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Time Varying-VAR and Stochastic Volatility: Application to Exchange Rates (Asia-Pacific Currencies and Major Currencies).

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CONTENT

INTRODUCTION

The economy in the world has experienced several distinct periods of macroeconomic activity in recent decades, resulting in many of macroeconomic variables exhibiting changing behaviors over time. As we have been able to see during the financial crisis of 2008, open economies are exposed to exogenous monetary policy shocks triggered, for example, by an event occurring many miles away. They can be also exposed to exchange rate movements reflecting internal or external factors such as political instability or sudden changes in investors' sentiment. For this reason the behavior of exchange rate is one of the major fields of study in macroeconomics especially in international economics. Although a large number of papers have analyzed the exchange rates dynamics but it is recently that a flexible estimation framework allowing for time variation has been applied. Accounting for time variation is very important, especially for economies that have experienced significant structural and institutional changes over time.

In this thesis we will estimate a time-varying parameter vector autoregressive (TVP-VAR) model for some exchange rates in Asia-Pacific and also for some major currencies.

A vector autoregressive (VAR) is an econometric tool used in a wide range of applications. Among the VAR models we have an other model which is broadly used especially in macroeconomics: The time-varying parameter VAR (TVP-VAR) model with stochastic volatility proposed by Primiceri (2005). The TVP-VAR model enables us to capture the potential time-varying nature of the underlying structure in the economy in a flexible and robust manner. All parameters in the VAR specification are assumed to follow a first-order random walk process, thus allowing both temporary and permanent shifts in the parameters.

The TVP-VAR stochastic volatility assumption plays an important role in many applications. In recent years, it has been used frequently in macroeconomics.

This thesis is organized as follows:

-Chapter 1 provides a review of the literature on exchange market and exchange rate.

-Chapter 2 introduces TVP-VAR and presents the Bayesian inference approach to TVP-VAR estimation.

- Chapter 3 is related to the empirical part: The Application of TVP-VAR to exchange rates (Three exchange rates from Asia-Pacific area and the three major currencies).

CHAPTER I: REVIEW ON EXCHANGE MARKET AND EXCHANGE RATE LITERATURE.

Introduction

The study of open trading economies is very complex. There will be always a difference in the transactions between domestic and foreign residents as compared with those between residents of the same country. An Italian importer will generally have to pay a Japanese exporter in yen and an Indian exporter in Rupee; that the way international trade works. In order to do so, the Italian importer will have to buy the yen and the Rupee with Euros. This process is made in what we usually call the foreign exchange market.

The foreign exchange market cannot be considered to be a single physical place. It could rather be defined as a market where the various national currencies are traded (bought and sold). At this stage, the mains questions which should be asked are the following. What is the exchange rate? What factors determine the level of the exchange rate between two currencies? What are the different characteristics of the foreign exchange market? We are going to give some answers to these questions in this chapter.

Section.1 Definition of exchange rate

The exchange rate can be defined as the price of one currency in terms of another (*see k. Pilbeam, 1992, chap.1*). Having this definition in mind, it appears obviously that there are two methods of expressing it.

1) Domestic currency units per unit of foreign currency- for example, taking the pound sterling as the domestic currency, on 10 June 2015 there was approximately 0.65 required to purchase the US dollar
2) Foreign currency units per unit of domestic currency- again taking the pound sterling as the domestic currency, on 10 June 2015, approximately 1.53 dollars were required to obtain one pound.

The two ways of expressing are the same, both have the same meaning. So, it doesn’t really matter which method of expressing the exchange rate is employed. The main thing is that it is necessary to be careful when talking about a rise or fall in the exchange rate because the economic interpretation will be very different depending upon which definition is used.

Section.2 Characteristics and the main participants of the foreign exchange market.

The foreign exchange market is a worldwide market. Among the most important foreign exchange centers, we can enumerate the center of Frankfurt, New York, Zurich, Tokyo and London. Usually, the foreign exchange market is composed by foreign exchange brokers, commercial banks, and other authorized agents trading in most of the currencies of the world. These groups are kept in close and continuous contact with one another.

Among the different currencies, the most heavily traded one is the US dollar which is known as a vehicle currency- a currency widely used to denominate international transactions (oil, coffee, gold…).

Now we are going to elaborate on the main participants in the foreign exchange market we enumerated above.

Many people interact on the exchange rate market. They can be divided into 04 groups.

Retail clients: When we talk about retail clients we think about international investors, multinational corporations and every person who needs foreign exchange for the purposes of operating his/her businesses. In a real world, retail clients don't directly purchase or sell foreign currencies themselves; rather they operate by placing buy/sell orders with the commercial banks.

Commercial banks: The commercial banks take orders from their retail clients and buy or sell currencies on their own account so as to alter the structure of their assets and liabilities in different currencies. The banks can deal directly with other financial institution or through foreign exchange brokers.

Foreign exchange brokers: In real world, it is difficult to see two banks trading directly with one another; they usually do their transactions through brokers. Operating via brokers is advantageous because they collect quotations for most currencies from many banks, so the banks can obtain favorable quotation quickly and at very low cost by trading via brokers. Each financial center normally has just a handful of authorized brokers through which commercial banks conduct their exchanges.

Central banks: Normally the monetary authorities of a country are not indifferent to changes in the external value of their currency and even through exchange rates of the major industrialized nations have been left to fluctuate freely. Since 1973 central banks frequently intervene to buy and sell their currencies in a bid to influence the rate at which their currency is traded.

Section.3 The spot and forward exchange rates

When you are called foreign exchange dealer, you are not only dealing with a wide variety of currencies. You also have to set of dealing rates for each currency. We usually call these rates the spot and forward rates.

I.3.1 The spot exchange rate

The spot exchange rate represents the quotation between two currencies for immediate delivery. In other words, the spot exchange rate is the current exchange rates of two currencies vis-à-vis each other. In practice, there is normally a two day lag between a spot purchase or sale and the actual exchange of currencies to allow for verification, paperwork and clearing of payments.

I.3.2 The forward exchange rate

In addition to the spot exchange rate it is possible for economic agents to agree today to exchange currencies at some specified time in the future, most commonly for 1 year, 9 months, 6 months, 3 months and 1 month. The rate of exchange at which such a purchase or a sale can be made is known as the forward exchange rate.

Exactly how the forward exchange rate quotation is determined is subject we will look at later in this thesis.

Section.4 Nominal and real exchange rates.

So many people are very much concerned about analyzing the implications of exchange-rate changes for the economy: economists, policy makers etc. According to *K. Pilbean (1992)*, the exchange rate itself doesn't convey much information. To analyze the effects and implications of exchange rate changes economists compile indices of the nominal, real and effective exchange rates. Since most national and international authorities quote nominal, real and effective exchange rates as foreign currency per unit of domestic currency, we shall compile some hypothetical nominal, real and effective exchange rates using this definition. This means that a rise of the nominal, real or effective exchange-rate index represents an appreciation of the currency.

Section 4 .1 The nominal exchange rate

The nominal exchange rate is the number of units of the domestic currency that can purchase a unit of a given foreign currency.

It is called nominal because the fact that it measures only the numerical exchange value. It doesn't say anything about other aspects such as the purchasing power of that currency.

Section.4.2 The real exchange rates.

The real exchange rate can be defined in two ways (*Maxwell Opoku Afari 2004*).

- In external terms, it is defined as the nominal exchange rate adjusted for the difference of prices between countries i.e the ratio of the aggregate foreign price(or cost) level to home country's aggregate price (or cost) level measured in a common currency.

- In internal terms, the real exchange rate is defined as the ratio of domestic price (in the same country) of goods we can trade to goods we are not able to trade.

In this chapter we dealt with exchange rate and the exchange rate market. Now we know exactly how exchange rate markets work. We also know the roles of the different participants in this market.

