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Conference Paper

Cointegration Analysis: Exchange Rate Markets Of The European Monetary System

40th Congress of the European Regional Science Association: "European Monetary Union and Regional Policy", August 29 - September 1, 2000, Barcelona, Spain

Provided in Cooperation with:
European Regional Science Association (ERSA)

Suggested Citation: Amigo Dobaño, Lucy (2000) : Cointegration Analysis: Exchange Rate Markets Of The European Monetary System, 40th Congress of the European Regional Science Association: "European Monetary Union and Regional Policy", August 29 - September 1, 2000, Barcelona, Spain, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:
https://hdl.handle.net/10419/114881

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COINTEGRATION ANALYSIS: EXCHANGE RATE MARKETS OF THE EUROPEAN MONETARY SYSTEM

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This paper examines empirically the evolution of the daily spot exchange rate returns over the European currency crises of 1992-93. The long-run equilibrium relationship is estimated using the Johansen maximum likelihood-method for cointegration models. The model is tested for five currencies such as the lira, sterling, French franc, peseta and Deutsch mark. In addition, a similar analysis has been specified for the stability period 1995-97. The results indicate that, for the stability periods' overcoat, we find cointegration between these currencies, playing the Deutsch mark exchange rate a certain "leadership".

1. INTRODUCTION

The aim of this paper is to carry out an empirical analysis on the interdependence of the return and volatility of the exchange rate markets of the European Monetary System over the European crises of 1992-1993 and during the stability period 1995-1997. We consider two alternative methodologies: on one hand, the existence of simultaneous relations among markets using the correlation matrix between these series; on the other hand, the existence of a causality and long term relations evaluated in a cointegration context.[1]

For this analysis we use the exchange rates of the European Union's main economies, considering the exchange rates of the Italian lira, the French franc, pound sterling, Deutsch mark, and the Spanish peseta with regard to the US dollar, as it is the reference currency in the principal trade and financial relations. The interest of this study is also increased by the presence of the current fifteen members in the sample period 1995-97 and, in any case, taking into account the imminence of the process through the European Monetary Union (EMU).[2]

The results that have been obtained seem to demonstrate a high correlation between the foreign exchange market in Germany–leading country in the European Monetary Union – and the rest of the analyzed markets, mainly during stability periods, which correspond, in this case, to the sample 1995-97.

This paper is organized as follows: in section 2 we analyze the data and the statistical properties of the series, the daily exchange rate returns and volatilities of five international currencies in relation to the dollar; in section 3 we deal with the methodology, paying special attention to Johansen maximum likelihood-method for cointegration models; in section 4 we fit the normalized cointegrating coefficients of four international currencies -LIT/USD, FRF/USD, GBP/USD and PTE/USD- against the DM/USD; finally, in section 5 the

[1]This epigraph is based on a work by De Miguel, M.M. et al. (1988) in which a study on markets integration and volatility in the context of the main stock markets in the European Union is carry out.

[2]At the same time, the interest in this type of research is being increased if we take into account that, although it does exist a large number of works analyzing the relations among the interest rates within the European Union countries, there are but a few empirical studies which deal with the foreign exchange market. Among the works referring to the integration of financial markets we can mention those by Caporale and Pitis (1993), by Caporales, Kalyvitis and Pitis (1996), and by Camarero, Esteve and Tamarit (1997).

conclusions are presented.

2. THE DATA

The database used is made up of daily data from the spot exchange rates of the Italian lira/US dollar (LIT/USD), French franc/US dollar (FRF/USD), sterling pound/US dollar (GBP/USD), Deutsch marc/US dollar (DM/USD), and Spanish peseta/US dollar (PTE/USD) with a daily periodicity. The sample period runs from January 2nd 1992 to December 31st 1993 (483 observations), and from January 2nd 1995 to December 30th 1997 (730 observations). All data come from the Servicio de Estadística y Central de Balances del Banco de España (Statistics Service and Commercial Performance Information Bureau of the Spanish Central Bank)

In Tables 2-A and 2.1-B the main statistics of returns series are shown, for the subperiods 1992-93 and 1995-97 respectively; all of them are written as logarithms. From the descriptive statistics related to the returns, we can observe that the mean almost equals 0, as it is usual in most financial series. The LIT/USD exchange rate undergoes the maximum increase of its return (depreciations) during the period 1992-93 (7,1%), in opposition to the 5,4% undergone by the PTE/USD and the DM/USD, and the 3,2% and 2,4% of the FRF/USD and PTE/USD rates, respectively. During the period 1995-97 the Italian lira was also the one that underwent the highest percentage of depreciation in relation to the dollar, although it was -logically enough- lower than that registered during the period of turbulences that took place between 1992 and 1993.

However, the most significant falls in the daily rates of return (appreciations) during the 1992-93 period were those undergone by the DM/USD exchange rate (5,8%), followed by the 4,6% of the GBP/USD. On the other side we have the 3,8% of the PTE/USD, the 3,2% of the LIT/USD and the 2,5% of the FRF/USD. Similarly, during the period 1995-97, it was also the Deutsch marc rate the one that underwent one of the highest appreciation percentages.

So, as we can appreciate from our analysis, the DM/USD rate, followed by that of the LIT/USD, underwent the highest standard deviation in returns, which is higher during the

period of financial instability (1992-93), which reveals its higher volatility. This fact is confirmed if we analyze the volatilities' mean, as it is shown in Tables 2.1-C and 2.1-D.

