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# The impact of uncertainty on the job market in the United States of America: Vector Autoregressive / Vector Error Correction Models

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# Foreword

The financial crisis of 2007-2008 which started with the crisis in the subprime mortgage market in USA has been followed by a global economic crisis downgrading sharply the macroeconomic indicators of the USA.

In fact the GDP growth rate is spent from 2.67% in 2006 and 1.78% in 2007 to -2.78% in 2009, while the unemployement rate which was between 4.5% and 5% before the crisis,reached the historical level of 9.93% at the end of 2009, the household final consumption expenditure has known after the crisis (2009) its first decrease after a long and steady increase during the previous years.

However, a differences in the pace of recovery has been noted between the unemployement rate and the other main macroeconomic indicators which it was relatively fast for the GDP growth rate for exemple and much more slower for the unemployement which stayed at a higher level compared to before the crisis until 2014, so what could explain the fact that the job market has been impacted on a longer period before to come back to its level before the crisis ?

The differents studies on this topic showed that high level of uncertainty during the period played an important role by impacting on the short and long run the job market slowing down the recovery.

The differents models used (linear VAR or non linear VAR) confirmed the results of this analysis, but with differents amplitudes, using the VIX index as a proxy for the uncertainty level.This subject and the amplitude of this impact are still debated until now.

The setting up of a new indexes able to express better the uncertainty can give us a more refined picture regarding the impact of the uncertainty on the economy.

The purpose of this thesis in to construct a linear model including one of this new uncertainty indexes and the unemployement rate to assess the impact and compare it with the results of the previous analysis.

# Thanks

I would like to begin by thanking Professor Roberto Casarin for his help and support in the preparation of this thesis, I would also like to thank Professor Monica Billio for her hospitality and help during my installation in Venice, and at last I would like to thank Professor Girardin who allowed me to participate in this exchange program

# Summary

# Abstract

The paper of Caggiano et al. (2014) regarding the Uncertainty shocks and unemployement dynamics in US recession concludes, by using a smooth transition VAR and the VIX index as a proxy for the uncertainty,that the job market and more specifically the unemployement rate is impacted by the uncertainty shocks with a significant increase evaluated to 0.36 after the first year and 0.41 percentage points after the second year with the non linear smooth transition VAR modelisation and by 0.17 for the first year and 0.14 after the second year for the classical linear VAR approach modelisation. In this thesis we employ the new Economic Policy Uncertainty index (EPU) as measured in the paper of Baker et al. (2015) to construct an econometric model including in addition of the EPU index and the unemployement rate,the Fed interest rate and the CPI (Consumer Price Index) using for that the Strctural Vector Error Correction model (SVEC) to articulate the data an assess the impact of the uncertainty shocks on the unemployement through an impulse response functions.

## Introduction

The uncertainty is known to be highly unfavorable factor for the economic condition because it can push the differents economics agents to protect themselves by postponing their investment, hiring and consumption decisions.

To be able to measure and model these negative impact it is necessary to evaluate the uncertainty by an index which express the uncertainty level toward tax, government spending, monetary and regulatory policies .

The paper of Baker et al. (2015) (Measuring Economic Policy uncertainty) treated this question by suggesting a new index of economic policy uncertainty (EPU) which is built on three components (the frequency of newspaper references to economic policy uncertainty, the number of federal tax code provisions set to expire, and the extent of forecaster disagreement over future inflation and government purchases).

The empirical results of using the EPU index showed that it is a good proxy for the economic policy uncertainty.

In this paper we aim at investigating empirically how economic policy uncertainty affects the labor market? And we are going to take for that the American context.

The previous empirical studies in this field have clearly showed that the uncertainty is one of the major responsible of the slow recovery of the labor market in USA after the crisis of 2007, these results have been obtained either by classical linear modelisation VAR or by non linear modelisation STVAR using VIX index which is a measure of the implied volatility of Standard and Poor's 500 index as a proxy for the uncertainty.

The paper of Caggianno et al. (2014) (Uncertainty shock and unemployement dynamics) arrived to the conclusion by using non linear VAR model and the VIX index (volatility

index of the American Financial Market) that an uncertainty shock induces an increase in unemployement of 0.36 percentage points after the first year and 0.41 percentage points after two years, while by using the linear approach the impact was 0.17 percentage points after the first four trimesters ans 0.14 after the first eight trimesters, the amplitude of this impact is still debated and it seems to be higher as per a numerous economists.

In this paper we are going to use a time varying SVAR / SVEC (Structural Vector Autoregressive / Structural Vector Error Correction) model to investigate the link between the level of uncertainty expressed by EPU index and the level of unemployement in the United States of America.

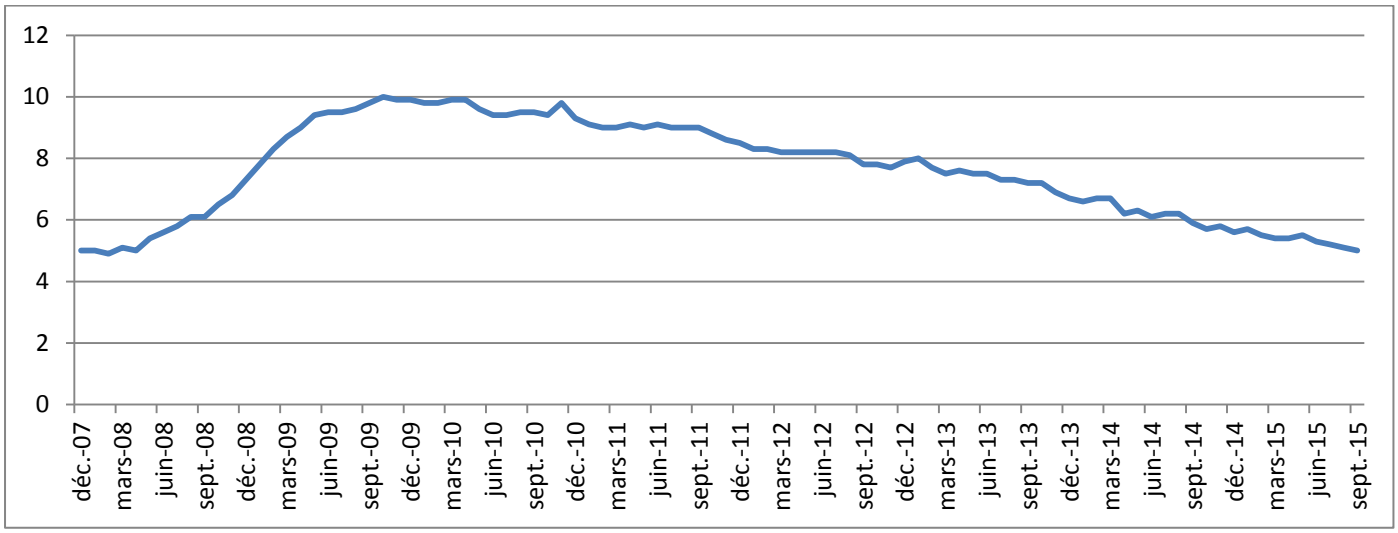


Figure 1 : The evolution of the unemployement rate between December 2007 and June 2015 in the USA.

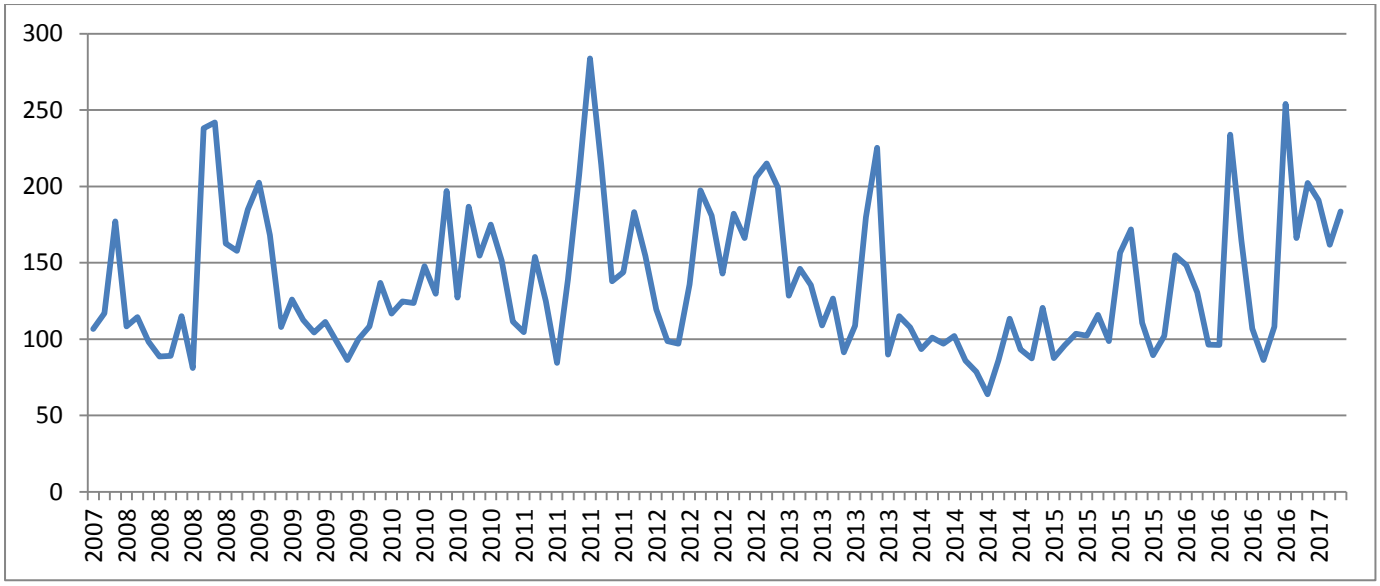


Figure 2 : The evolution of the EPU index between December 2007 and January 2017 in the USA.

# Chapter 1 The Theoritical Bases of the Vector Autoregressive Approach

The vector autoregressive model (VAR) is a statistical model which has been devloped by Christopher Sims in the beginning of 1980s. This model allows to capture the interdependences between several time series. In this model each variable is explained by its own past values and by the past values of the other variables.

## 1.1 The Vector Autoregressive Model

The SVAR modél describes the evolution of a set of endogenous variables over the same sample period (t from 1 to T) as a linear function of only their past values, the variables are collected in a vector $Y_t$ which gather in our case the level of uncertainty (EPU index or VIX index) and the level of unemployement in USA in addition of other variables

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + e_t,$$

It is then a linear time-series model designed to capture the joint dynamics of multiple time series with $e_t$ normaly distributed N(0,Σ).