The exchange rate has been studied in several academic papers. So we will not go deeply in this issue. The main purpose of our thesis is to deal with new notions like time varying parameter VAR, stochastic volatility and so on. We want to apply these notions to some specific exchange rates. In order to do so, we need to understand what is a time varying parameter model? What stochastic volatility refers to?

The following chapter is dedicated to this purpose.

CHAPTER II. TVP-VAR MODEL OF PRIMICERI (2005)

Section.1 The model (Primiceri 2005)

Time varying coefficients VAR (TVC-VAR) is a generalization of VAR models in which the coefficients are allowed to change over the time; the coefficients and the variance covariance matrix. In this thesis we will refer to Primiceri (2005) paper. Let $y_t$be a vector of time series; an n×1 vector of observed endogenous variables. We assume the following equation y_t.

$$y_t = c_t + B_{1,t}\, y_{t-1} + \ldots + B_{k,t}\, y_{t-k} + \mu_t \quad t = 1 \ldots T. \qquad (1)$$

c_t is a vector(n×1) of time varying coefficients that multiply constant terms; $B_{i,t}$ i= 1,…,k are n× n matrices of time varying coefficients; μ_t are heteroscedastic unobservable shocks with variance covariance matrix Ω_t

The drifting coefficients are meant to capture possible heteroscedasticity of the shocks and nonlinearities in the relations among the different variables.

We consider the triangular reduction of Ω_t defined by:

$$A_t \Omega_t A_t^{'} = \Sigma_t \Sigma_t^{'} \qquad (2)$$

A_t is the lower triangular matrix

$$A_t = \begin{bmatrix} 1 & 0 & \cdots & 0 \\ \alpha_{21,t} & 1 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ \alpha_{n1,t} & \cdots & \alpha_{nn-1,t} & 1 \end{bmatrix}$$

$$\Sigma_t = \begin{bmatrix} \sigma_{1,t} & 0 & \cdots & 0 \\ 0 & \sigma_{2,t} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_{n,t} \end{bmatrix}$$

Allowing both coefficients and variance covariance matrix to vary over the time leaves the data to determine whether the time variation of the model is caused by a change in the size of the shocks (we refer to impulse) or a change in the propagation mechanism (we refer to responses).

Let's notice that the model admits many types of shocks. However, the heteroscedasticity assumption is limited to the additive innovations.
The model in equation (1) can be rewritten as follows:

$y_t = c_t + B_{1,t}\, y_{t-1} + \ldots + B_{k,t}\, y_{t-k} + A_t^{-1}\ \sum_t \varepsilon_t$ (3)

$V(\varepsilon_t) = I_n$

By stacking in a vector B_t all the R.S.H coefficients of the model, the equation (3) can be re-written as:

$y_t = X_t' B_t + A_t^{-1}\ \sum_t \varepsilon_t$ (4)

$X_t' = I_n \otimes [1, y_{t-1}', \ldots, y_{t-k}']$,

Where $\otimes$ denotes Kronecker product.

From now, we will estimate the coefficients based on (4) instead of (1).

Now we assume α_t to be the vector of non-zero and non-one elements of the matrix A_t and in the same way we assume σ_t to be the vector of diagonal elements of the matrix$\sum_t$. The dynamic of the model's time varying parameters is specified as follows:

$B_t = B_{t-1} + \upsilon_t$ (5)

$\alpha_t = \alpha_{t-1} + \varsigma_t$ (6)

$\log\sigma_t = \log\sigma_{t-1} + \eta_t$ (7)

We model the elements of the vector B_t as random walks. The standard deviations are assumed to evolve as geometric random walks, belonging to a class of stochastic volatility's models. This can be considered as an alternative model to ARCH models. The main difference is that the variances generated by (7) are unobservable components.

In the first hand we assume the innovations in this model to be jointly normally distributed. In the other hand, we suppose:

$$V = Var\begin{pmatrix}\begin{bmatrix}\varepsilon_t\\ \upsilon_t\\ \xi_t\\ \eta_t\end{bmatrix}\end{pmatrix} = \begin{bmatrix}I_n & 0 & 0 & 0\\ 0 & Q & 0 & 0\\ 0 & 0 & S & 0\\ 0 & 0 & 0 & W\end{bmatrix} \qquad (8)$$

I_n is an identity matrix of dimension n. Q, S, and W are supposed to be positive definite matrices..

As done in Primiceri (2005) paper , we take another assumption about S. We assume that S is a block diagonal, with blocks corresponding to parameters belonging to separated equations. This assumption means that the coefficients of the contemporaneous relations among variables are assumed to evolve independently in each equation.

Section.2 Bayesian inference

In this section we will present econometric techniques used to estimate the time varying structural VAR model. We use the Bayesian methods to evaluate the posterior distributions of the parameters of interest. We recall that these parameters of interest are unobservable. In such case, the Bayesian approach is the natural one to use. The classical maximum likelihood is not appropriate in this case. The main advantage of Bayesian methods is that they can deal with the high dimension of the parameter space and the nonlinearities of the model. In this thesis, we use Gibbs sampling for the posterior evaluation of the parameters of interest.

Gibbs sampling is a part of Markov Chain Monte Carlo methods (MCMC). It's a smoothing method and therefore delivers smoothed estimates.

Section 3 Priors and ordering

We are going to choose priors distribution in intuitive way and according to their convenience in the applications (Primiceri (2005)). We make three assumptions here:

First, we consider that the initial states for the hyper parameters, the log volatilities, the coefficients and the covariance are independent of each other.

Second, we assume that the priors for the blocks of S, Q, W and the hyperparameters follow an independent inverse-wishart distribution.

Third we assume the priors for the initial states of the time varying coefficients to be normally distributed.

Section.4 Posterior approximation.

In order to simulate the model, we simulate the distribution of the parameters of interest, given the data. As mentioned before, Gibbs sampling is used in order to do so. The process is divided in 04 steps.

1) First we draw the coefficient states

2) Secondly we draw the covariances states

3) Then we draw the volatilities states
4) Finally we draw the hyperparameters

Each block of variables is drawn conditional on the observed data and the rest of the parameters.

Conditional on A^T and $\sum^T$, the state space form given by (4) and (5) is linear and Gaussian.

Therefore, the conditional posterior of B^T is a product of Gaussian densities and B^T can be drawn using a standard simulation smoother (Carter and Kohn for example).

In the same way, the posterior A^T conditional on B^T and $\sum^T$ is also product of normal distributions. So, A^T can be easily drawn using the same process. In order to draw $\sum^T$ we first need to transform the nonlinear and non-Gaussian state space form into a linear and approximately Gaussian one. The Simulation of the conditional posterior of V is standard given that it is the product of independent inverse-wishart distributions.

Before moving further, let's take a break to elaborate on the carter and Kohn (1994) we mentioned.

New procedures for simulating from the posterior density of states given a Gaussian state space time series have appeared. Some are extension of old ones. Carter and Kohn (1994) method is one of those. It consists in introducing and studying a simulation smoother, which draws from the multivariate posterior distribution of the disturbances of the model, so avoiding the degeneracies inherent in state samplers. As in our case, this technique is important in Gibbs sampling for possibly non linear and non Gaussian time series models.

We know by now what a TVP-VAR is and what stochastic volatility refers to. The next chapter will deal with the empirical part. We will use TVP-VAR model to assess six currencies from specific areas.

III. EMPIRICAL PART: APPLICATION OF TVP-VAR TO EXCHANGE RATES.

Section.1 Asia-Pacific currencies.

In this section we shall try to apply a TVP-VAR to three exchange rates in Asia-Pacific area .The Rupiah of Indonesia (Rupiah), the Philippine peso (PHP) and the Taiwan new dollar (TWD). All is against the dollar. Having three exchange rates mean we have three (03) variables in each equation of our TVP-VAR of order one.