We can also see in Table 2.1-A that the return distributions of the lira, the franc, and the peseta, during the period 1992-93, have a skew to the right, while in the cases of the sterling pound and Deutsch marc, the skew is to the left. Jarque-Bera statistic clearly rejects the hypothesis of normality of the distributions in all cases. Similarly, we can see in the aforementioned table that all distributions are leptocurtic, especially for the case of the most volatile rates in our study, i.e., the Italian lira and the Deutsch marc in relation to the US dollar. This same analysis was carried out for the period 1995-97 -Table 2-B- obtaining some variable results, although in any case, the marc still has a positive skew.

Ljung-Box statistic values are shown in Table 2.2 in order to check, as a whole, the signification of the first 10 and 20 serial autocorrelations. We can see that, at levels of usual significance, the returns series show, in general, a reduced degree of autocorrelation; particularly the autocorrelation coefficients corresponding to Q(10) are not significant except in the case of the peseta and the Deutsch marc during the period 1992-93 (Table 2.2-A), and the Italian lira during the period 1995-97 (Table 2.2-B). On the contrary, as we can see in Tables 2.2-C and 2.2-D, the hypothesis of non-correlation is always rejected for the volatilities' series, which let us notice the existence of autoregressive elements.

3. METHODOLOGY

Simultaneous and short term relations

In Tables 3.1-A and 3.1-B we can see the correlation matrixes for the returns during the periods 1992-93 and 1995-97, respectively. Next, in Tables 3.1-C and 3.1-D for the volatilities.

As we can see in Table 3.1-A, in the case of the returns, the highest correlation during the period 1992-93 is that between the Spanish peseta and the Deutsch marc (0,8365) in relation to the US dollar. On the other hand, the lower correlation is that undergone by the DM/USD-LIT/USD rates. In short, we can see that the analyzed foreign exchange markets show a quite high correlation in relation to the Deutsch marc; although it is the PTE/USD rate the most

correlated one. As for volatilities -Table 3.1-C-, the highest correlation is also that of the Detsch marc and the Spanish peseta. In any case, it can be verified in our study that, for all the cases presented here, the volatility correlations are always lower that the returns correlations.

Similar results can be extracted from the period 1995-97, although with some variations. So, even though in this case the returns correlation between the PTA/USD and the DM/USD is even higher (0.9143 vs. a previous 0.8365), and in the same degree the volatilities correlation is also higher (0.9997 vs. a previous 0.7741), we can verify, however, that in high-volatility periods (1992-93) the volatility correlations are lower than the returns correlations, while in periods which are characterized by the lack of financial instabilities (1995-97) it occurs the other way around, i.e., the volatilities correlations are higher than the returns correlations.

However, the existence of correlation among the foreign exchange markets we are dealing with here does not shed any light to determine the short term, dynamic relation which probably exists among them. In order to achieve that, we are going to carry out a causality analysis using Granger tests (1969)[3].

Our main goal is to test the effect of the causality relations between daily exchange rates over the European Monetary System. The tests are shown in Table 3.2-A (1992-93) and in Table 3.2-B (1995-97). The analyses are carried out considering 2 lags in the independent variables[4]. Each cell *(i,j)* indicates the statistic value associated to the null hypothesis that the index do not causes index *i*.

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[3]A variable causes another, in Granger's sense, if past values of the first variable offer better predictions about the second one. The usual way of carrying out this contrast is to establish an two-variable autoregressive model including, as explaining variables the variable of interest's past observations, as well as past observations of the variable that is possibly causing the other. The contrast is performed by verifying the statistical significance of the coefficients which are relative to the variable that is possibly causing the other, by means of a standard contrast (F o _[2]). In the case of the relationship between 2 dayly exchange rates (e.g. I_t^1 and I_t^2), the Granger test would be expressed as follows:

Install Equation Editor and double-click here to view equation.

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We have to take into account that we are making particular the analysis for the case of two variables at levels that they can be cointegrated. The concept of cointegration can be extended to a regression model which contains *k* regressors. In this case we would have *k* cointegrated parameters.

[4]That was proved using Box-Pierce's contrast. In this way, a second-rate VAR model was enough to capture the short term dynamic that exist between those rates, as it does not have remainders from the estimated models of a significant serial correlation.

As we can observe, there are a large number of apparent causality relations. However, we are just going to deal with the ones we consider to be more interesting. The Deutsch marc is the rate for which there exist more causality relations during the period 1992-93 (only for the French franc, the null hypothesis of non-causality cannot be rejected). In this respect, we can see that the evidence brought forward by Granger's contrast could be a bit surprising, as it does show that important markets as sterling pound's and French franc's affect the rest of the markets we are dealing with in this study, but it does not occur for the case of the Deutsch marc. This conclusion can also be figured out from the results of this contrast for the sample period 1995-97.

Another important conclusion for our study is that the peseta, particularly during the period 1992-93, does not seem to be affected by such an important market as that of the sterling pound. However, for the levels of usual significance the null hypothesis of no causality of the French franc and the Deutsch marc is not rejected. On the contrary, during the period of monetary stability that runs from 1995 to 1997, the Spanish peseta does not seem to be affected neither by the French franc nor by the Deutsch marc, being the null hypothesis of no causality not able to be rejected only for the case of the sterling pound.

