1.132	1.113
2002	1.132	1.146	1.142	1.127	1.103	1.047	0.993	1.013	1.023	1.018	0.992	0.974
2003	0.945	0.931	0.922	0.931	0.882	0.844	0.860	0.869	0.924	0.847	0.841	0.814
2004	0.788	0.789	0.824	0.832	0.834	0.833	0.809	0.814	0.814	0.814	0.814	0.753
2005	0.767	0.770	0.745	0.775	0.791	0.826	0.827	0.813	0.813	0.834	0.857	0.831
2006	0.826	0.840	0.831	0.811	0.782	0.793	0.796	0.778	0.789	0.799	0.781	0.756
2007	0.772	0.762	0.756	0.736	0.737	0.752	0.724	0.742	0.716	0.704	0.681	0.695
2008	0.681	0.687	0.639									

Figure II: USD/EUR exchange rate (partial): 01/2000-12/2008

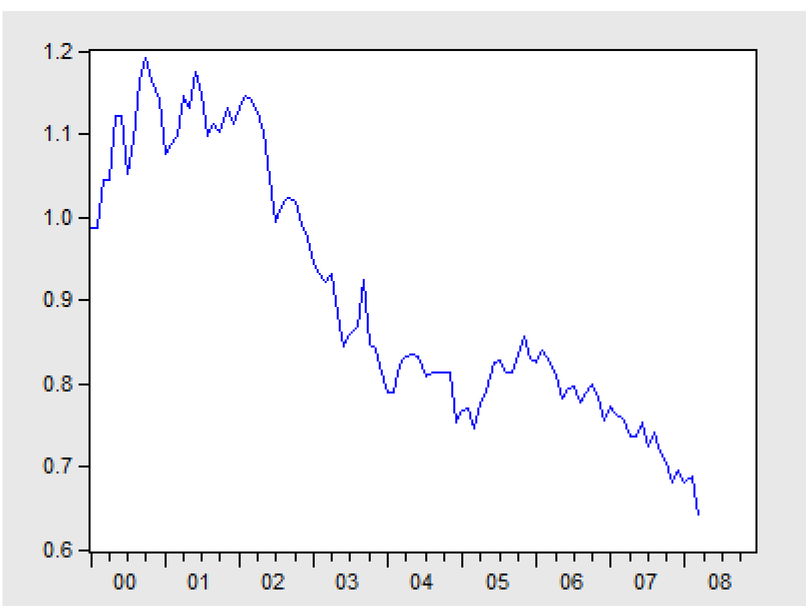

Table III: The autocorrelation between the U.S. equity market return and the USD/EURO rate at the same period

Correlation			
	RETURN	EXRATE	
RETURN	1.000000	-0.161127	
EXRATE	-0.161127	1.000000	

We can see that they do exhibit negative correlation.

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