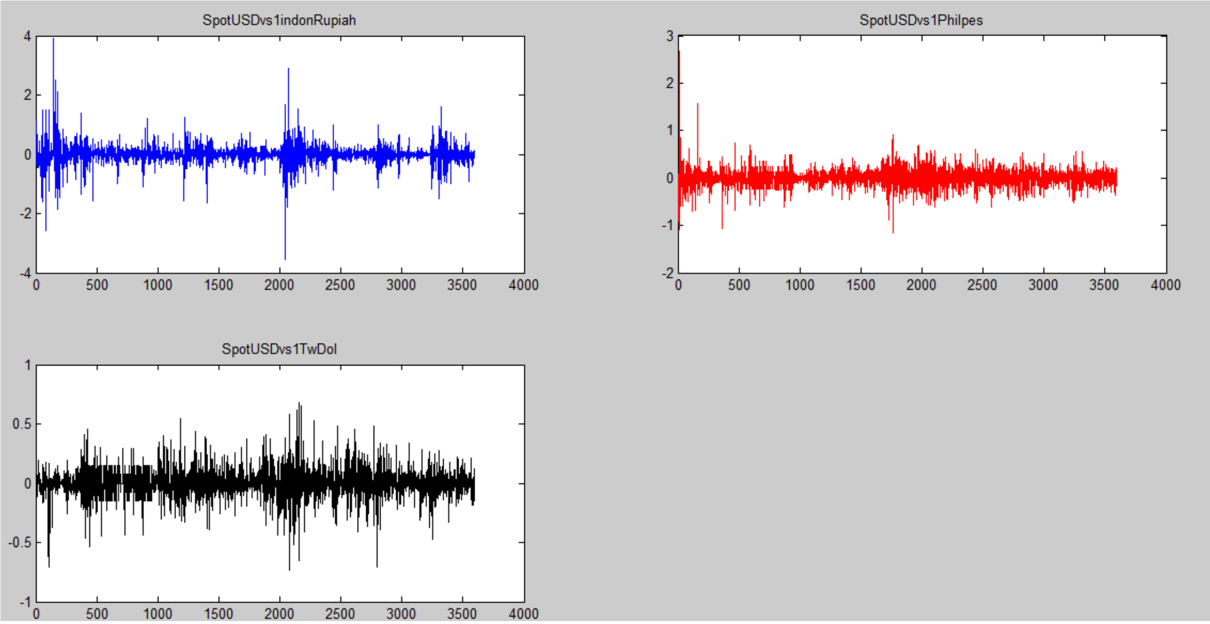
The sample runs from 29/12/2000 to 10/10/2014. We are dealing with 3597 daily observations. One lag is used for the estimation. The simulations are based on 50 iterations of the Gibbs sampler. Table (1) gives the information about the series and their sources.

Table (1): Data source.

Variables	Period	Frequency	Source
SpotUSDvs1indonRupiah	29/12/2000-10/10/2014	Daily	Bloomberg Database
SpotUSDvs1Philpes	29/12/2000-10/10/2014	Daily	Bloomberg Database
SpotUSDvs1TwDol	29/12/2000-10/10/2014	Daily	Bloomberg Database

Figure (1) provides plots of the logdiff of the returns of the exchange rates. It is a way for us to see the evolution over time of the exchange rate in each country.

Figure(1) exchange rates of each country over time



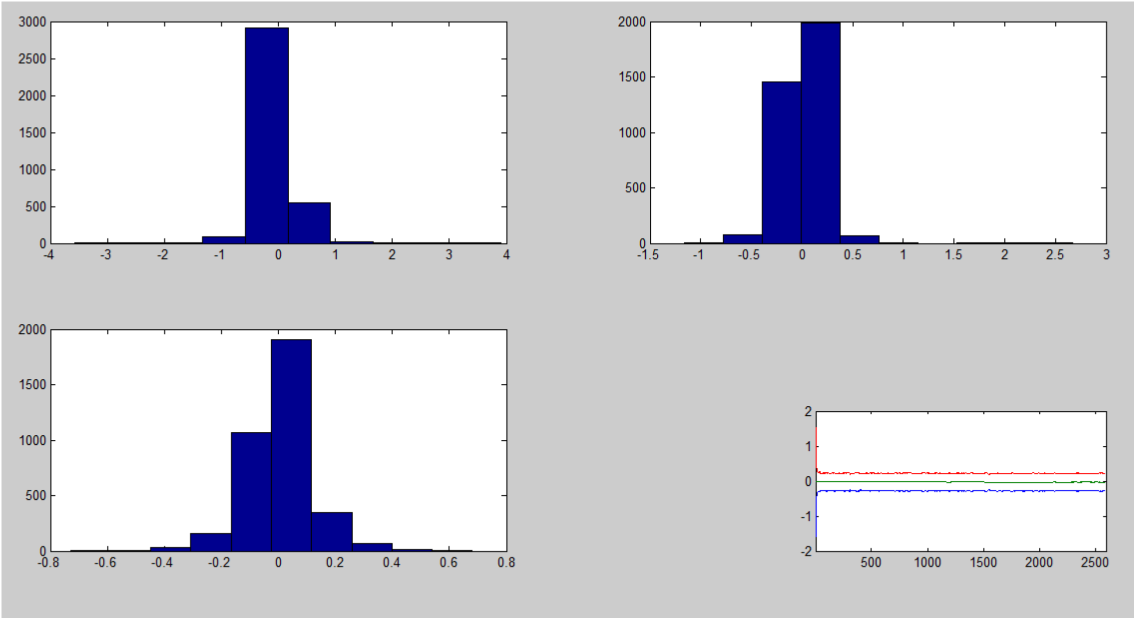
All series exhibit cluster of volatility which calls for the use of the stochastic volatility models.

We will also estimate the correlation functions of the sample and the different histograms.

As far as the histograms are concerned, they will help us to assess the densities of the data in the threes samples. By analyzing the kurtosis and the skewness we will also be able to say whether it is useful to use TVP-VAR or not.

The following figure represents the histograms of the three samples.

Figure (2): The histograms of the three samples.



The histograms show us an excess kurtosis. Let's recall that the excess kurtosis is a statistical term describing that the sample distribution has a kurtosis coefficient larger than the coefficient associated with a normal distribution which is around 3. The excess kurtosis signals us that the probability of obtaining an extreme value in the future is high.

Kurtosis is often referred to the "volatility of volatility"; and this is why we decided to study the stochastic volatility.

All this is confirmed by the Jarque-Bera test we made on matlab. In fact we got the following results:

1) h1=jbtest(VarName1)=1
2) h2=jbtest(VarName2)=1
3) h2=jbtest(VarName3)=1

That means we should reject the null hypothesis at 5% significance level. Let's recall that the null hypothesis is that our data comes from a normal distribution.

Now we draw the autocorrelation functions to check if the data are stationary.