The paradox could be explained if we consider that the information given in a market is included during the same session, which can be translated into a high instant correlation in the markets but not necessarily into the existence of daily, dynamic causality relations. In fact, and as it can be seen in Table 3.2-A, the highest correlations of the peseta occur firstly in relation with the Deutsch marc (0.8365), followed by the French franc (0.7511). These correlations are even higher during the stability period of 1995-97, with values of 0.9143 and 0.8778 respectively.

These results can be also corroborated if we consider the volatilities series. In this way, the highest correlations in volatilities between the peseta and the marc -see Table 3.2-D- occur in the period 1995-97, with a value of 0.997, while during the period 1992-93 –Table 3.2-C- we have a value of 0.7741.

In the next section, we will examine the possible relationship between the daily exchange rate

LIT/USD, FRF/USD, GBP/USD, and PTE/USD in relation to the DM/USD rate –as it is Germany the leading country in the European Union-. For this purpose, we will follow Johansen´s approach. Our results would support that in the sample 1992-93 (financial turbulence) the analyzed daily exchange rates do not show any correlation, although the LIT y and the PTE are the most susceptible to be affected by the German exchange rate. On the contrary, in stability periods (1995-97) all daily exchange rates are correlated, being the FRF the one that shows a higher long-term sensibility coefficient in relation to the DM.

Long-term relations

Particularly, our goal is to estimate and to contrast the possible existence of some kind of tendency in the long term between the Deutsch marc and the rest of the considered rates[5] that might have been being affecting the behavior in the short term. To achieve that, we are going to use Johansen method, as it is the present-day, most popular tendency in applied econometrics analysis.

As stated before, the econometric methodology used in this paper is based on Johansen´s test (1990). There are three main reasons for this choice: firstly Gonzalo (1994) shows that Honansen´s test achieves better results than other approaches under various specifications errors. Secondly, this test allows incorporating the entire cointegration issue into the familiar VAR representation, without restrictions on the exogeneity characteristics of the variables. Finally, the procedure provides simultaneous test statistics (the λ-max and Trace tests) to infer the number of cointegrating relationships and estimates of the cointegration vector. The main difference between the λ-max and the Trace tests is that the former tests for the existence of r cointegration vectors against the alternative $r+1$, whereas the latter tests against the alternative of more than r cointegration vectors.[6]

The empirical framework to test for cointegration we define X_t, a $(n \times 1)$ row-vector. This vector admits the following *VAR(p)* representation:

[5]It could be also possible to make a similar analysis but in a multiple-variant context, by analyzing not only the possible relations of each of the rates we are dealing with in relation to the marc, but in relation to each of the remaining rates, which exceeds the purpose of this study.

[6]As it is well known, the results from Granger-causality test (Granger, 1969) are highly sensitive to the order of lags in the autoregressive process. On the other hand, there are several important differences between this test and other alternative procedure in the literature (see, Gregory and Hansen, 1996).

$$\Delta X_t = \sum_{i=1}^{n-1} \Gamma_i \Delta X_{t-i} + \Gamma_n X_{t-n} + \mu + \varepsilon_t \quad (1)$$

where $__t$ is a vector white noise process with zero mean and variance Σ, X_t should be stationary and μ is a vector of constant terms. $\Gamma_i = -I + \Pi_1 + ... + \Pi_i$, with $i=1,...,n$. If $0<r<n$, in which case there would be r cointegration vectors. In this case Γ_n can be written as the product of two rectangular matrices α and β or orden $(n \times r)$ such that $\Gamma_n = \alpha\beta'$. Observe that in this case $\beta' X_t$ will be stationay given the $__t$ is a white noise process. Therefore, one could define the r columns of β to be the cointegrating vectors, that is the linear combination of X_t that are stationary, and α to be the loading matrix, the matrix which describes how important each of those r vectors are to the dynamics.

As a first step on the analysis, we tested for the order of integration of the variables using Dickey-Fuller's and Phillips-Perron's tests. According to the results from both tests, the null hypothesis of a unit root was not rejected in all cases, at the same time that the null of a second unit root was always rejected.

Tables 4.1-A and 4.1-B report the results of the Johansen test for both samples under an analysis using 2 lags in the VAR. The number of lags has been chosen according to the Akaike information criterion. In the aforementioned tables we can also see, along with the estimations of the cointegration equation coefficients, the results achieved after using Johansen's (1988) and Johansen and Juselius' (1990) cointegration contrast to detect whether there exists or not long term relations between the series, and also the adjustment speed parameter -γ-.

As it can be seen, the daily exchange rates of these currencies do not appear to be cointegrated with the DM/USD ones in the bivariate case. The only exception would be the bilateral Johansen tests found for PTE/USD during 1995-97 period.[7]

However, those results are possibly contradictory to the expecting ones, taking into account that all these economies belong to an integrated economic area, where there do exist strong

[7]We have to bear in mind that, in any case, as in the Test of Engle y Granger, this one analyzes the relations of cointegration from a lineal perspective, which does not allow considering general, long-term relations. For further details on this subject see Olmeda (1997).

interdependencies among the different countries' macro-magnitudes, which would affect to their respective exchange markets.

In order to show the graphic evidence of the above mentioned exchange markets' relations, in the Figures 4.1 to 4.4 the evolution of the tax rates of LIT/USD, FR/USD, GBP/USD, and PTA/USD in relation to the DM/USD during the period 1992-93 is presented; and in the Figures 4.5 to 4.8, for the period 1995-97.