We have then to asses p as being the best order of our SVAR, we can obtain that either by checking if the errors terms are autocorrelated then if yes we have to increase p until the autocorrelation desapears, or by using the information criteria and choosing the p which deliver the smallest (Akaike Information Criterion (AIC)), and or the Bayesian Information Criterion (BIC) or also the Hannan Quinn Criterion (HQC)).

Regarding the errors terms (innovation) of each endogenous variables which could be correlated and constitute an disadvantage then it is better to create a new error terms that are orthogonal (structural) with diagonalised variance – covariance matrix of the errors terms,

this new error term $\mathcal{E}_t$ (normally distributed) which is equal to $B_0 e_t$ and has a diagonalised variance and therefore avoid the crossed effects.

This structural VAR will be as below

$$B_0 y_t = c_0 + B_1 y_{t-1} + B_2 y_{t-2} + \cdots + B_p y_{t-p} + \epsilon_t,$$

matrix can be obtained by cholesky decompsition which allow us to define $B_0$. We have also to take in account in this approach the fact that we have to choose and make restrictions on $B_0$ and put the proper order of the individual variables in the vector $Y_t$ by determining which between our variables depend from the other in the reality to construct our vector properly these identification restrictions are obviously motivated by economic theory and by The causality test (linear and non linear links) and at least n(n-1)/2 restrictions must exist (Rothenberg – 1971) and require to follow a certain pattern.

## 1.2 The Vector Error Correction Model

In the case where the times series employed in our model appear to be integrated of the order one and if it is determined that these time series are cointegrated it will be therefore clear that the VAR modelisation will only express the short run relationships between the variables while the long run relationships will be ignored.

The VAR concept has been therefore extended to catch these long run relationships through the use of the Vector Error Correction model.

Starting from the classical VAR modelisation and based on the paper of Pagan and Pesaran (2008) we can write below the formula of the SVAR

$$\mathbf{y_t = B_1\, y_{t-1} + B_2\, y_{t-2} \ldots\ldots B_{t-p} + \mathcal{E}_t}$$

From that we can therefore derive the VECM as you can see below:

$$\mathbf{\Delta\, y_t = \Pi\, y_{t-1} + \sum_{t=0}^{p} \Gamma_i\, \Delta y_{t-1} + \mathcal{E}_t}$$

With $\Pi = \sum_{j=i+1}^{p} B_I - I$ and $\Gamma_i = -\sum_{j=i+1}^{p} B_j$

As per the literature we can have five type of cointegration relationships and

$\Pi\, y_{t-1}$ depends on the type of this relationships as we can see below:

- No trend and no constant model with $\Pi\, y_{t-1} = \alpha\beta y_{t-1}$
- No trend with constant available with $\Pi\, y_{t-1} = \alpha\,(\beta y_{t-1} + p_0)$
- Linear trend and constant available with $\Pi\, y_{t-1} = \alpha\,(\beta y_{t-1} + p_0) + \alpha'(\gamma_0)$
- Linear trend and linear trend with $\Pi\, y_{t-1} = \alpha\,(\beta y_{t-1} + p_0 + p_1 t) + \alpha'(\gamma_0)$
- Quadratic trend and linear trend $\Pi\, y_{t-1} = \alpha\,(\beta y_{t-1} + p_0 + p_1 t) + \alpha'(\gamma_0 + \gamma_1 t)$

The model can be generlised as follow:

$$\Delta y_t = \alpha\beta y_{t-1} + \Sigma_{t=0}^{t=p-1} \Gamma_i\, \Delta y_{t-1} + \varepsilon_t$$

We can obviously introduce the structural approach by adding $A_0$ as being the matrix of the instantanous effects:

$$A_0\, y_t = A_0\, B_1\, y_{t-1} + A_0\, B_2\, y_{t-2} \ldots\ldots A_0\, B_{t-p} + A_0 \varepsilon_t$$

$$A_0\, \Delta y_t = A_0\, \Pi\, y_{t-1} + A_0 \left(\sum_{t=0}^{t=p-1} \Gamma_i\, \Delta y_{t-1}\right) + A_0\, \varepsilon_t$$

## 1.3 The Impulse Response Function

The impulse response function describes the reaction of a dynamic system to external change, in the macroecnomic modelisation this function describe the reaction over time of the endogenous variables of the system to exogenous impulse ( shocks ).

This impulse function can be written under the form below

$$Y_t = A^{-1}\varepsilon_t + \Psi_1 A^{-1}\varepsilon_{t-1} + \Psi_2 A^{-1}\varepsilon_{t-2}$$

## 1.4 The Variance Decompsition

The variance decomposition or the forecast error variance decomposition indicates the amount of information each variable contributes to the other, and give us how much of the forecast error variance of each of the variables can be explained by exogenous shocks of the other variables.

The calculation of the percentage of forecast error generated by each variable's shock related to the total amount of the forecast errors is calculated as per the following formula:

$$\mathbf{FEVD= VAR(e_{f,ki}) / VAR(e_{f,k})}$$

Where $VAR(e_{f,k})$ is the total variance of the forecast error of variable k and $VAR(e_{f,kk})$ is the part of variance due to the error forcast of each endogenous variable of the model ( k = 1…,n)

## Chapter 2 Impact of the Uncertainty on the Unemployement in the US

In this chapter we are going through a SVAR/SVEC modelisation to measure the impact of the uncertainty expressed by the new EPU index on the job market in united state of America using the unemployement rate as a proxy.

This model will also include the consumer price index (CPI) and the FED interest rate ( 4 endogenous variables ) and the first purpose will be to find the best linear model to explain the short and the long run dynamics of our endogenous variables, in the second step we will apply a positive shock on the uncertainty index in order to understand the reaction on the short and long run of the job market through a focus on the unemployement rate ( impulse response function ).

## 2.1 Data Analysis

To build our model which will include a vector of 4 endogenous variables, we are going to take in account the quarterly unemployement rate in united states of America between january 1994 and december 2016, regarding the proxy of the uncertainty in our model we will use as explained above the logarithm of new policy uncertainty index (Log EPU) constructed by Baker et al. (2015), we will also take in account as an endogenous variables the quarterly FED interest rate (from the Federal reserve Bank website) and the quarterly logarithm of the consumer price index (Log CPI) during the same period.

- Quarterly FED interest rate = D
- Quarterly LOG IPC = C
- Quarterly Unemployement rate =A
- Quareterly LOG EPU = P

we are going to use R software for our modelisation and calculation

Firstly we have to convert our data file to a txt file and load it through rcmdr ( package ) and organize them as below:

a) D=Data[ ,1] for the Quarterly FED interest rate.
b) C=Data[ ,2] for the Quarterly LOG IPC.
c) A=Data[ ,3] for the Quarterly Unemployement rate.
d) P=Data[ ,4] for the Quarterly LOG EPU index.

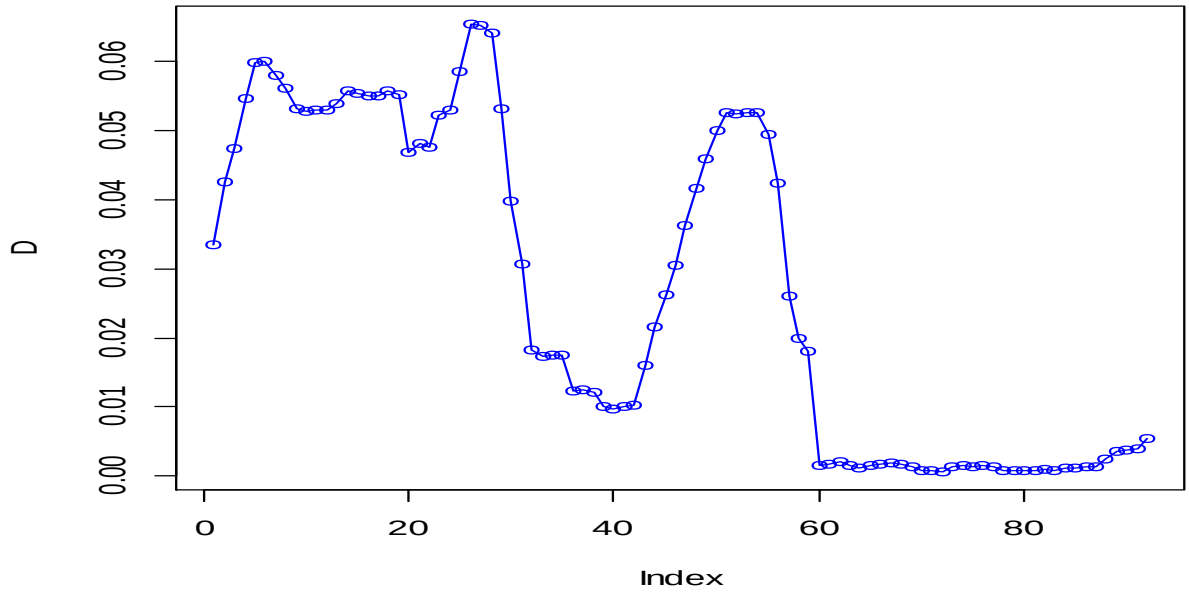


Figure 3:Evolution of the FED Interest Rate (1994-2016).