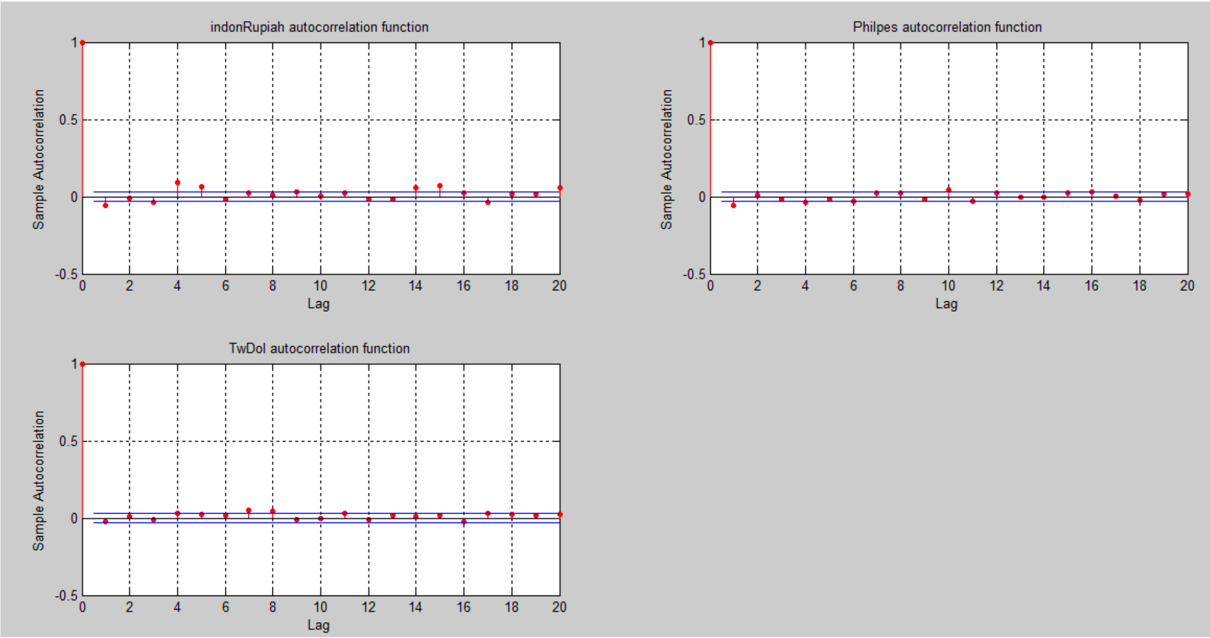
Correlation functions are a useful indicator of dependencies as a function of distance in time or space, and they can be used to assess the distance required between sample points for the values to be effectively uncorrelated. In addition, they can form the basis of rules for interpolating values at points for which there are no observations.

Let x_t be a series (exchange rate for example).

The sample autocorrelation function (ACF) gives the correlations between the series $x_t$and lagged values of the series for lags of 1, 2, 3, and so on. The lagged values can be written as x_{t-1}, x_{t-2}, x_{t-3}, and so on. The ACF gives correlations between $x_t$and x_{t-1}, x_t and x_{t-2}, and so on. It can be used to identify the possible structure of time series data, for checking the randomness in a data set.

Autocorrelation should be near-zero for randomness. In this case we can easily see that the functions of the three samples decay to zero. Because of that we can conclude the randomness assumption holds. The figure (3) exhibits the autocorrelation functions of the samples.

Figure (3): The autocorrelation functions of the samples



Section.2 Priors setting

In order to calibrate the prior distributions we are going to use the first 50 observations and follow what is done in Primiceri (2005) paper. The mean and the variance of B_0 are respectively the OLS point estimates and four (04) times its variance in a time invariant VAR, estimated on the small initial subsample. We compute in the same way a prior forA_0. For logσ_0 , in the first hand, we consider the mean of the distribution to be the logarithm of the OLS point estimates of the standard errors of the same time invariant VAR; in the other hand, we assume that the variance covariance matrix is an identity matrix.

Finally, degrees of freedom and scale matrices are needed for the inverse-wishart prior distributions of the hyperparameters. The degrees of freedom are set to 2 and 3 for the two blocks of S and 4 for W. For Q the degree of freedom is set to 40 in order to avoid implausive behaviours of time varying coefficients.

Here are the different prior distributions:

$B_0 \sim$ N($\hat{B}_{OLS}$, 4 V($\hat{B}_{OLS}$))

$A_0 \sim$ N($\hat{A}_{OLS}$, 4 V($\hat{A}_{OLS}$))

log $\sigma_0 \sim$ N(log$\hat{\sigma}_{OLS}$, I_n)

Q ~ IW($40k_Q^2$ V($\hat{B}_{OLS}$), 40)

W~ IW($4k_W^2\ I_n$, 4)

S_1~ IW($2k_S^2$V($\hat{A}_{1,OLS}$), 2)

S_2~ IW($3k_S^2$V($\hat{A}_{2,OLS}$), 3)

S_1 and S_2 denote the two blocks of S; $\hat{A}_{1,OLS}$ and $\hat{A}_{2,OLS}$ stand for the two corresponding blocks of $\hat{A}_{OLS}$.

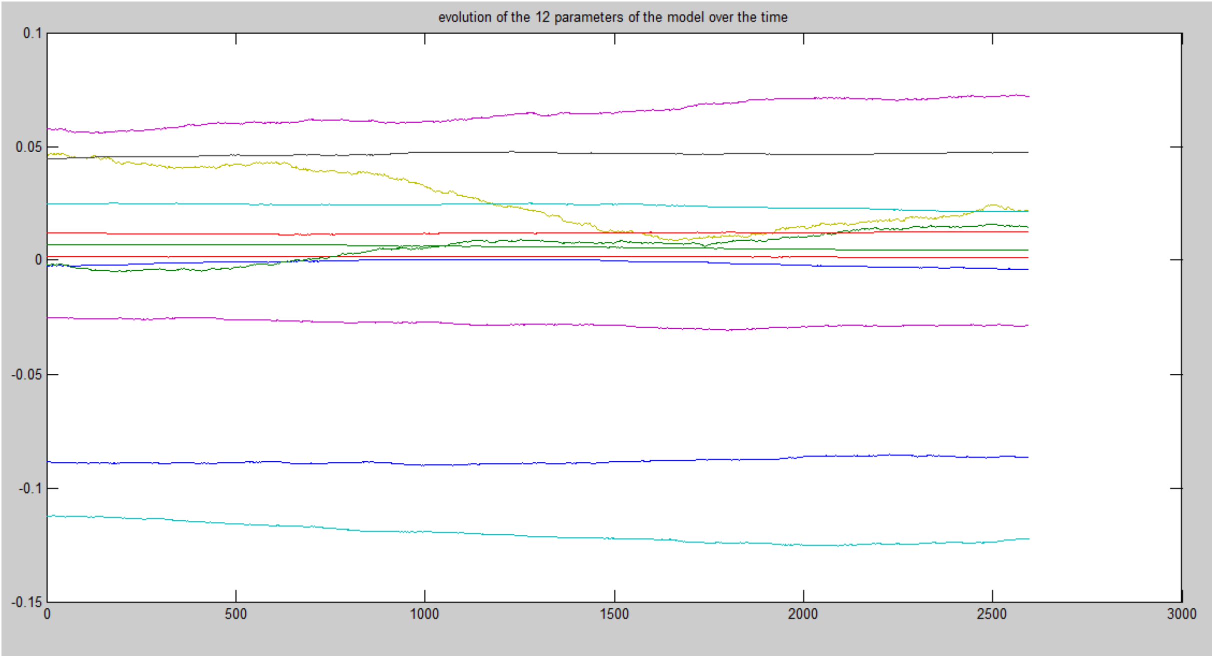
The results presented of this thesis are obtained using the following values: $k_Q = 0.01$ $k_S = 0.1$ k_W=0.01

These values allow us to deal with diffuse informative priors.

Section 3. Empirical results for the Asia-Pacific currencies.