In the Figures 4.1 to 4.4 it seems to be proved that, with the exception if the sterling pound rate, the rest of the currencies we are considering here registered a considerable appreciation in relation to the US dollar form the mid 1992 on, which is a tendency that from September onwards was reversed, due to the economic conditions already studied in the first chapter of the paper. In other words, it seems to exist for these three rates an important relation with the DM/USD rate. During the period 1995-97, the rates we have been dealing with did not undergo abrupt changes, as it is demonstrated in Figures 4.5 to 4.8. In any case, it seems to exist an important relation between the FRF/USD and PTE/USD rates in relation to the evolution of the DM/USD, in the sense of showing shared tendencies in time, but, above all, during the stability period 1995-97.

We can see, though, that the results obtained in the cointegration contrasts for this group of currencies are not the expected ones, in general. The explanation of this fact can be found in the existence of a tendency not recorded in the data, in such a way that it is not possible to find a stationary lineal combination between two variables.

Next, we are going to apply a different contrast in order to analyze whether it does exist a integration process for those rates in relation to the Deutsch marc, as it is broadly shown in the previous graphics. Taking into account that the foreign exchange markets are in general correlated with the economic cycle of their respective economies, we think that in order to analyze more accurately the evolution of the exchange rates, we should apply the possibility of existing a determinist tendency *(t)* in the relation of the exchange rates of the Italian lira, French franc, sterling pound, and Spanish peseta with the carc/dollar rate[8]. The results

[8]So far, to analyze the level of integration among those rates, we have only applied contrasts of "determinist cointegration". The determinist cointegration implies that the cointegration

obtained from the estocastic estimation[9] are recorded in Tables 4.2-A and 4.2-B for the periods 1992-93 and 1995-97 respectively.

As we can see in the Tables 4.2-A and 4.2-B, the results of the cointegration contrasts when we insert a lineal tendency in the equation are different from those obtained in the Tables 4.1-A and 4.1-B. In fact, although in the cases of the period 1992-93 we cannot reject the null hypothesis of non-cointegration, so there are not important differences with the results that have been obtained previously; in the period 1995-97 we can both reject the null hypothesis and accept that there is a long-term relationship between the PTE/USD and the DM/USD.

As for the period 1992-93, we want to emphasize that, despite the differences involved in the evolution of the studied exchange rates, they also have common characteristics. For instance, during the period 1992-93 for all the currencies we are dealing with, including the Spanish peseta, the cointegration analysis leads us to affirm that there are no common tendencies in the evolution of these currencies in relation to the referent currency, which, in this case, is the Deutsch marc. It is a normal behavior if we take into account the turbulences process they suffer from September 1992 on[10].

On the contrary, as we can see in Table 4.2-B, during the period that runs from 1995 to 1997, there is an evidence of integration between the LIT/USD, the PTA/USD, the FRF/USD, and the GBP/USD in relation to the DM/USD, and which is recorded in the cointegration equation. All of the cointegration equation coefficients are significant and they have the expected sign.

5. CONCLUSIONS

As a conclusion we can say that the results obtained from the cointegration analysis are very

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vector eliminates, at the same time, both the determinist and estocastic tendencies. For instance, in the cointegration equation only a constant is included as a determinist element.

[9]The estocastic cointegration implies that the cointegration vector eliminates the estocastic tendencies, but not the determinist. So, in the cointegration equation a lineal tendency is included, besides the constant.

[10]As a complement it was also carried out –although the results were not presented in this paper- the same cointegration analysis adding a fictitious variable to the cointegration equation, which equals 0 until August 1992, and 1 from September of that year on. Its aim is to distinguish between two different stages in the exchange rates' behavior. The obtained

interesting. The results indicate that, for instability periods (1992-93) we do not find cointegration in these currencies, although the adjustment speed parameter is significant for the LIT/USD and PTE/USD rates. The reason lies, maybe, on external factors.

On the contrary, the empirical evidence which is available shows that the main effects of the DM/USD and these analyzed daily exchange rates leads us to reject the null hypothesis of non-cointegration among the lira, the franc, the sterling pounds, and the peseta rates in relation to the Deutsch marc, showing a common tendency and so a high level of integration in relation to the Deutsch marc. In particular, the results show a higher cointegration between the FRF/USD-DM/USD, followed by the relation between the PTE/USD-DM/USD, the GBP/USD-DM/USD and the LIT/USD. Similar results were obtained trough the correlation analysis among the currencies of the sample. Therefore, the inspection of the Figures suggests that within the period 1995-97, the trajectories of these series have not diverged.

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results did not lead us not to reject the null hypothesis of non-cointegration, either.