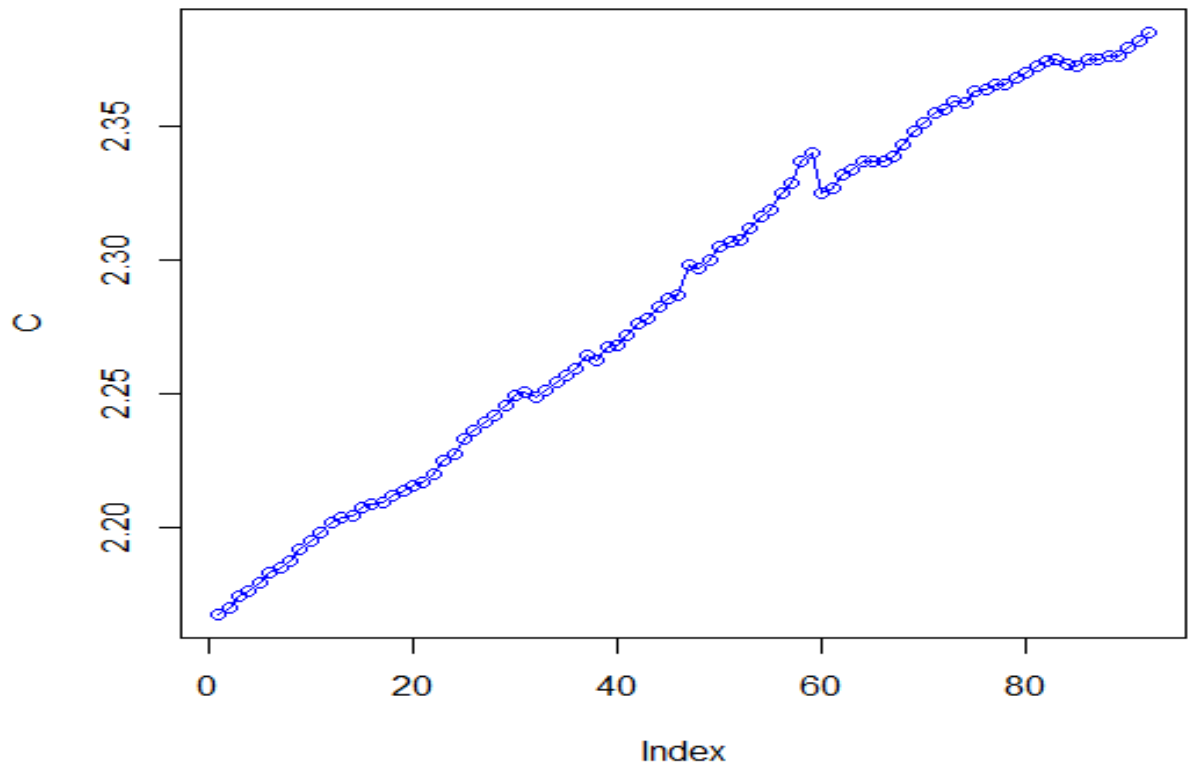


Figure 4:Evolution of the LOG CPI Index (1994-2016).

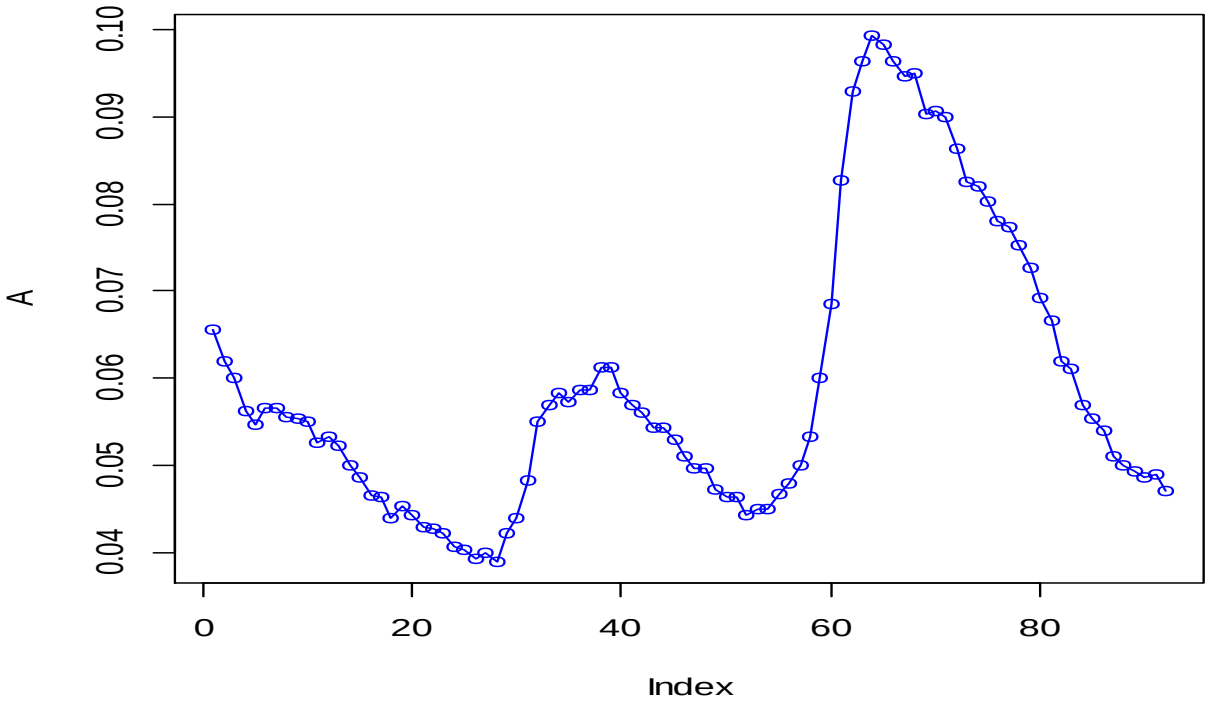


Figure 5:Evolution of the Unemployement rate (1994-2016).

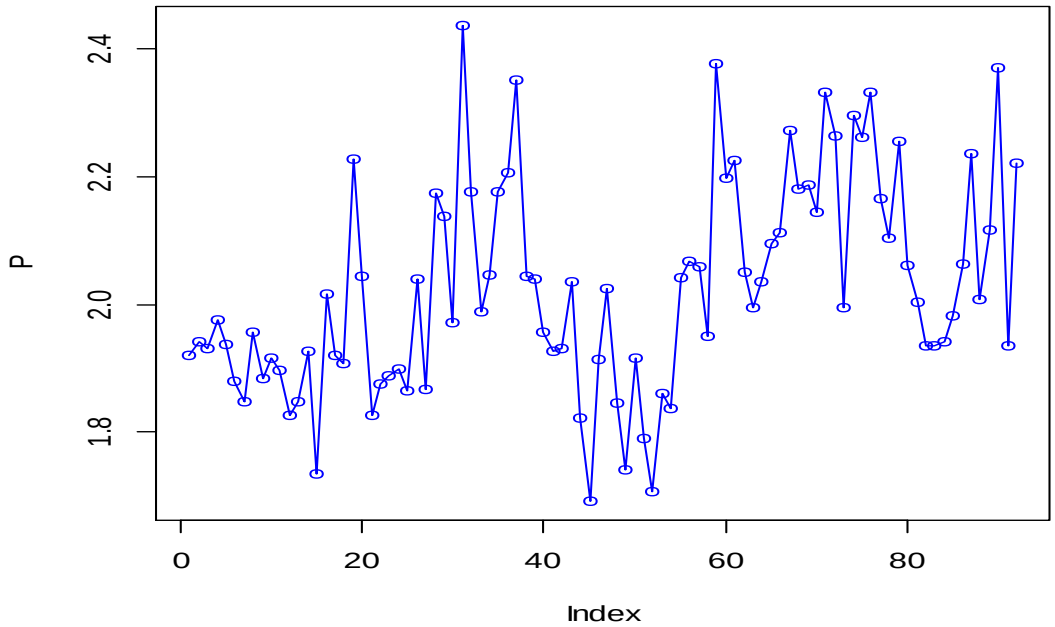


Figure 6:Evolution of the  log EPU Index (1994-2016).

## 2.2 The Stationarity Analysis

We need first of all to test the stationarity of our times series.We will use for that the KPSS test and the augmented Dickey – Fuller test on our data through the R software (adf.test( )) available in the package tseries and urca, in the ADF test the null hypothesis is the non-stationarity of the time serie while in KPSS test the null hypothesis is the stationarity of the time serie.

The results show clearly that the four endogenous variables are non statitionary in level and stationary for the first differenciation

The boards below is summing up our results:

**Table 1: KPSS Test (Null hypothesis:stationarity)**

| Endogenous Variables | test value | P-value | Outcome |
|---|---|---|---|
| P=EPU index Quarterly Data(1994-2016) | 0,9208 | 0,01 | rejected |
| First differenciation of P = P1 | 0,0291 | 0,1 | accepted |
| D=Fed interest rate Quarterly Data(1994-2016) | 2,1701 | 0,01 | rejected |
| First differenciationof D = D1 | 0,0997 | 0,1 | accepted |
| A=unemployement rate Quarterly Data(1994-2016) | 0,9432 | 0,01 | rejected |
| First differenciationof A = A1 | 0,1998 | 0,1 | accepted |
| C= log IPC Quarterly Data (1994-2016) | 3,1599 | 0,01 | rejected |
| First differenciationof C = C1 | 0,2966 | 0,1 | accepted |

**Table2: ADF Test (Null hypothesis:non stationarity**

| Endogenous Variables | test value | P-value | Outcome |
|---|---|---|---|
| P=EPU index Quarterly Data(1994-2016) | -2,7752 | 0,2567 | accepted |
| First differenciation of P = P1 | -5,2468 | 0,01 | rejected |
| D=Fed interest rate Quarterly Data(1994-2016) | -3,0145 | 0,1581 | accepted |
| First differenciationof D = D1 | -4,1021 | 0,01 | rejected |
| A=unemployement rate Quarterly Data(1994-2016) | -2,0028 | 0,5751 | accepted |
| First differenciationof A = A1 | -3,6657 | 0,03174 | rejected |
| C= log IPC Quarterly Data (1994-2016) | -0,4966 | 0,9801 | accepted |
| First differenciationof C = C1 | -4,4653 | 0,01 | rejected |

## 2.3 The Choice of the Lag Order

In this step we are going to determine the lag order of our SVAR model through the use of 4 indicators (Akaiké criterion (AIC), Hannan Quin criterion (HQ), Schwarz criterion (SC) and the Forcast Prediction Error (FPE), the function VARselect in R allows us to run this test.The results are below:

**Table3: The criterions results of the lag order**

| AIC(n) | HQ(n) | SC(n) | FPE(n) |
|---|---|---|---|
| 3 | 2 | 2 | 3 |

**Table4: The details of the criterions by lag order**

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| AIC(n) | -3.884741e+01 | -3.964758e+01 | -3.970463e+01 | -3.963091e+01 | -3.947189e+01 |
| HQ(n) | -3.856822e+01 | -3.918227e+01 | -3.905319e+01 | -3.879334e+01 | -3.844819e+01 |
| SC(n) | -3.815289e+01 | -3.849005e+01 | -3.808409e+01 | -3.754735e+01 | -3.692532e+01 |
| FPE(n) | 1.346506e-17 | 6.070776e-18 | 5.780282e-18 | 6.312971e-18 | 7.573280e-18 |

| | 8 | 6 | 7 |
|---|---|---|---|
| AIC(n) | -3.929446e+01 | -3.921665e+01 | -3.916069e+01 |
| HQ(n) | -3.808463e+01 | -3.782070e+01 | -3.757861e+01 |
| SC(n) | -3.628488e+01 | -3.574406e+01 | -3.522508e+01 |
| FPE(n) | 9.356114e-18 | 1.060786e-17 | 1.196990e-17 |

As per these results we have to decide between the second and the third lag order, but we will consider the the third the higher order by caution

## 2.4 The Cointegration Relationships

As per what we saw above, our data are not stationary in level,but all of them are stationary by first differentiation,we can therefore apply a test to assess if we have long run equilibrium relationships between them through a trace test.