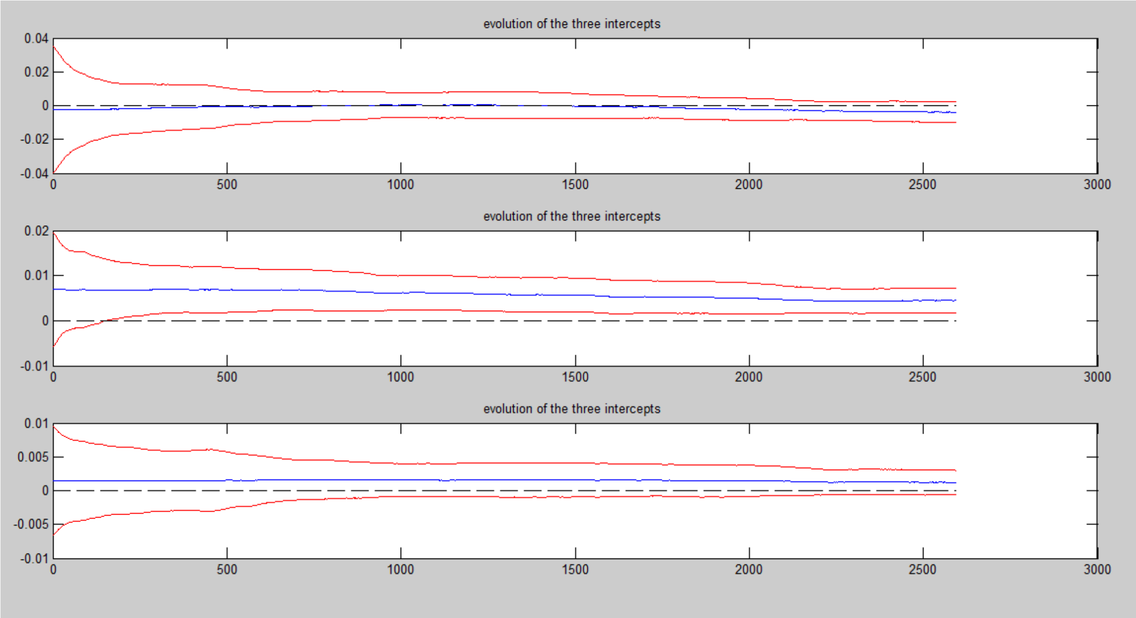
First of all, let's consider the time varying coefficients (TVP). We compute the posterior mean of the TVP and we plotted it to see the evolution of the different coefficients (12) over the sample period. Figure 4 shows the coefficients.

Figure (4) Evolution of the 12 coefficients.



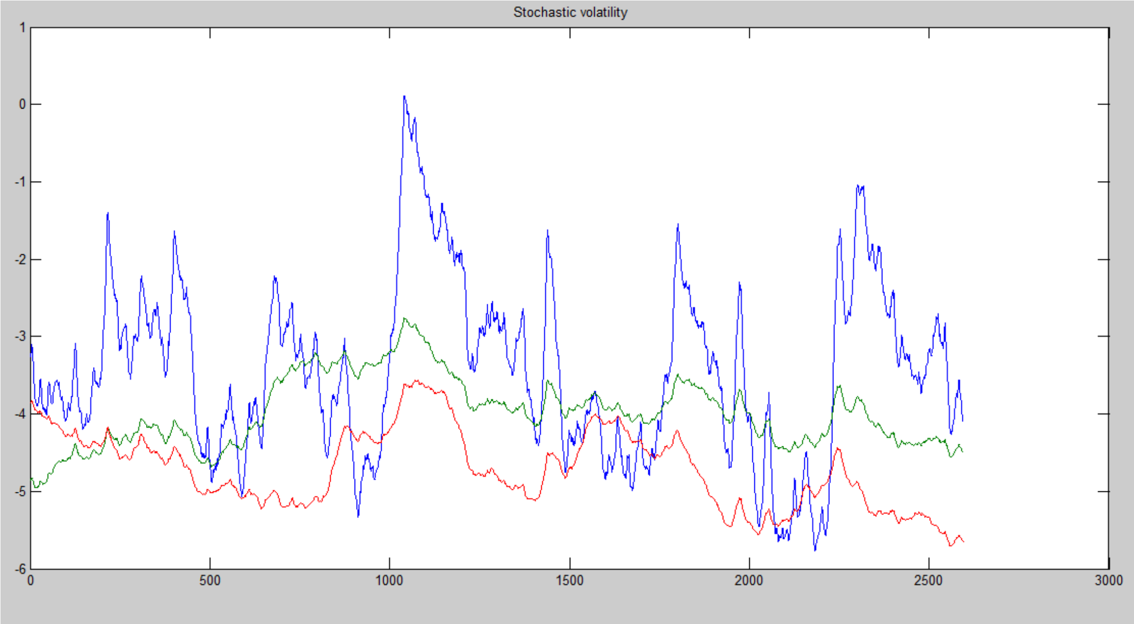
Among the 12 coefficients, the 9 associated with the cross-rate dependence (in the lag) are quite stable over time. Whereas the 3 intercepts exhibit time variation (see figure 5). Note that following the credible intervals (red lines), the variation over time of one intercept (PHP against US dollar) is statistically significant.

Figure (5): Evolution of the three (03) intercepts.



The TVP-VAR allows us to capture possible changes in the volatility. The stochastic volatility is reported in Figure 6.

Figure (6): Stochastic volatility



From this graph we can easily detect four high volatility periods:

-13/12/2001-28//11/2002 (observations 250-500): This period could be referred to the Dot-com bubble. It was a historic speculative bubble during which stock markets in industrialized nations saw their equity value rise rapidly from growth in the Internet sector and related fields (James K. Galbraith and Travis Hale (2004)). We think that the high volatility is due to this crisis.

-17/04/2003-10/06/2004 (observations 600-900): We think about the increasing in oil prices happened by the beginning of 2003.

-28/10/2004-28/09/2006 (observations 1000-1500): This interval can be associated to the period before the global financial crisis of 2008. We think it was a period during which the market was much prospered. The prosperity attracted many investors and the volatility we are seeing is a consequence of a large volume of trading.

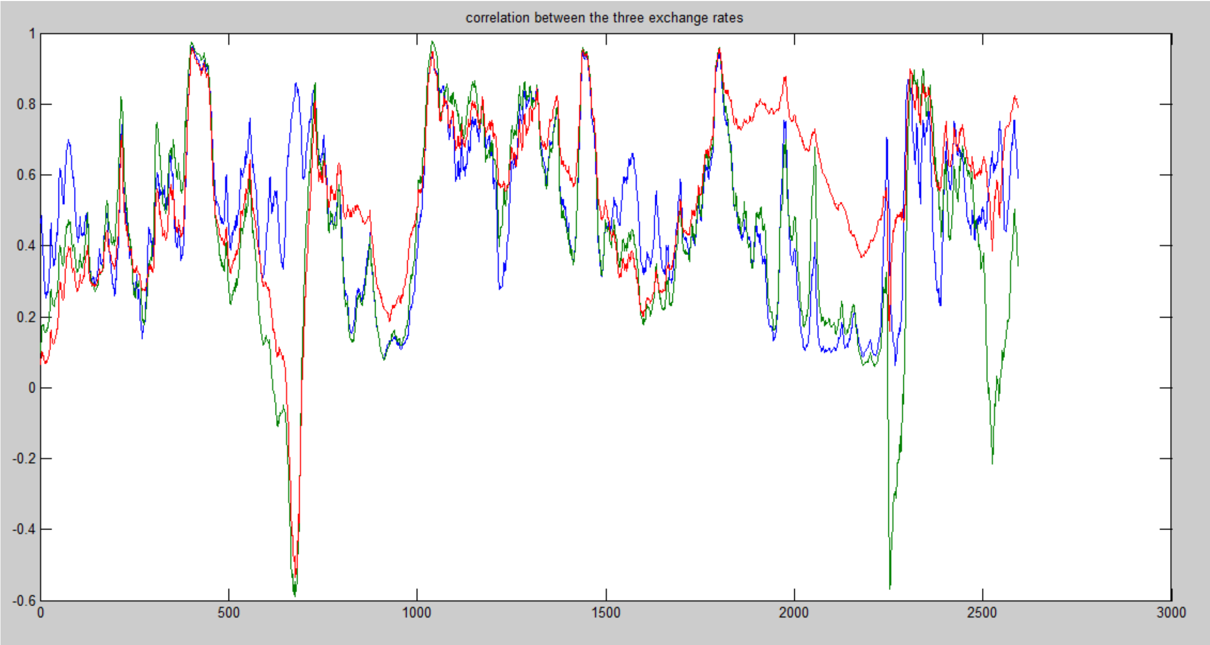
-13/09/2007-28/08/2008 (observations 1750-2000): This period is exactly linked to the financial crisis of 2008 which had very disastrous consequences on the exchange rate markets.