APPENDIX

TABLE 2.1
STATISTICAL PROPIERTIES

TABLE 2.1-A DAYLY SPOT EXCHANGE RATE RETURNS (1992-93)

	LIT/USD	FRF/USD	GBP/USD	PTE/USD	DM/USD
Mean	0.0007	0.0002	-0.0004	0.0007	0.0003
Maximum	0.0717	0.0320	0.0240	0.0543	0.0543
Minimum	-0.0329	-0.0252	-0.0464	-0.0383	-0.0589
Std.Dev.	0.0092	0.0079	0.0085	0.0089	0.0093
Skewness	1.3479	0.5751	-0.7465	0.7959	-0.2263
Kurtosis	11.4192	4.9028	5.7090	7.9252	10.5985
J-B (P-value)	1169.55 (0.000)	99.29 (0.000)	192.16 (0.000)	538.09 (0.000)	1163.69 (0.000)

TABLE 2.1-B DAYLY SPOT EXCHANGE RATE RETURNS (1995-97)

	LIT/USD	FRF/USD	GBP/USD	PTE/USD	DM/USD
Mean	0.0001	0.0002	8.3E-05	0.0003	0.0002
Maximum	0.0557	0.0296	0.0243	0.0367	0.0319
Minimum	-0.0244	-0.0380	-0.0187	-0.0341	-0.0358
Std.Dev.	0.0056	0.0058	0.0047	0.0064	0.0064
Skewness	1.2013	-0.4832	0.0056	-0.0027	-0.4363
Kurtosis	16.7777	7.5937	5.3566	7.1614	7.1006
J-B (P-value)	5940.99 (0.000)	669.35 (0.000)	168.69 (0.000)	526.01 (0.000)	531.89 (0.000)

TABLE 2.1-C VOLATILITIES (1992-93)

	LIT/USD	FRF/USD	GBP/USD	PTE/USD	DM/USD
Mean	8.5E-05	6.3E-05	7.3E-05	8.1E-05	8.7E-05
Maximum	0.0051	0.0010	0.0021	0.0029	0.0034
Minimum	6.9E-11	0.000	0.000	0.000	0.000
Std.Dev.	0.0002	0.0001	0.0002	0.0002	0.0003
Skewness	13.1173	4.6884	7.1980	7.2965	8.2819
Kurtosis	225.5028	30.6483	76.4165	75.8480	86.5827
J-B (P-value)	10080 (0.000)	17118.2 (0.000)	11241.1 (0.000)	1108.5 (0.000)	14582.3 (0.000)

TABLE 2.1-D VOLATILITIES (1995-97)

	LIT/USD	FRF/USD	GBP/USD	PTE/USD	DM/USD
Mean	3.2E-05	3.3E-05	2.3E-05	4.2E-05	4.2E-05
Maximum	0.0031	0.0014	0.0005	0.0013	0.0012
Minimum	3.3E-11	0.000	0.000	0.00	0.000
Std.Dev.	0.0001	8.6E-05	4.8E-05	0.0001	0.001
Skewness	19.3231	9.0125	5.0464	7.2176	7.0600
Kurtosis	451.8382	119.4617	40.6337	71.2155	67.8817
J-B (P-value)	61645 (0.000)	42185.5 (0.000)	4611.4 (0.000)	1476.5 (0.000)	1476.7 (0.000)

TABLA 2.2
SERIAL CORRELATION

TABLE 2.2-A EXCHANGE RATE RETURN (1992-93)

	LIT/USD	FRF/USD	GBP/USD	PTE/USD	DM/USD
_1	0.035	-0.041	0.000	0.012	-0.087
_2	0.051	0.070	0.081	0.057	0.052
_3	0.049	-0.041	-0.004	0.024	-0.033
_4	0.010	0.033	0.069	0.076	0.080
_5	-0.059	0.009	0.043	-0.047	-0.065
Q(10)	7.889 (Pr.0.640)	8.323 (Pr.0.597)	10.653 (Pr.0.385)	19.152** (Pr.0.038)	17.442* (Pr.0.065)
Q(20)	20.322 (Pr.0.438)	16.159 (Pr.0.707)	20.971 (Pr.0.399)	34.764** (Pr.0.021)	26.379 (Pr.0.154)

Q(10) and Q(20) denotes the Ljung-Box statistic (1979) for the first k autocorrelations. (**) significant at the 5% and (*) significant at the 10%, respectively.

TABLE 2.2-B EXCHANGE RATE RETURN (1995-97)

	LIT/USD	FRF/USD	GBP/USD	PTE/USD	DM/USD
_1	-0.116	-0.026	0.004	-0.083	-0.052
_2	-0.084	0.035	0.045	-0.014	0.012
_3	0.080	0.044	-0.005	0.057	0.029
_4	0.009	-0.101	-0.079	-0.045	-0.090
_5	0.012	0.026	0.009	-0.035	0.012
Q(10)	21.382** (Pr.0.019)	14.072 (Pr.0.170)	8.641 (Pr.0.566)	10.284 (Pr.0.416)	10.508 (Pr.0.397)
Q(20)	49.526** (Pr.0.000)	28.219* (Pr.0.104)	15.138 (Pr.0.768)	32.320** (Pr.0.040)	27.556 (Pr.0.120)

Q(10) and Q(20) denotes the Ljung-Box statistic (1979) for the first k autocorrelations. (**) significant at the 5% and (*) significant at the 10%, respectively.

TABLE 2.2-C VOLATILITIES (1992-93)

	LIT/USD	FRF/USD	GBP/USD	PTE/USD	DM/USD
_1	0.059	0.056	0.064	0.149	0.055
_2	0.165	0.138	0.128	0.205	0.143
_3	0.204	0.223	0.203	0.091	0.040
_4	0.016	0.030	0.019	0.039	-0.010
_5	0.060	0.118	0.062	0.102	0.068
Q(10)	47.585** (Pr.0.000)	87.516** (Pr.0.000)	37.975** (Pr.0.000)	69.719** (Pr.0.000)	23.299** (Pr.0.010)
Q(20)	53.403** (Pr.0.000)	114.31** (Pr.0.000)	58.686** (Pr.0.000)	84.016** (Pr.0.000)	28.540** (Pr.0.097)

Q(10) and Q(20) denotes the Ljung-Box statistic (1979) for the first k autocorrelations. (**) significant at the 5% and (*) significant at the 10%, respectively.