There exist different kinds of cointegration long run relationships which it can be a trend relationships, constant relationships or different from both of them, therefore in our trace

test we are going to test all these possibilities.

This test has been done through the ca.jo (Johansen Test) function in R and the results are below:

**Table5 :Trend term cointegration relationships**

| | | Critical Values | | |
|---|---|---|---|---|
| H0 | Test Value | 10% | 5% | 1% |
| r<=3 | 3,0945 | 10,49 | 12,25 | 16,26 |
| r<=2 | 16,366 | 22,76 | 25,32 | 30,45 |
| r<=1 | 33,2801 | 39,06 | 42,44 | 48,45 |
| r=0 | 65,7908 | 59,14 | 62,99 | 70,05 |

**Table6 :Constant term in cointegration relationships**

| | | Critical Values | | |
|---|---|---|---|---|
| H0 | Test Value | 10% | 5% | 1% |
| r<=3 | 4,2615 | 7,52 | 9,24 | 12,97 |
| r<=2 | 16,7146 | 17,85 | 19,96 | 24,6 |
| r<=1 | 42,5194 | 32 | 34,91 | 41,07 |
| r=0 | 78,3721 | 49,65 | 53,12 | 60,16 |

**Table7 :No intercept in cointegration relationships**

| | | Critical Values | | |
|---|---|---|---|---|
| H0 | Test Value | 10% | 5% | 1% |
| r<=3 | 2,1835 | 6,5 | 8,18 | 11,65 |
| r<=2 | 7,2356 | 15,66 | 17,95 | 23,52 |
| r<=1 | 20,5489 | 28,71 | 31,52 | 37,22 |
| r=0 | 48,2625 | 45,23 | 48,28 | 55,43 |

As per the results we can note that we have a one cointegration equation in the case of trend relationships and two cointegration equations in the case of constant relationships while we have no cointegration equation for the case without intercept in cointegration relationships,

we are therefore going to consider the situation of constant relationships with a cointegration rank = 2, and the situation of trend relationships with a cointegration rank = 1.

As per these results and in order to catch in our model the long and the short run relationships, we are going to use the Vector Error Correction model instead of the classical Vector Autoregressive.

But in order to avoid the covariance between the errors terms with the purpose to isolate the effects of each choc separately, we are going to use the structural approach SVEC.

To construct our A0 the matrix of instantaneous effects we have to specify our 6 identification constraints (n(n-1)/2) using for that the economic theory and the causality test of granger .

## 2.5 Causality and Instantaneous Effects

Before to carry out our SVEC modelisation, it is important to test the causality between the variables through Granger test in order to set our identifications constraints, therefore in the case that the causality between two variables is absent , we will put zero on the matrix of our instantanous effects.

This test has been done through the package (MSBVAR) on R (granger.test(X, p=2)) with

lag of semesters (P=2) and the results are below:

**Table8: Granger Test Results**

| Tested Variables H0 | Fisher Stat | P-Value | Comments |
|---|---|---|---|
| **C ( Log CPI ) dont cause D ( Fed interest rate )** | **4,697** | **0,01161** | **causality** |
| A ( unemployement rate ) dont cause D ( Fed interest rate ) | 0,6678 | 0,5154 | No causality |
| **P ( uncertainty Log EPU index ) dont cause D ( Fed interest rate )** | **12,6234** | **0,0000158** | **causality** |
| D ( Fed interest rate ) dont cause C ( Log CPI ) | 0,2927 | 0,7469 | No causality |
| A ( unemployement rate ) dont cause C ( Log CPI ) | 0,5526 | 0,577 | No causality |
| P( uncertainty Log EPU index ) dont cause C ( Log CPI ) | 2,22 | 0,1148 | No causality |
| **D ( Fed interest rate ) dont cause A ( unemployement rate )** | **3,6274** | **0,03** | **causality** |
| C ( Log CPI ) dont cause A ( unemployement rate ) | 2,1863 | 0,1185 | No causality |
| **P ( uncertainty Log EPU index ) dont cause A ( unemployement rate )** | **3,7481** | **0,0274** | **causality** |
| **D ( Fed interet rate ) dont cause P( uncertainty Log EPU index )** | **4,025** | **0,02135** | **causality** |
| C ( Log CPI ) dont cause P( uncertainty Log EPU index ) | 2,15 | 0,122 | No causality |
| A ( uncemployement rate ) dont cause P ( uncertainty Log EPU index ) | 0,93 | 0,3978 | No causality |

As per these results we are going to extract our indentification constraints.

regarding the Log CPI we can note that it influence the FED interest rate which is logical with the economic theory.

The Fed interest rate itself influence the unemployement rate which is also influenced by our uncertainty index confirming the existing link

We can also note that the Fed interest rate and the uncertainty index influence each other but we will just consider that the FED interest rate influence the uncertainty index to avoid reciprocal relationships in our instantanous effects matrix

Using the economic theory we are also going to consider that the ICP index influence the Unemployement rate (Phillips curve) and the uncertainty index is influenced by the CPI index.

Now we have our six identification constraints, we can then construct our instantanous effects Matrix $A_0$ :

$$A_0 = \begin{array}{c} \\ D \\ C \\ A \\ P \end{array} \begin{array}{c} \begin{array}{cccc} D & C & A & P \end{array} \\ \begin{pmatrix} C_{11} & C_{12} & 0 & 0 \\ 0 & C_{22} & 0 & 0 \\ C_{31} & C_{32} & C_{33} & C_{34} \\ C_{41} & C_{42} & 0 & C_{44} \end{pmatrix} \end{array}$$

## 2.6 The Structural Vector Error Correction SVEC Modelisation

We are going now to use the SVEC model using for that with two differents form of cointegrations (with constant cointegration relationships(r=2) and trend cointegration relationships (r=1)), and we will compare after that between them in the sense of adjusted coefficient of determination.

### 2.6.1 SVEC2 Modelisation with Constant Cointegration Relationships ( rank = 2 )

Basing on the results of our notation in the theoritical part, the SVEC form of our endogenous variables vector will be :

$$\mathbf{A_0\ \Delta\ y_t = A_0\ \alpha\ (\ \beta y_{t-1} + p_0\ ) + A_0 A_1 \Delta y_{t-1} + A_0 A_2 \Delta y_{t-2} + A_0\ \varepsilon_t}$$

And the general form is:

$$\mathbf{A_0\ \Delta\ y_t = A_0\ \alpha\ (\ \beta y_{t-1}) + A_0 A_1 \Delta y_{t-1} + A_0 A_2 \Delta y_{t-2} + A_0\ \varepsilon_t}$$

Through the package VARS in R and using the function SVEC we can specify the differents elements of our model as below:

- **The cointegration marix β is :**

$$\begin{array}{l} \\ \textbf{D.l1} \\ \textbf{C.l1} \\ \textbf{A.l1} \\ \textbf{P.l1} \\ \textbf{constant} \end{array} \begin{array}{c} \begin{array}{cc} \textbf{ect1} & \textbf{ect2} \end{array} \\ \begin{pmatrix} 1.000000e+0 & 0.0000000 \\ -1.328148e-17 & 1.0000000 \\ 2.239469e-01 & -1.7159011 \\ -2.611186e-02 & 0.6356406 \\ 1.134987e-01 & -3.9816725 \end{pmatrix} \end{array}$$

- **The adjustement coefficients matrix α is :**

$$\begin{array}{c} \begin{array}{cccc} \textbf{D.d} & \textbf{C.d} & \textbf{A.d} & \textbf{P.d} \end{array} \\ \begin{pmatrix} -0.11959549 & 0.01970553 & 0.04291870 & -0.82696979 \\ -0.0249640 & -0.0018051 & 0.0078545 & -0.1493443 \end{pmatrix} \end{array}$$

- **The coefficients matrix (short run) of the reduced form $A_1$ is :**

$$\begin{array}{l} \\ \textbf{D.dl1} \\ \textbf{C.dl1} \\ \textbf{A.dl1} \\ \textbf{P.dl1} \end{array} \begin{array}{c} \begin{array}{cccc} \textbf{D.d} & \textbf{C.d} & \textbf{A.d} & \textbf{P.d} \end{array} \\ \begin{pmatrix} 0.4332400 & -0.1587452 & -0.0386579 & -8.3802104 \\ -0.1494984 & -0.0311967 & -0.1993478 & 4.4452349 \\ -0.1476324 & -0.1094722 & 0.4145549 & 1.5792427 \\ 0.0010158 & -0.0024326 & 0.0007438 & -0.5446001 \end{pmatrix} \end{array}$$

- **The coefficients matrix (short run) of the reduced form $A_2$ is :**

$$\begin{array}{l} \\ \textbf{D.dl2} \\ \textbf{C.dl2} \\ \textbf{A.dl2} \\ \textbf{P.dl2} \end{array} \begin{array}{c} \begin{array}{cccc} \textbf{D.d} & \textbf{C.d} & \textbf{A.d} & \textbf{P.d} \end{array} \\ \begin{pmatrix} 0.1155279 & 0.1417591 & -0.1367033 & 3.1607511 \\ -0.2238344 & -0.2039954 & 0.0298152 & 1.2549622 \\ 0.0194816 & 0.0149060 & 0.1833500 & -8.0452335 \\ 0.0049260 & -0.0020320 & -0.0007617 & -0.4338606 \end{pmatrix} \end{array}$$

- **The estimated contemporaneous impact matrix (instantanous effects matrix(Short run)) $A_0$ is :**

$$\begin{array}{c} \\ D \\ C \\ A \\ P \end{array} \begin{array}{c} \begin{array}{cccc} D & C & A & P \end{array} \\ \begin{pmatrix} 2.586e\text{-}03 & 0.0008507 & 0.000000 & 0.0000000 \\ 0.000e+00 & 0.0025411 & 0.000000 & 0.0000000 \\ 3.297e\text{-}05 & -0.0001287 & 0.001735 & 0.0003434 \\ -1.320e\text{-}02 & -0.0043735 & 0.000000 & 0.1326454 \end{pmatrix} \end{array}$$

It is also interesting to understand the impact on the long run of the endogenous variables one over the other through determining the the multiplier matrix long run, the function svec in R allow us to obtain this matrix (M):

- **The estimated long run impact matrix M is:**

$$\begin{array}{c} \\ D \\ C \\ A \\ P \end{array} \begin{array}{c} \begin{array}{cccc} D & C & A & P \end{array} \\ \begin{pmatrix} -0.0004986 & 1.581e\text{-}04 & -8.441e\text{-}04 & 0.0001482 \\ 0.0069321 & -1.244e\text{-}03 & 6.477e\text{-}03 & -0.0151504 \\ 0.0013937 & -6.975e\text{-}04 & 3.767e\text{-}03 & 0.0030898 \\ -0.0071432 & 7.409e\text{-}05 & -2.172e\text{-}05 & 0.0321759 \end{pmatrix} \end{array}$$

We have also two cointegration equations which offer us a form of long run equilibrium, these two equations are:

- $\mathbf{D_t - 1.328e\text{-}17C_t + 2.239e\text{-}01A_t - 2.61e\text{-}02P_t + 1.135e\text{-}01 = e_t}$
- $\mathbf{C_t - 1.7159A_t + 0.6356P_t - 3.9817 = e_t}$

Through these equations we can understand that our 4 variables are linked by a two long run economic relationships.