-*13/08/2009-29/07/2010* (observations 2250-2000): This interval is characterized by the period after the financial crisis of 2007-2008. The high volatility is the consequences of this crisis which lead many investors in Europe or USA to relocate their activity in Asia-Pacific

Now we will deal with the correlation functions of the three exchange rates (see figure 7). In order to better understand this graph, its meaning and its importance we will make a break and recall some important notions in Markowitz portfolio selection also called Modern Portfolio Theory (MPT).

Modern Portfolio Theory (MPT) is a portfolio selection theory. It emphasizes that investors can diversify away the risk of investment loss by reducing the correlation between the returns from the select securities in their portfolio. The goal is to optimize expected return against a certain level of risk. According to the modern portfolio theorist, investors should measure the correlation coefficients between the returns of different assets and strategically select assets that are less likely to lose value at the same time (Investopedia).

Figure (7): correlation function between the three (03) exchange rates.



MPT looks for correlation between expected returns and expected volatility of different investments. This expected risk-reward relationship was titled "the efficient frontier" by Chicago-school economist Harry Markowitz. The efficient frontier is the optimal correlation between risk and return in MPT.

Correlation is measured on a scale of -1.0 to +1.0. If two assets have an expected return correlation of 1.0 that means that they are perfectly correlated. When one gains 5%, the other gains 5%; when one drops 10%, so does the other. A perfectly negative correlation (-1.0) implies that one asset's gain is proportionally matched by the other asset's loss. A zero correlation has no predictive relationship. MPT stresses that investors should look for a consistently uncorrelated (near zero) pool of assets to limit risk. This theory has some limits. In fact, Markowitz thinks that the correlation between the assets is fixed and predictable. That is not really the case in reel world. In real world, the relationships between assets don't remain constant over time, which means that MPT is less useful during times of uncertainty (Investopedia).

Our TVP-VAR allows us to find if the correlation changes are supported by the data (see figure 7).

We can notice from figure 7 that the correlations are moving over the time. If we are investors, we will have to adjust our portfolio at each period of time in order to keep it safe and less risky. That is one the advantages of our TVP-VAR model.In this case, the largest variations in the correlations correspond to the period 2002-2004 (observations 1500-2000) and the period 2008-2010.

Section.4 Empirical results for the major's currencies

In this section we shall apply the TVP-VAR to the three major exchange rates: the US Dollar, the Euro and the Yen. We took Dollar, Yen and Euro as major currencies because they are the most traded currencies in the world. We have three (03) variables in each equation of our TVP-VAR of order one.

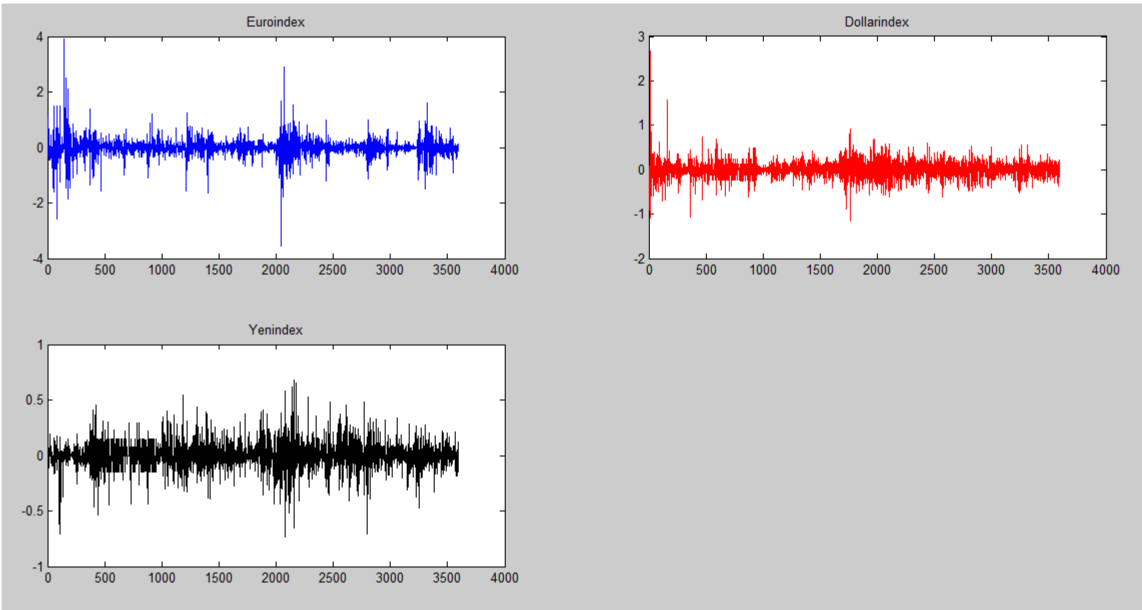
The sample runs from 29/12/2000 to 10/10/2014. We are dealing with 4117 daily observations. One lag is used for the estimation. The simulations are based on 50 iterations of the Gibbs sampler. Table (1) gives the information about the series and their sources.

Table (2): Data source.

Variables	Period	Frequency	Source
Dollar	29/12/2000-10/10/2014	Daily	Bloomberg Database
SpotUSDvs1Euro	29/12/2000-10/10/2014	Daily	Bloomberg Database
SpotUSDvs1Yen	29/12/2000-10/10/2014	Daily	Bloomberg Database

Figure (8) provides a plot of the logdiff of the returns of the exchange rates. It is a way for us to see the evolution over time of the three exchange rates.

Figure (8): Three exchange rates over the time.



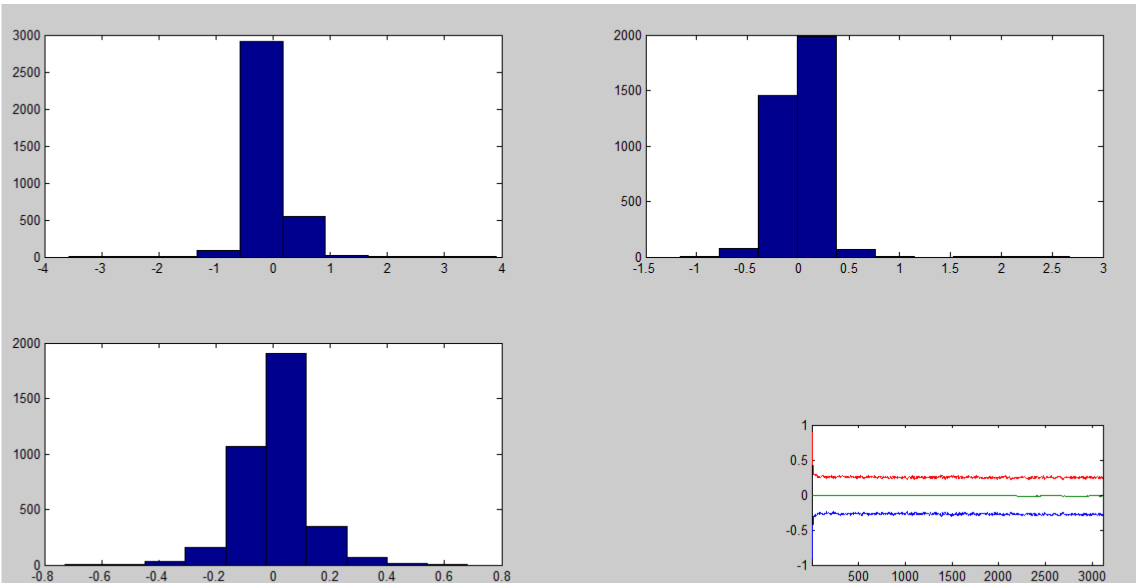
All series exhibit cluster of volatility which calls for the use of the stochastic volatility models. We will also estimate the auto-correlation functions of the samples and the different histograms to see if lag dependence, fat tails and asymmetry are present in the series.