TABLE 2.2-D VOLATILITIES (1995-97)

	LIT/USD	FRF/USD	GBP/USD	PTE/USD	DM/USD
_1	0.224	0.095	0.179	0.103	0.105
_2	0.104	0.034	0.113	0.042	0.044
_3	0.089	0.010	0.041	0.023	0.024
_4	0.056	0.286	0.088	0.195	0.197
_5	0.084	0.080	0.037	0.065	0.065
Q(10)	61.989** (Pr.0.000)	94.631** (Pr.0.000)	48.927** (Pr.0.000)	69.739** (Pr.0.000)	72.037** (Pr.0.000)
Q(20)	117.45** (Pr.0.000)	107.81** (Pr.0.000)	55.114** (Pr.0.000)	97.121** (Pr.0.000)	99.678** (Pr.0.000)

Q(10) and Q(20) denotes the Ljung-Box statistic (1979) for the first k autocorrelations. (**) significant at the 5% and (*) significant at the 10%, respectively.

TABLE 3.1
CORRELATION MATRIZ

TABLE 3.1-A DAYLY SPOT EXCHANGE RATE RETURNS (1992-93)

	LIT/USD	FRF/USD	GBP/USD	PTE/USD	DM/USD
LIT/USD	1	0.7684	-0.7111	0.6660	0.5748
FRF/USD		1	-0.7850	0.7511	0.6957
GBP/USD			1	-0.6569	-0.5406
PTE/USD				1	0.8365
DM/USD					1

TABLE 3.1-B DAYLY SPOT EXCHANGE RATE RETURNS (1995-97)

	LIT/USD	FRF/USD	GBP/USD	PTE/USD	DM/USD
LIT/USD	1	0.5985	-0.3546	0.5233	0.5295
FRF/USD		1	-0.5446	0.8778	0.9502
GBP/USD			1	-0.4670	-0.5449
PTE/USD				1	0.9143
DM/USD					1

TABLE 3.1-C VOLATILITIES (1992-93)

	LIT/USD	FRF/USD	GBP/USD	PTE/USD	DM/USD
LIT/USD	1	0.6293	0.5406	0.5002	0.3617
FRF/USD		1	0.6019	0.6193	0.5270
GBP/USD			1	0.5469	0.3235
PTE/USD				1	0.7741
DM/USD					1

TABLE 3.1-D VOLATILITIES (1995-97)

	LIT/USD	FRF/USD	GBP/USD	PTE/USD	DM/USD
LIT/USD	1	0.1790	0.0941	0.1706	0.1726
FRF/USD		1	0.5274	0.9120	0.9146
GBP/USD			1	0.5722	0.5680
PTE/USD				1	0.9997
DM/USD					1

TABLE 3.2-A

GRANGER-CAUSALITY TESTS (1992-93)

	LIT/USD	FRF/USD	GBP/USD	PTE/USD	DM/USD
LIT/USD		3.1038** (Pr.0.045)	2.0905 (Pr.0.124)	0.5701 (Pr.0.565)	0.8834 (Pr.0.414)
FRF/USD	1.1410 (Pr.0.320)		2.3549* (Pr.0.096)	2.1879 (Pr.0.113)	1.4051 (Pr.0.246)
GBP/USD	0.8531 (Pr.0.426)	7.8573** (Pr.0.000)		0.0650 (Pr.0.937)	0.8778 (Pr.0.416)
PTE/USD	1.8200 (Pr.0.163)	3.2468** (Pr.0.039)	1.0157 (Pr.0.362)		3.0786** (Pr.0.046)
DM/USD	3.2574** (Pr.0.039)	0.4490 (Pr.0.638)	2.2531* (Pr.0.106)	2.9100** (Pr.0.055)	

*reject the null hypothesis of no cointegration for significance at the 10% level
**reject the null hypothesis of no cointegration for significance at the 5% level

TABLE 3.2-B

GRANGER-CAUSALITY TESTS (1995-97)

	LIT/USD	FRF/USD	GBP/USD	PTE/USD	DM/USD
LIT/USD		2.4121* (Pr.0.090)	7.3754** (Pr.0.001)	2.3994* (Pr.0.091)	2.2074 (Pr.0.110)
FRF/USD	1.9024 (Pr.0.149)		6.7280** (Pr.0.001)	5.1165** (Pr.0.006)	4.4263** (Pr.0.012)
GBP/USD	0.3873 (Pr.0.678)	1.3761 (Pr.0.253)		1.7055 (Pr.0.182)	1.4262 (Pr.0.240)
PTE/USD	1.6835 (Pr.0.186)	1.6958 (Pr.0.184)	6.6047** (Pr.0.001)		1.1348 (Pr.0.322)
DM/USD	1.6475 (Pr.0.193)	2.9156** (Pr.0.054)	5.4280** (Pr.0.004)	5.1068** (Pr.0.006)	

*reject the null hypothesis of no cointegration for significance at the 10% level
**reject the null hypothesis of no cointegration for significance at the 5% level

TABLE 4.1-A

COINTEGRATION BETWEEN DAYLY EXCHANGE RATE (1992-93)

Exchange rate	Cointegration equation	Johansen test	γ
LIT/USD	*LIT*= 5.567 + 3.413*DM/USD* (8.68) (2.64)	6.6010	0.0173 (2.301)
FRF/USD	*FRF*= 1.266 + 0.926*DM/USD* (19.03) (6.54)	8.9411	-0.030 (-1.735)
GBP/USD	*GBP*= 2.340 - 3.781*DM/USD* (1.48) (-1.19)	7.3075	0.004 (2.158)
PTE/USD	*PTE*= 3.423 + 2.728*DM/USD* (12.39) (4.80)	9.4540	0.014 (2.775)

Notes:

(i) Exchange rates are expressed as logarithm.