Considering $\beta_i$ as the long run effect of D(FED interest rate) on the other variables, we can consider that the expression of A (unemployement rate) which is our interest variable, with the three others variables is not completely in agreement with the economic theory (negative correlation with the FED interest rate on the long run), while the second cointegration relationship doesn't take in account the FED interest rate.

The structural equations derived from the SVEC2 modelisation are:

**Equation 1:**

- **$D_t$ ( FED interest rate ) =+0.3290$C_t$+ 1.2709$D_{t-1}$ +0.1344 $C_{t-1}$ -0.0857$A_{t-1}$ -6.9046$P_{t-1}$ -0.3422 $D_{t-2}$ +0.2437$C_{t-2}$ – 0.02266 $A_{t-2}$ +10.4915$P_{t-2}$ -0.0418 $D_{t-3}$ +0.0747$C_{t-3}$ + 0.1269$A_{t-3}$ -3.5736$P_{t-3}$ +0.0889**

**Equation 2:**

- **$C_t$ ( Log CPI ) = -0.1298$D_{t-1}$ +0.9670$C_{t-1}$ -0.1918 $A_{t-1}$ +4.4436 $P_{t-1}$ -0.0743$D_{t-2}$ -0.1728$C_{t-2}$ +0.2292$A_{t-2}$ -3.1903$P_{t-2}$+0.2238$D_{t-3}$+0.2040$C_{t-3}$ - 0.0298$A_{t-3}$ – 1.2550$P_{t-3}$ +0.0094**

**Equation 3:**

- **$A_t$ = -0.0190$D_t$ +0.0742$C_t$ -0.1979$P_t$ -0.2336 $D_{t-1}$ - 0.2069$C_{t-1}$ +1.4387$A_{t-1}$ +1.1911$P_{t-1}$ +0.1674$D_{t-2}$ +0.1430$C_{t-2}$ -0.2504$A_{t-2}$ -9.1466$P_{t-2}$ -0.0393$D_{t-3}$ -0.0323$C_{t-3}$ -0.1784$A_{t-3}$+8.1641 $P_{t-3}$+0.0736**

**Equation 4:**

- **$P_t$ ( Log EPU index ) =+0.0995$D_t$+0.0330$C_t$ -0.9524$D_{t-1}$ -0.16538 $C_{t-1}$ +0.0804$A_{t-1}$ +1.0708$P_{t-1}$ + 0.0380 $D_{t-2}$ - 0.02381$C_{t-2}$ + 0.0007$A_{t-2}$ + 0.9326 $P_{t-2}$-0.0008$D_{t-3}$ + 0.0094$C_{t-3}$ -0.0119$A_{t-3}$ + 0.7898 $P_{t-3}$+ 0.4919**

These four equations link between the long run equilibrium relationships (implied by our two cointegration relationships) and the short run dynamic.

### 2.6.2 SVEC1 Modelisation with Trend Cointegration Relationships ( rank = 1 )

Basing on the results of our notation in the theoritical part, the SVEC form of our endogenous variables vector will be:

$$\mathbf{A_0\ \Delta\ y_t = A_0\ \alpha\ (\ \beta y_{t-1} + p_0\ ) + A_0\ \alpha'(\gamma_0) + A_0 A_1 \Delta y_{t-1} + A_0 A_2 \Delta y_{t-2} + A_0\ \varepsilon_t}$$

Through the package VARS in R and using the functions cajorls and SVEC we can specify the differents elements of our modelisation as below :

- **The cointegration marix β is :**

| | ect1 |
|---|---|
| D.l1 | 1.000000000 |
| C.l1 | 2.564848869 |
| A.l1 | -1.118626005 |
| P.l1 | 0.192219620 |
| trend.l1 | -0.006112131 |

- **The adjustement coefficients matrix α is :**

| | D.d | C.d | A.d | P.d |
|---|---|---|---|---|
| ect1 | -0.046224 | 0.003723 | 0.036652 | -0.650587 |

- **The coefficients matrix (short run) of the reduced form $A_1$ is :**

| | D.d | C.d | A.d | P.d |
|---|---|---|---|---|
| D.dl1 | 0.426748 | -0.157451 | -0.001918 | -9.240751 |
| C.dl1 | -0.081764 | 0.014089 | -0.262662 | 7.368121 |
| A.dl1 | -0.091806 | -0.078650 | 0.339309 | 3.296733 |
| P.dl1 | -0.001987 | -0.003995 | -0.001633 | -0.512036 |

- **The coefficients matrix (short run) of the reduced form $A_2$ is :**

| | D.d | C.d | A.d | P.d |
|---|---|---|---|---|
| D.dl2 | 0.086509 | 0.197598 | -0.099422 | 2.236529 |
| C.dl2 | -0.124341 | -0.177005 | -0.047404 | 4.484648 |
| A.dl2 | 0.027446 | 0.003752 | 0.209748 | -8.796264 |
| P.dl2 | 0.002897 | -0.003156 | -0.001737 | -0.420602 |

- **The estimated contemporaneous impact matrix (instantanous effects matrix(Short run)) $A_0$ is :**

$$\begin{array}{c} \\ D \\ C \\ A \\ P \end{array} \begin{array}{c} \begin{array}{cccc} D & C & A & P \end{array} \\ \begin{pmatrix} 2.728e\text{-}03 & 8.345e\text{-}04 & 0.000000 & 0.0000000 \\ 0.000e+00 & 2.598e\text{-}03 & 0.000000 & 0.0000000 \\ 9.719e\text{-}05 & -6.640e\text{-}05 & 0.001608 & 0.0004062 \\ -1.322e\text{-}02 & 7.103e\text{-}05 & 0.000000 & 0.1319435 \end{pmatrix} \end{array}$$

- **The estimated long run impact matrix M is:**

$$\begin{array}{c} \\ D \\ C \\ A \\ P \end{array} \begin{array}{c} \begin{array}{cccc} D & C & A & P \end{array} \\ \begin{pmatrix} 0.0042226 & -0.003340 & 2.146e\text{-}03 & -0.0034882 \\ 0.0003238 & 0.002065 & -5.874e\text{-}05 & -0.0006251 \\ 0.0002296 & 0.002458 & 1.194e\text{-}03 & 0.0045068 \\ -0.0249519 & 0.004122 & -3.434e\text{-}03 & 0.0527150 \end{pmatrix} \end{array}$$

- **The constant adjustement coefficients vector $\alpha'(\gamma_0)$ is:**

$$\begin{array}{c} \\ \text{constant} \end{array} \begin{array}{c} \begin{array}{cccc} D.d & C.d & A.d & P.d \end{array} \\ \begin{bmatrix} 0.274483 & -0.019327 & -0.216815 & 3.832907 \end{bmatrix} \end{array}$$

We have also one cointegration equation which offers us a form of long run equilibrium, this equation is:

- **$D_t$ +2.5648$C_t$ - 1.1186 $A_t$ + 0.1922$P_t$ - 0.0061 = $e_t$**

Through this cointegration equation above, we can understand that our 4 variables are linked by just one long run economic relationship compared to SVEC2 where we have two long run relationships

Considering $\beta_i$ as the long run effect of D (FED interest rate ) on the other variables , we can consider that the expression of A (unemployement rate) which is our interest variable with the three others variables is logical and coherent with the economic theory(positive correlation with the FED interest rate, the log CPI and the log EPU)

This cointegration equation is more coherent with the economic theory compared to the cointegrations equations of SVEC2

The structural equations derived from The SVEC1 modelisation will be:

**Equation 1:**

- **$D_t$ ( FED interest rate ) =+0.3059$C_t$+ 1.3566$D_{t-1}$ +0.0371$C_{t-1}$ -0.0318$A_{t-1}$ -6.9955$P_{t-1}$ -0.3533$D_{t-2}$ +0.2966$C_{t-2}$ – 0.0317$A_{t-2}$ +10.5952 $P_{t-2}$ -0.0485 $D_{t-3}$ -0.1435$C_{t-3}$ + 0.1139$A_{t-3}$ -3.6084 $P_{t-3}$ +0.2688**

**Equation 2:**

- **$C_t$ ( Log CPI ) = -0.0780$D_{t-1}$ +1.0236$C_{t-1}$ -0.2668$A_{t-1}$ +7.3688$P_{t-1}$ -0.0426$D_{t-2}$ -0.1911$C_{t-2}$ +0.2153$A_{t-2}$ -2.8835$P_{t-2}$+0.1243$D_{t-3}$+0.1770 $C_{t-3}$ +0.0474$A_{t-3}$ – 4.4846$P_{t-3}$ -0.0190**

**Equation 3 :**

- **$A_t$ = -0.0604$D_t$ +0.0413$C_t$ -0.2526$P_t$ -0.1333$D_{t-1}$ -0.4661$C_{t-1}$ +1.4958$A_{t-1}$ +2.5321$P_{t-1}$ +0.1017 $D_{t-2}$ +0.1120$C_{t-2}$ -0.1444$A_{t-2}$ -11.2571$P_{t-2}$ -0.03854$D_{t-3}$ -0.0222$C_{t-3}$ -0.2053$A_{t-3}$+8.9525 $P_{t-3}$+0.7696**

**Equation 4:**

- **$P_t$ ( Log EPU index ) =+0.1002$D_t$-0.0005$C_t$ -0.7909 $D_{t-1}$ -1.6444$C_{t-1}$ +0.7210$A_{t-1}$ +1.2936$P_{t-1}$ + 0.0390$D_{t-2}$ - 0.0348$C_{t-2}$ + 0.0098$A_{t-2}$ -1.0601$P_{t-2}$-0.0058$D_{t-3}$ + 0.0230$C_{t-3}$ -0.0082$A_{t-3}$ + 0.6423$P_{t-3}$+ 3.8093**

These four equations link between the long run equilibrium relationships (implied by our cointegration relationships) and the short run dynamic

## 2.7 VECM1 and VECM2 Comparison

As explained we are going to compare the properties of the VECM 1 and 2 model with constant cointegration relationships (rank = 2) and trend cointegration relationship (rank = 1) respectively.