As said before, histograms will help us to assess the densities of the data in the threes samples. By analyzing the kurtosis and the skewness we will also be able to check if it is useful to use nonlinear models such as the TVP-VAR for these series.

The figure 9 represents the histograms of the three samples. The Jarque-Bera test we made gives the following results:

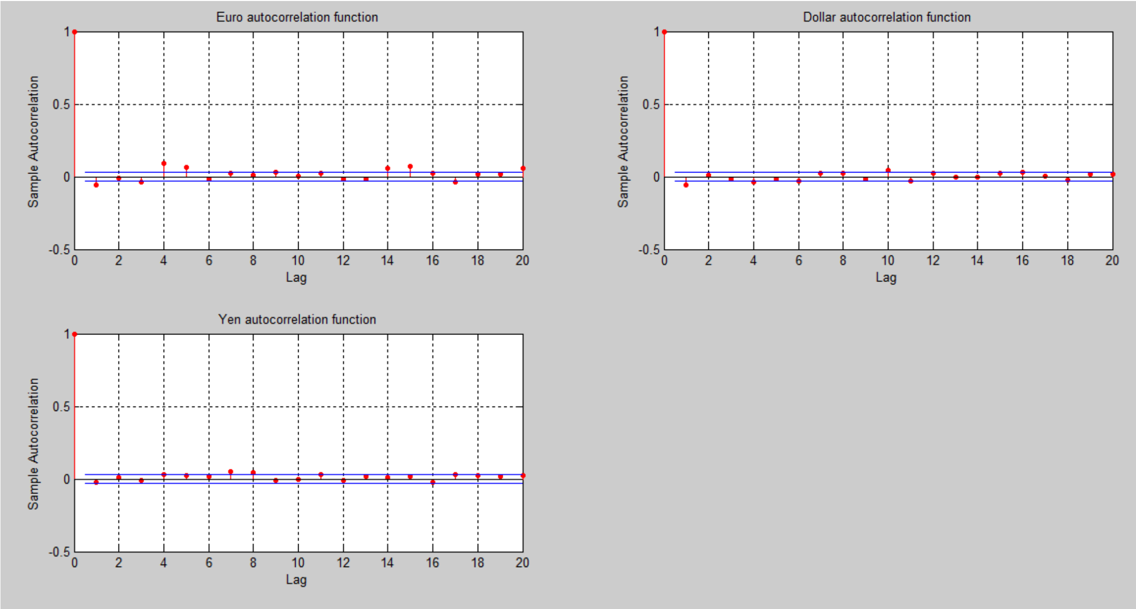
1) h1=jbtest(VarName1)=1
2) h2=jbtest(VarName2)=1
3) h2=jbtest(VarName3)=1
4) That means we should reject the null hypothesis at 5% significance level. Let's recall that the null hypothesis is that our data comes from a normal distribution.
5) Figure (9) and Jarque-Bera test amply allow us to conclude that our data don't come from normal distribution. We can obviously see an excess kurtosis exhibited in figure (9)

Figure (9): Histograms



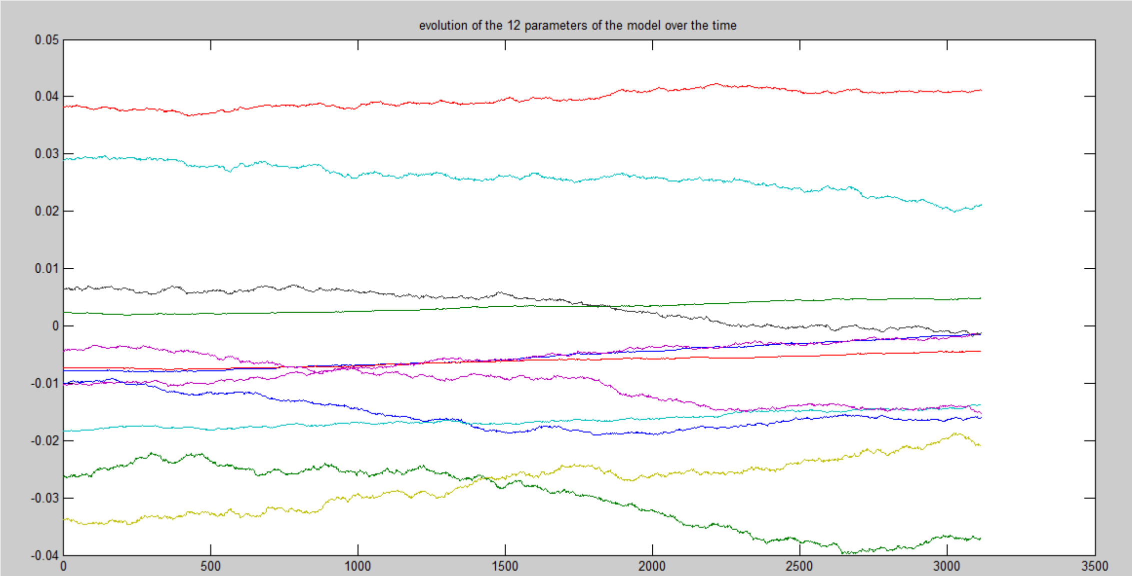
Now we will plot the autocorrelation functions of the samples to check the dependencies between the data.

Figure (10): the autocorrelations of the samples.



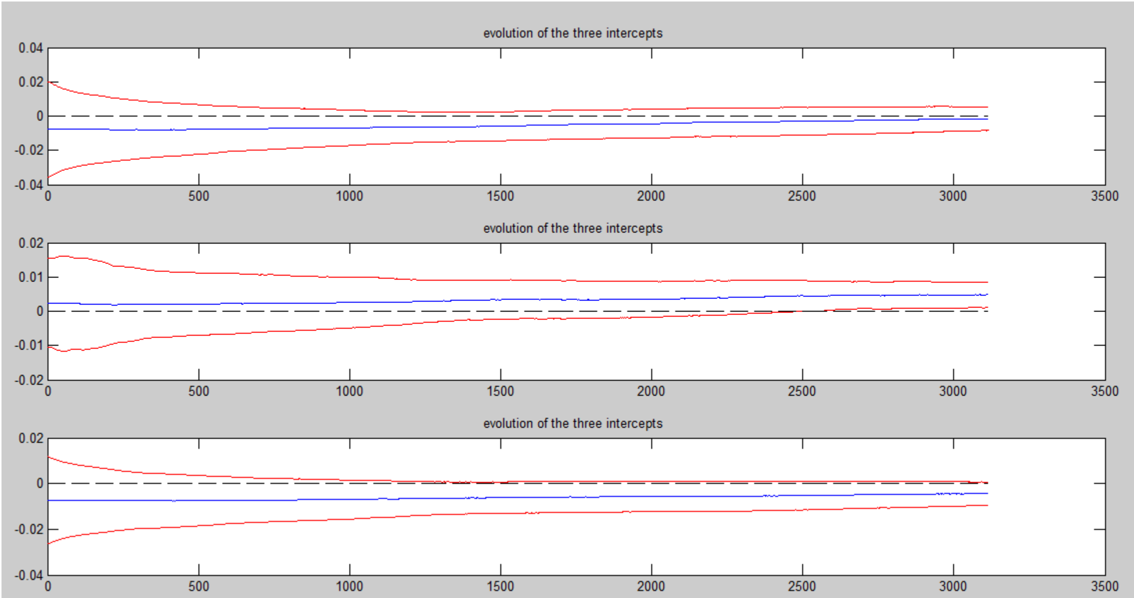
The priors in this case are also set after Primiceri (2005) paper (See Chap 2). We compute the posterior mean of the TVP and we plotted it to see the evolution of the different coefficients (12) over the sample period. The following graph is the result.