(ii) The critical values Johansen statistics are 15.41 (5%) and 20.04 (1%) significance level, respecctively. *reject the null hypothesis of no cointegration for significance at the 10% level **reject the null hypothesis of no cointegration for significance at the 5% level.

(iii) t-statistics are given in parentheses.

TABLE 4.1-B

COINTEGRATION BETWEEN DAYLY EXCHANGE RATE (1995-97)

Exchange rate	Cointegration equation	Johansen test	γ
LIT/USD	*LIT*= 7.195 + 0.481 *DM/USD* (68.57) (2.00)	5.4039	-0.009 (-1.995)
FRF/USD	*FRF*= 1.290 + 0.860*DM/USD* (86.70) (25.80)	10.0428	-0.068 (-3.047)
GBP/USD	*GBP*= 0.366 + 0.215*DM/USD* (9.81) (2.58)	11.1973	-0.018 (-2.654)
PTE/USD	*PTE*= 4.441 + 0.997*DM/USD* (231.63) (23.30)	23.1200**	0.018 (1.270)

Notes:

(i) Exchange rates are expressed as logarithm.

(ii) The critical values Johansen statistics are 15.41 (5%) and 20.04 (1%) significance level, respecctively. *reject the null hypothesis of no cointegration for significance at the 10% level **reject the null hypothesis of no cointegration for significance at the 5% level.

(iii) t-statistics are given in parentheses.

TABLE 4.2-A

STOCHASTIC COINTEGRATION BETWEEN DAYLY EXCHANGE RATE

(1992-93)

Exchange rate	Cointegration equation	Johansen test	γ
LIT/USD	*LIT* = 4.913 + 0.0008*t* + 5.395 *DM/USD* (318.33) (0.32) (0.70)	9.13	0.013 (1.741)
FRF/USD	*FRF* = 1.148 - 0.0002*t* + 1.260*DM/USD* (137.09) (-1.94) (6.33)	15.29	-0.012 (-0.785)
GBP/USD	*GBP* = 4.32 - 0.0299*t* - 11.66*DM/USD* (41.85) (-0.03) (-0.03)	9.94	0.001 (1.135)
PTE/USD	*PTE* = 3.904 + 0.0004*t* + 1.575*DM/USD* (380.93) (4.08) (6.26)	15.43	0.020 (1.389)

Notes:

(i) Exchange rates are expressed as logarithm.

(ii) The critical values Johansen statistics are 25.32 (5%) and 30.45 (1%) significance level, respecctively. *reject the null hypothesis of no cointegration for significance at the 10% level **reject the null hypothesis of no cointegration for significance at the 5% level.

(iii) t-statistics are given in parentheses.

(iv) $\beta_i t$ is the determinist trend and γ is the estimate adjustment speed paramether.

TABLE 4.2-B

STOCHASTIC COINTEGRATION BETWEEN DAYLY EXCHANGE RATE

(1995-97)

Exchange rate	Cointegration equation	Johansen test	γ
LIT/USD	*LIT* = 6.487 - 0.0011*t* + 2.972 *DM/USD* (740.85) (-1.92) (2.11)	25.70*	-0.001 (-0.851)
FRF/USD	*FRF* = 1.203 + 0.0001*t* + 1.174 *DM/USD* (588.07) (4.17) (14.35)	29.58*	0.033 (1.645)
GBP/USD	*GBP* = 0.108 + 0.0005*t* + 1.192*DM/USD* (55.55) (1.87) (2.18)	30.22*	-0.004 (-1.389)
PTE/USD	*PTE* = 4.440 + 1.05E-06*t* + 0.995*DM/USD* (343.90) (0.02) (8.07)	33.79**	0.019 (1.425)

Notes:

(i) Exchange rates are expressed as logarithm.

(ii) The critical values Johansen statistics are 25.32 (5%) and 30.45 (1%) significance level, respecctively. *reject the null hypothesis of no cointegration for significance at the 10% level **reject the null hypothesis of no cointegration for significance at the 5% level.

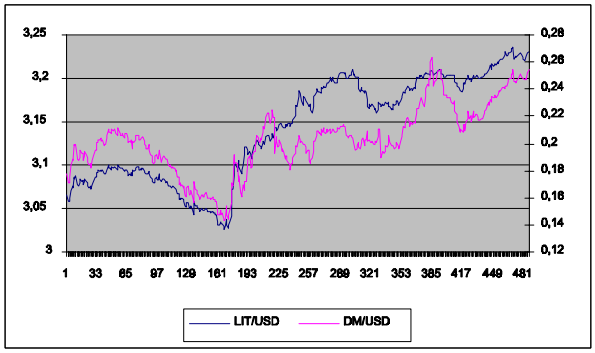
(iii) t-statistics are given in parentheses.