We will base our comparaison on two indicators R-squared and adjusted R-squared ( determination coefficient) to see which model explain better the dynamic of our endogenous variables.

**Table9: VECM1 model with trend cointegration relationships with rank = 1**

| Equation | D | C | A | P |
|---|---|---|---|---|
| R-Squared | 0,5715 | 0,4874 | 0,6917 | 0,3311 |
| Adjusted R-Squared | 0,5173 | 0,4225 | 0,6527 | 0,2464 |

**Table10 :VECM2 model with constant cointegration relationships with rank = 2**

| Equation | D | C | A | P |
|---|---|---|---|---|
| R-Squared | 0,6099 | 0,5097 | 0,6493 | 0,3233 |
| Adjusted R-Squared | 0,5605 | 0,4476 | 0,6049 | 0,2376 |

The results being shared, then let's now apply a fischer[1] test on the parameters of both modelisations the results are:

**Table11 : VECM model with trend cointegration relationships with rank = 1**

| H0= β1=β2=β3=…….βN = 0 | D | C | A | P |
|---|---|---|---|---|
| Fischer Test Value | 10,54 | 7,512 | 17,72 | 3,91 |
| P-Value | 4.304e-11 | 2.793e-08 | < 2.2e-16 | 0,0002427 |

[1] *Fisher (1960)*

**Table12 : VECM model with constant cointegration relationships with rank = 2**

| H0= β1=β2=β3=…….βN = 0 | D | C | A | P |
|---|---|---|---|---|
| Fischer Test Value | 11,05 | 6,851 | 16,96 | 3,648 |
| P-Value | 5.297e-12 | 6.106e-08 | < 2.2e-16 | 0,0003412 |

As per the results above we can note a better results for the VECM1 modelisation with trend cointegration.

At last we are are going to looking up to student test applied on the parameters to compare their significance (you can find the results of this test in the annexe 1), the results showed that VECM1 modelisation with trend cointegration has more significant parameters (17 with a p value < 0.07) while the VECM2 modelisation with constant cointegration has just 14

we are now going to apply an impulse response function on both modelisations to assess the impact on the unemployement

## 2.8 Structural Shocks Analysis

Through using the IRF function in R, we will plot on 12 periods (3 year) the Response of the unemployement rate in our both case of modelisation (constant cointegration relationships with r=2 and trend cointegration relationships with r = 1) to the differents positifs shocks or innovations, equivalent to one standard deviation increase applied on the Fed interest rate, the Log CPI index and the Log of the uncertainty index .

### 2.8.1 The Impulse Response Function of SVEC-1 (trend cointegration relationships with r=1)

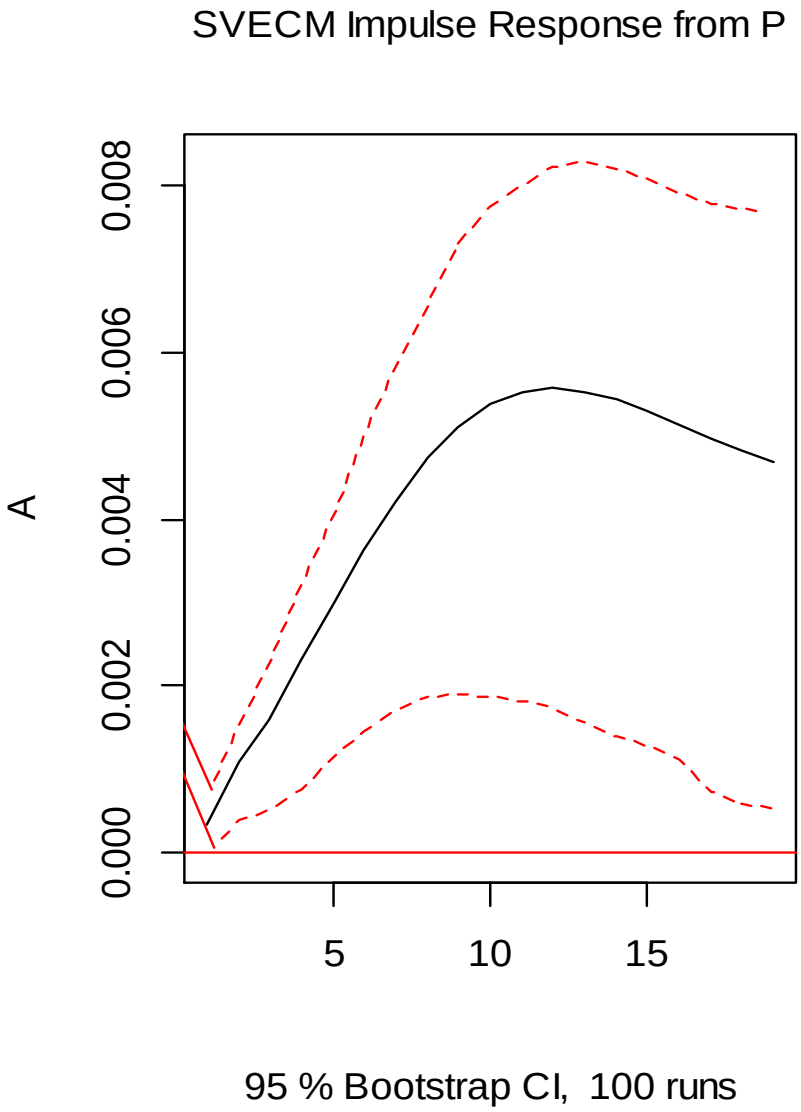


Figure 7: Plot of the reaction of the unemployement rate (A) to a positive shock on the Log EPU (P).

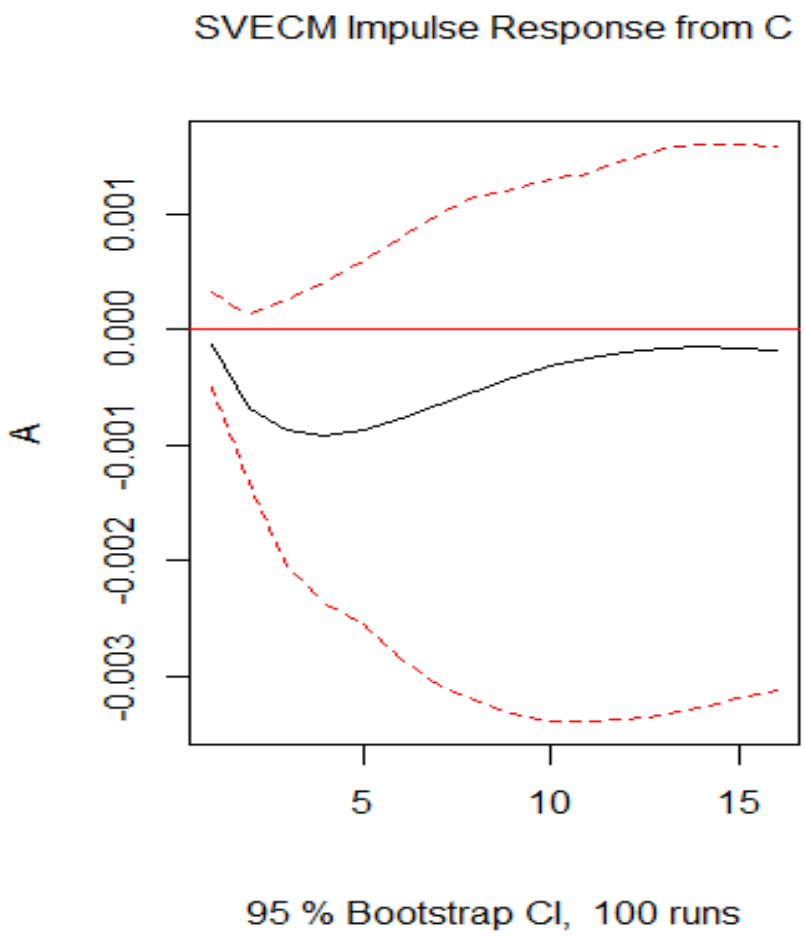


Figure 8: Plot of the reaction of the unemployement rate (A) to a positive shock on the Log CPI (P).

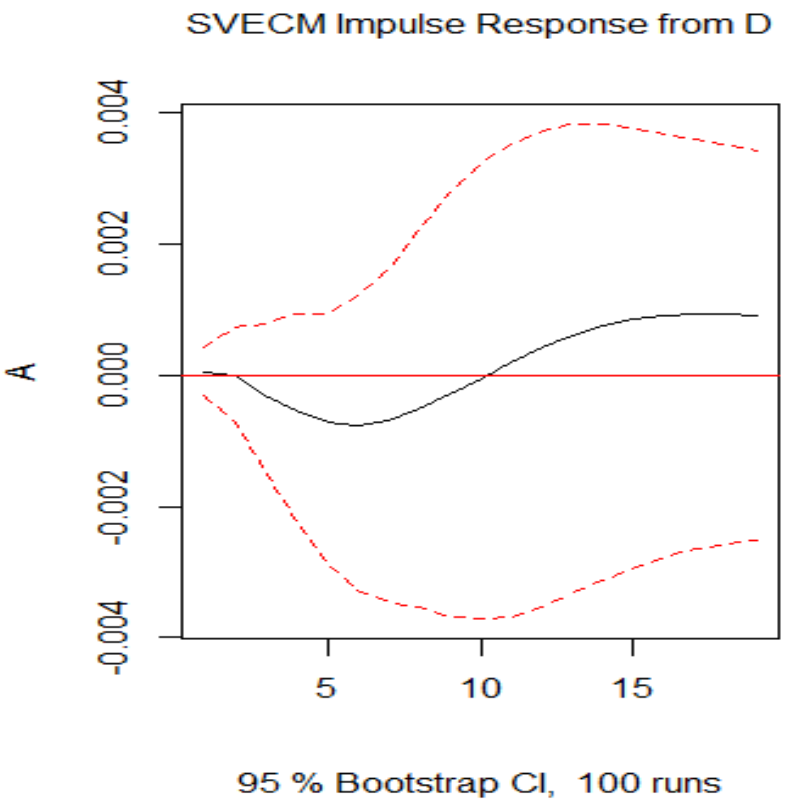


Figure 9: Plot of the reaction of the unemployement rate (A) to a positive shock on the FED interest rate(D).

the positive shock applied on the uncertainty expressed by the EPU index induce an increase in the unemployement rate by 0.38 percentage points after four trimesters and it reachs 0.57 percentage points after almost eight trimesters ( 2 years ) after this , this impact start to decrease and it become stable arround 0.40 confirming the analysis of in the The paper of Giovanni Gaggianno and al ( 2014 ( Uncertainty choc and unemployement dynamics , 2014 ) but with higher amplitude ( 0.36 and 0.41 percentage points for the non linear VAR approach for the first and the second year respectively and 0.17 and 0.14 for the classical linear VAR approach respectively after the first and second year )

As waited the positive shock applied to the inflation expressed by the Log CPI lead to a decrease in the unemployement rate ( 0.08 percentage points ) after 1 year but this impact become close to zero after around 2 years confirming the economic theory about the impact of the inflation on the job market , in fact an inflation shock lead to a decrease in the

unemployement rate on the short run (Philips curve), but on the long run this impact become null (New classical analysis on the rational anticipations of the agents, the agents understand that they have been fooled and come back to the original situation before the shock).