Figure (11) Evolution of the 12 coefficients.



Among the 12 coefficients, 3 coefficients are quite stable over time. Whereas (09) coefficients exhibit time variation. We think that the stable coefficients are the intercepts. In order to check our assumption we are going to plot the intercepts of the three equation of our model in a single graph and analyze them (see figure 12).

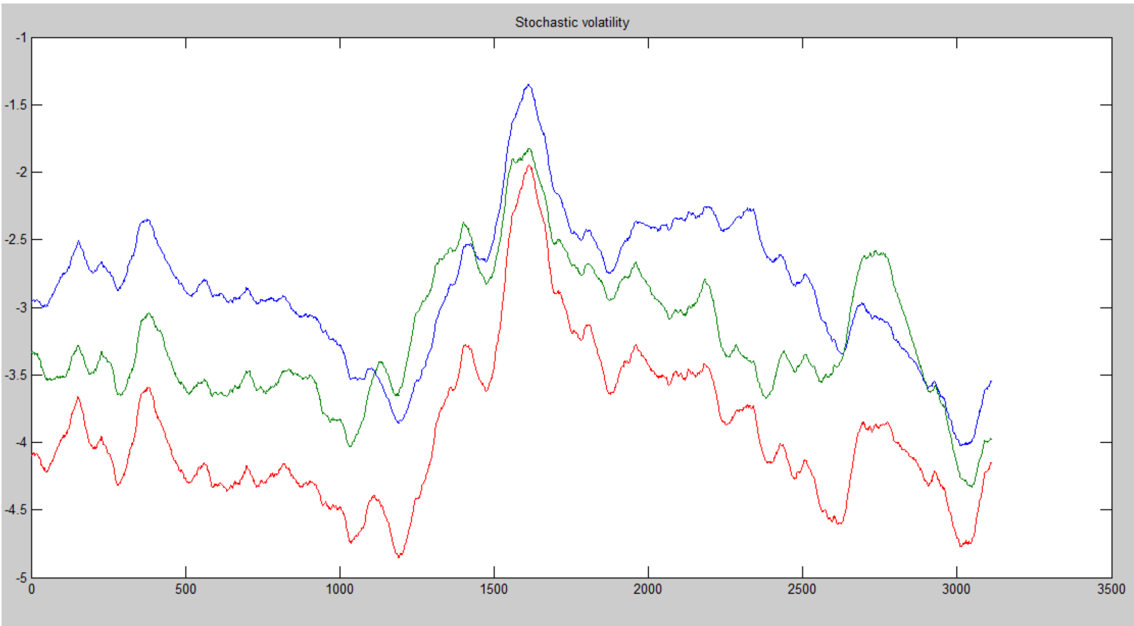
Figure (12) evolution of the three intercepts.



From figure (12) we can see that all the intercepts are quite stable over the time. We can conclude that the 9 coefficient moving over the time are the 9 coefficients associated with the cross-rate dependence (in the lag).

In this case also the TVP-VAR allows us to capture possible changes in the volatility. The stochastic volatility is reported in the following graph.

Figure (13): Stochastic volatility



Three main periods of high volatility can be exhibited from this graph:

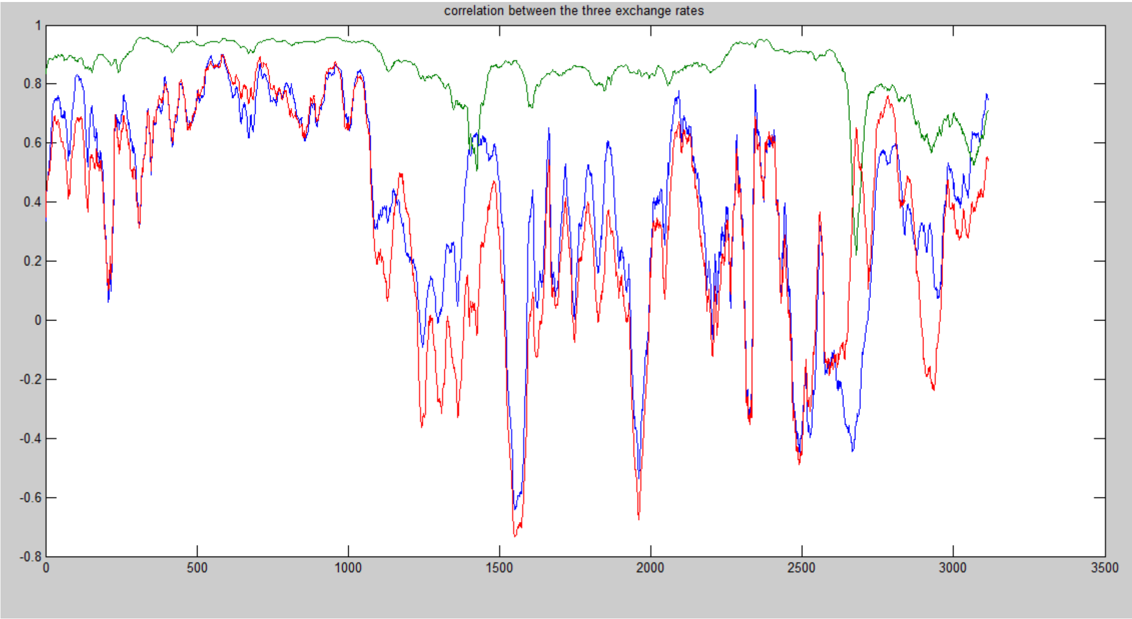
-2001-2002 (observations 250-500): This period refers to the Dot-com bubble. A speculative bubble during which stock markets in industrialized nations saw their equity value rise rapidly from growth in the Internet sector and related fields (James K. Galbraith and Travis Hale (2004)). We think that the high volatility is due to this crisis.

-2006-2008 (observations 1500-200): This period can be associated to the period before the global financial crisis of 2008. We think it was a period during which the market was much prospered.

-2011-2014 (observations 2500-3000): This period is characterized by the period after the financial crisis of 2007-2008. The high volatility is the consequences of this crisis which lead to the failure of Lehman Brothers.

Now we will deal with the correlation between the three exchange rates (see figure 14). Applying a TVP-VAR allows us to find if the correlation changes are supported by the data. We can notice from figure 14 that the correlations are moving over the time. As we said before, if we are investors, we will have to adjust our portfolio at each period of time in order to keep it safe and less risky. That is one the advantages of our TVP-VAR model. In our case, the largest variations in the correlations correspond to the 2006-2008 (observations 1500-2000).

Figure (14): Correlation functions between the three (03) exchange rates.



CONCLUSION

This thesis applies MCMC methods to the estimation of a time varying parameter VAR (TVP-VAR) on exchange rate data. The time variation is related to the coefficients and the variance covariance matrix. The variation of the variance covariance matrix allows us to analyze the volatility and correlation dynamics of the different variables in the model.

The first chapter of the thesis has been dedicated to the analysis of exchange rate and exchange rate markets. We highlighted the various participants in these markets and their main roles. The second chapter dealt with TVP-VAR model. Based on Primiceri (2005) paper we tried to give an explanation of the TVP-VAR and its advantages. Chapter three is dedicated to the empirical analysis. First we applied the TVP-VAR to the Rupiah, the new dollar of Taiwan, and the Philippine peso in Asia-Pacific area and then we did the same for the US Dollar, the Euro and the Yen.

We found evidence of variations over time of some of the coefficients and intercepts of the VAR model for the two currency areas. Also, there is a strong evidence of time-varying volatilities for all exchange rates analyzed and of change in the correlation between the exchange rates. The largest variations in the correlations correspond to the 2006-2008.

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