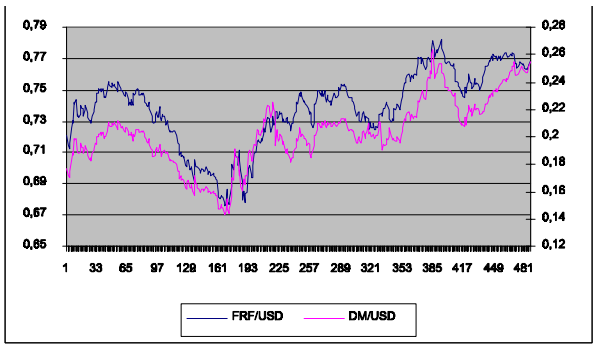
(iv) $\beta_i t$ is the determinist trend and γ is the estimate adjustment speed paramether.

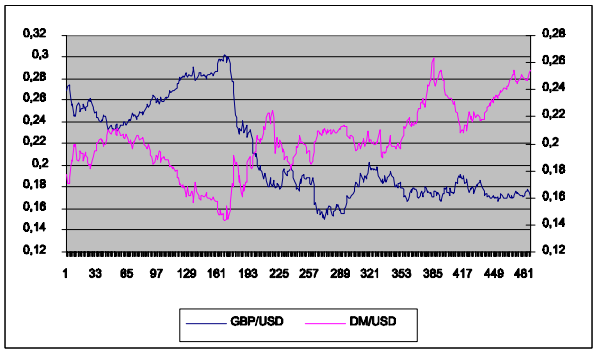
FIGURES 4.1 - 4.4

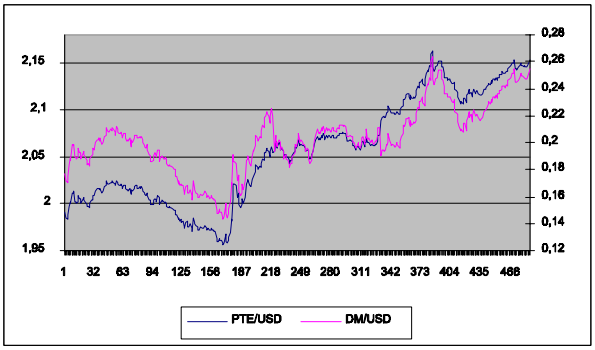
DAYLY EXCHANGE RATE (1992-93)

(logarithm)





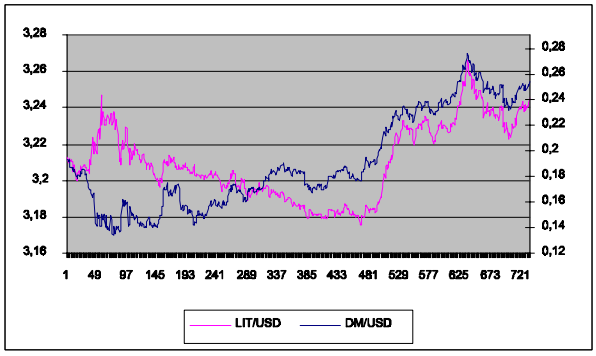


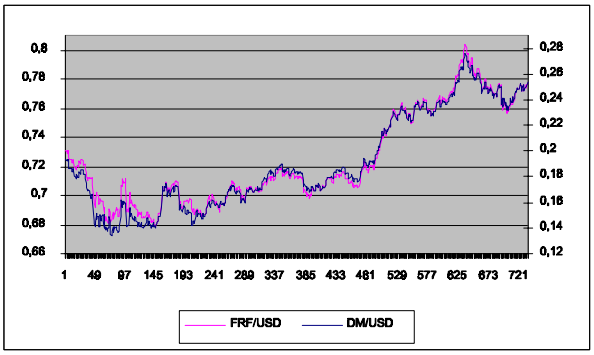


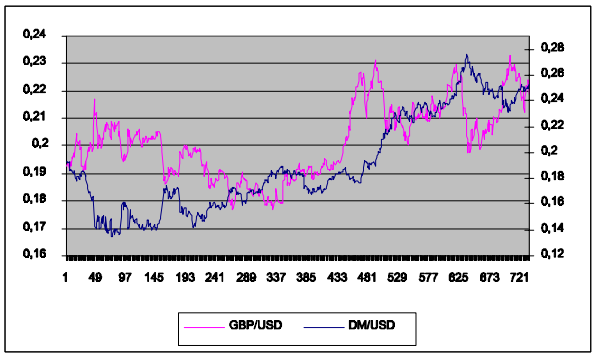
FIGURES 4.5 - 4.8

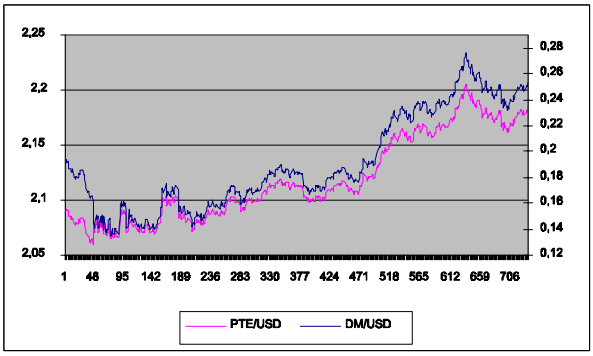
DAYLY EXCHANGE RATE (1995-97)

(logarithm)









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