Regarding at last the impact on the unemployement rate of the shock on the FED interest rate we can note that during the first two years it induce a decrease in the unemployement rate which it can be explained by the fact that the increase of the Fed interest is the result of an improvement in the mains indicators of the american economy , this increase in the interest rate will also lead to an improvement in the confidence in the economy , but after more than 2 years (10 semesters) we can note an increase in the unemployement rate , this increase can be explained by the fact that the persistence of the increase in the FED interest rate induce a change in the behaviour of the agents by the increase of the propension to save and a decrease in the propension to consum which induce a decrease in the demand and consequently less recruitement by the firms[2].

### 2.8.2 The Impulse Response Function of SVEC-2 (constant cointegration relationships with r=2)

[2] Johanna Etner ,Patricia Le Maitre L'impact du taux d'intérêt sur l'évolution simultanée du chômage et de l'épargne,1999

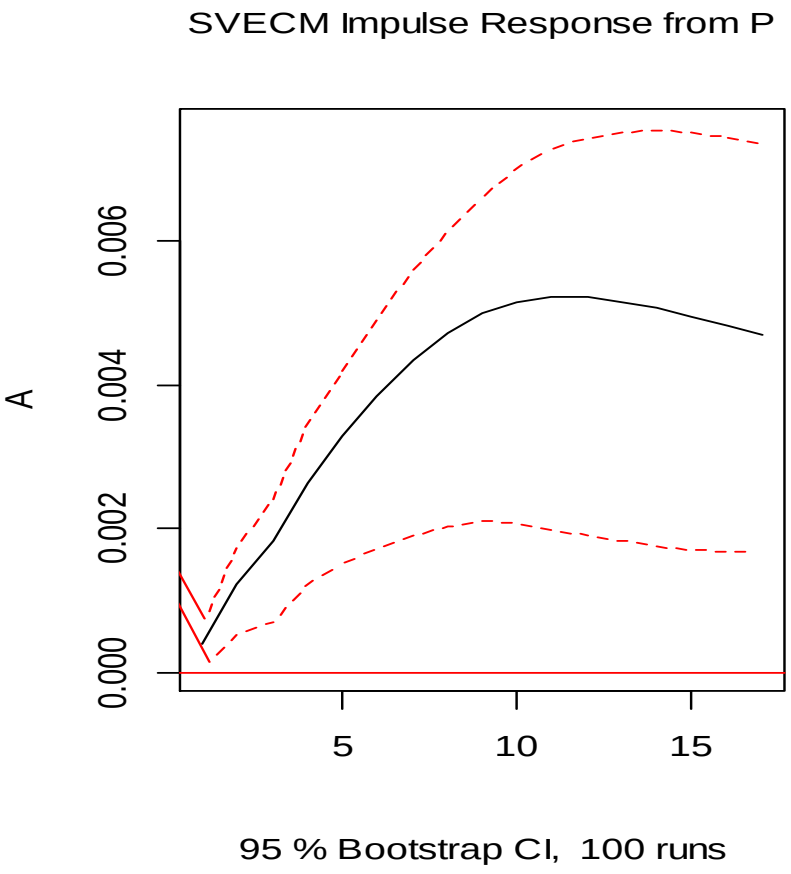


Figure 10: Plot of the reaction of the unemployement rate (A) to a positive shock on the Log EPU index (P).

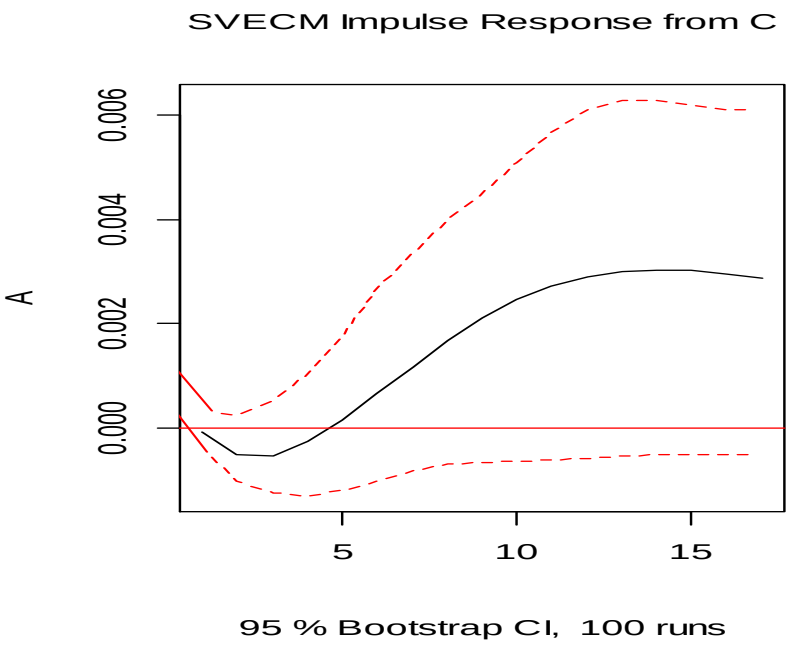


Figure 11: Plot of the reaction of the unemployement rate (A) to a positive shock on the Log CPI index (C).

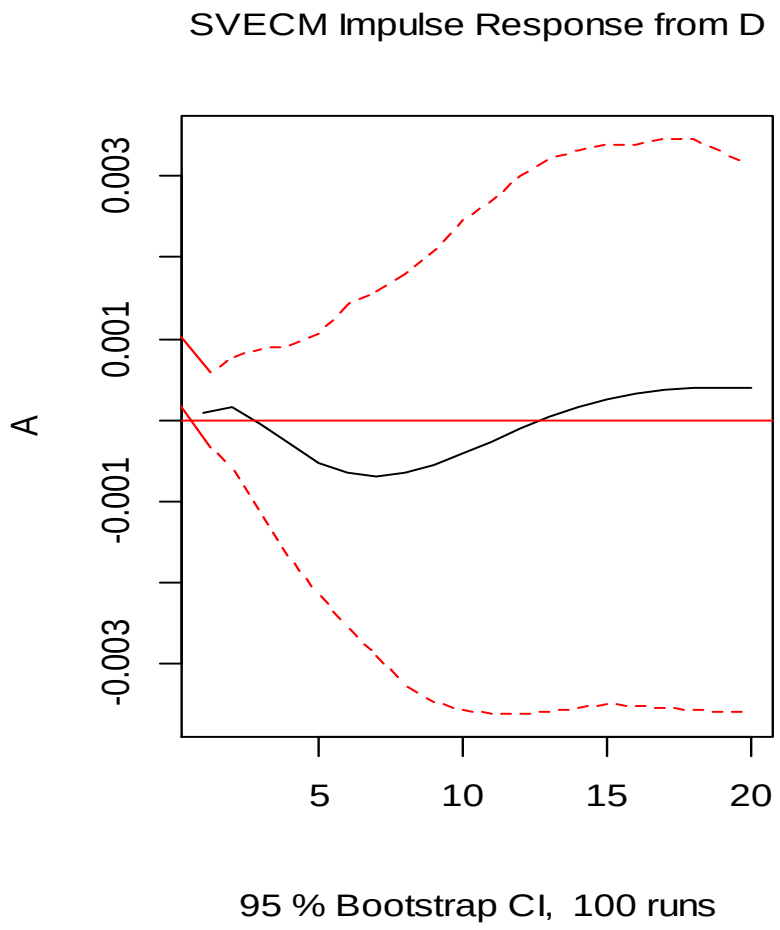


Figure 12: Plot of the reaction of the unemployement rate (A) to a positive shock on the FED interest rate (D).

the positive shock applied on the uncertainty expressed by the EPU index induce an increase in the unemployement rate by 0.35 percentage points after four trimesters and it reachs 0.50 percentage points after almost eight semesters (2 years) after this this impact start to decrease and it become stable arround 0.40 confirming the analysis of in the The paper of Giovanni Gaggianno and al (2014) (Uncertainty shock and unemployement dynamics) but with higher amplitude (0.36 and 0.41 percentage points for the non linear VAR approach for the first ans the second years respectively and 0.17 and 0.14 for the classical linear VAR approach respectively after the first and second year)

As waited the positive shock applied to the inflation expressed by the Log CPI lead to a decrease in the unemployement rate (0.05 percentage points after 2 semesters) but this impact become positive after five semesters and reach 0.25 percentage points after ten semesters and stay stable confirming the economic theory about the impact of the inflation on the job market , in fact an inflation choc lead to a decrease in the unemployement rate on the short run (Philips curve) , but on the long run this impact become positive an correspond to what is occuring in a situation of stagflation[3].

Regarding at last the impact on the unemployement rate of the shock on the FED interet rate we can note that during the first two and half years it induce a decrease in the unemployement rate which it can be explained by the fact that the increase of the Fed interest is the result of an improvement in the mains indicators of the american economy , this increase in the interest rate will also lead to an improvement in the confidence in the economy , but after more than 2 and half years (13 semesters) we can note an increase in the unemployement rate , this increase can be explained by the fact that the persistence of the increase in the FED interest rate induce a change in the behaviour of the agents by the increase of the propension to save and a decrease in the propension to consum which induce a decrease in the demand and consequently less recruitement by the firms.

From the two impulse functions applied on the SVEC1(trend cointegration relationships with r=1) and SVEC2 (constant cointegration relationship with r=2) we can conclude obviously that the impact of uncertainty on the job market is more important that what we see in the conclusions of The paper of Giovanni Gaggianno and al (2014) (Uncertainty shock and unemployement dynamics) , this impact is much more emphesised in the SVEC1 compared to SVEC2 where the amplitude is close to be the same.

[3] The term "stagflation" was first coined during a period of inflation and unemployment in the United Kingdom ( situation of inflation and economic stagnation in the same time )

Regarding the impact of the inflation expressed by the log CPI and the Fed interest rate the conclusion is pretty coherent with the economic theory.

## 2.9 The Forecast Error Variance Decomposition

We are going now to decompose the variability of the forecast errors of our endogenous variable in order to analyse and understand how each exogenus shocks applied on each endogenous variables explains and impacts the errors variability of the endogenous variables.

To obtain this decomposition we are going to use the function fevd available in the package vars.

### 2.9.1 The Forecast Error Variance Decomposition of SVEC-1( Trend cointegration relationships with r=1)

These results show clearly that the variability of the error term of the unemployement rate is mainly explained by its own variability and by the variability of the uncertainty index shocks

**Table13:The forcast errors decomposition of SVEC1 on 13 lags**

| | D | C | A | P |
|---|---|---|---|---|
| [1,] | 0.003415986 | 0.001594286 | 0.9353281 | 0.05966166 |
| [2,] | 0.003554455 | 0.027922826 | 0.7775312 | 0.19099154 |
| [3,] | 0.001803504 | 0.027575793 | 0.7043817 | 0.26623898 |
| [4,] | 0.003483762 | 0.017669631 | 0.6179096 | 0.36093703 |
| [5,] | 0.007782525 | 0.011943471 | 0.5384114 | 0.44186265 |
| [6,] | 0.011334496 | 0.014250816 | 0.4642010 | 0.51021365 |
| [7,] | 0.013233960 | 0.024360779 | 0.3968446 | 0.56556063 |
| [8,] | 0.013524305 | 0.040156509 | 0.3387451 | 0.60757410 |
| [9,] | 0.012712629 | 0.059145712 | 0.2905577 | 0.63758396 |
| [10,] | 0.011353032 | 0.079068627 | 0.2513655 | 0.65821280 |
| [11,] | 0.009889003 | 0.098309179 | 0.2200102 | 0.67179161 |
| [12,] | 0.008586809 | 0.115895835 | 0.1951569 | 0.68036044 |
| [13,] | 0.007567081 | 0.131316726 | 0.1755117 | 0.68560451 |

### 2.9.2 The Forecast Error Variance Decomposition of SVEC-2 (Constant cointegration relationships with r=2)

We took 13 steps and we are focusing on the unemployement rate to confirm its strong link with the Log of uncertainty index (Log EPU) and the results are below:

**Table14:The forcast errors decomposition of SVEC1 on 13 lags**

| | D | C | A | P |
|---|---|---|---|---|
| [1,] | 0.0003454183 | 0.005262725 | 0.9569064 | 0.03748548 |
| [2,] | 0.0001016022 | 0.044903981 | 0.8328074 | 0.12218706 |
| [3,] | 0.0039379585 | 0.052502623 | 0.7797283 | 0.16383111 |
| [4,] | 0.0093052302 | 0.049556904 | 0.7225040 | 0.21863385 |
| [5,] | 0.0139705667 | 0.043102382 | 0.6682164 | 0.27471068 |
| [6,] | 0.0158803188 | 0.036447664 | 0.6167281 | 0.33094388 |
| [7,] | 0.0154330526 | 0.030387247 | 0.5685523 | 0.38562743 |
| [8,] | 0.0136321126 | 0.025329267 | 0.5247672 | 0.43627138 |
| [9,] | 0.0114402138 | 0.021295926 | 0.4862329 | 0.48103100 |
| [10,] | 0.0095384625 | 0.018148361 | 0.4529571 | 0.51935613 |
| [11,] | 0.0082869225 | 0.015719151 | 0.4247870 | 0.55120688 |
| [12,] | 0.0077791722 | 0.013849347 | 0.4013903 | 0.57698121 |
| [13,] | 0.0079336509 | 0.012403495 | 0.3822724 | 0.59739043 |

These results show clearly that the variability of the error term of the unemployement rate is mainly explained by its own variability and by the variability of the uncertainty index shocks but with a lower amplitude for the impact of the uncertainty index shocks on the unemployement rate error compared to this impact in SVEC2.

## Conclusion

The main purpose of this work was to construct an econometric model which articulates the unemployement rate and the uncertainty in order to evaluate the impact of an increase of uncertainty on the job market and simulate a similar structural shock relative to the last economic crisis (2008).

The results confirm the pretty emphasised negative impact of the uncertainty on the job market. This conclusion is coherent with the prediction of the macroeconomic theory about this impact.

In fact a positive shock on uncertainty downgrades the expectations and the confidence of the agents and consequently reduces the investment and the consumption which has an impact on the job market by inducing a lower demand.

This situation can explain the slow recovery of the job market in United State of America after the last economic and financial crisis.

Regarding the use of this new index to express the uncertainty it seems to be more adapted and worthy for this kind of analysis compared to the VIX index which is more suited for the stock market analysis.

Is this impact of the uncertainty on the job market stronger during the recession and the crisis periods compared to the periods of normal growth ? To answer we have to use another kind of model which is able to express the non linearity and the transition between two differents regimes (recession and non recession), a treshhold Vector Error Correction Model seems to be a good candidate for this analysis.

The preleminary studies on our data in order to detect the existance of treshold's cointegration using the function TVECM.SeoTest in R ( package tsDyn) showed clearly the existance of two regime as you can see below :

**## Test of no cointegration versus threshold cointegration of Seo 2006 ##**

**Test Statistic: 19.14449**

**P-value (100 bootstrap):1**

it would be then interesting in next research project to modelise our data under Treshold VECM modelisation through the function TVECM available also in the package tsDyn (R) an apply on this modelisation a non linear impulse function to compare the reaction of the job market proxied by the unemployement rate to the uncertainty shocks in each regime.

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- https://inflationdata.com/Inflation/Inflation_Rate/Monthly_Inflation.aspx (the rate of increase (or decrease) in the basket of goods and services tracked by the U.S. Bureau of Labor Statistics )

- https://fred.stlouisfed.org/series/FEDFUNDS ( Economic Research Division / FED interest rate )

- http://www.cboe.com/products/vix-index-volatility/vix-options-and-futures/vix-index/vix-historical-data ( Vix index )
- http://www.policyuncertainty.com/ ( GEPU index )
- https://data.oecd.org/fr/unemp/taux-de-chomage.htm#indicator-chart ( Unemployement rate )

# Annexes

# Annexe 1 : Student Test on VECM1 and VECM 2

- ## On VECM 1 :

Response D.d :

Coefficients:

| | t value | Pr(>\|t\|) |
|---|---|---|
| ect1 | -3.019 | 0.00341 ** |
| constant | 3.030 | 0.00330 ** |
| D.dl1 | 3.242 | 0.00174 ** |
| C.dl1 | --1.596 | 0.11444 |
| A.dl1 | --0.219 | 0.82693 |
| P.dl1 | -4.610 | 1.52e-05 *** |
| D.dl2 | 0.361 | 0.71875 |
| C.dl2 | -1.894 | 0.06184 . |
| A.dl2 | 0.496 | 0.62112 |
| P.dl2 | -1.850 | 0.06801 . |

Response C.d :

| | t value | Pr(>\|t\|) |
|---|---|---|
| ect1 | 00.267 | 0.7902 |
| constant | -0.234 | 0.8153 |
| D.dl1 | -1.438 | 0.1544 |
| C.dl1 | 0.207 | 0.8367 |
| A.dl1 | -0.497 | 0.6203 |
| P.dl1 | -1.527 | 0.1308 |
| D.dl2 | 1.983 | 0.0508 . |
| C.dl2 | -1.434 | 0.1556 |
| A.dl2 | -0.003 | 0.9977 |
| P.dl2 | --0.828 | 0.4103 |

---

Response A.d :

| | t value | Pr(>\|t\|) |
|---|---|---|
| ect1 | 4.107 | 9.72e-05 *** |

constant -4.106 9.75e-05 ***

D.dl1 0.508 0.613166

C.dl1 -2.305 0.023776 *

A.dl1 2.799 0.006430 **

P.dl1 3.937 0.000176 ***

D.dl2 -0.966 0.336974

C.dl2 0.623 0.534797

A.dl2 1.815 0.073366 .

P.dl2 2.814 0.006181 **

Response P.d :

t value Pr(>|t|)

ect1 -0.914 0.363417

constant 0.910 0.365465

D.dl1 -1.813 0.073673 .

C.dl1 0.977 0.331569

A.dl1 0.474 0.637064

P.dl1 -5.812 1.25e-07 ***

D.dl2 0.306 0.760339

C.dl2 0.472 0.637919

A.dl2 -1.088 0.279844

P.dl2 -3.627 0.000507 ***

- On VECM 2 :

Response D.d :

t value Pr(>|t|)

ect1 --3.749 0.00034 ***

ect2 0.026 0.97966

constant 0.195 0.84560

D.dl1 2.661 0.00945 **

C.dl1 -1.082 0.28237

A.dl1 -0.948 0.34629

P.dl1 -4.670 1.23e-05 ***

D.dl2 0.324 0.74687

C.dl2 -1.872 0.06490 .

A.dl2 0.121 0.90427

P.dl2 --1.869 0.06542 .

Response C.d :

t value Pr(>|t|)

ect1 0.824 0.4126

ect2 -0.418 0.6768

constant 0.404 0.6874

D.dl1 -1.219 0.2265

C.dl1 0.047 0.9629

A.dl1 -0.271 0.7872

P.dl1 -1.556 0.1237

D.dl2 1.993 0.0498 *

C.dl2 -1.457 0.1491

A.dl2 0.109 0.9138

P.dl2 -0.842 0.4026

Response A.d :

t value Pr(>|t|)

ect1 -0.115 0.908821

ect2 4.157 8.20e-05 ***

constant -4.250 5.88e-05 ***

D.dl1 0.072 0.942578

C.dl1 -1.920 0.058561 .

A.dl1 2.241 0.027896 *

P.dl1 4.081 0.000107 ***

D.dl2 -1.017 0.312100

C.dl2 0.700 0.485869

A.dl2 1.556 0.123791

P.dl2 2.897 0.004887 **

Response P.d :

| | t value | Pr(>\|t\|) |
|---|---|---|
| ect1 | 0.574 | 0.567453 |
| ect2 | -1.362 | 0.176966 |
| constant | 1.360 | 0.177850 |
| D.dl1 | -1.536 | 0.128648 |
| C.dl1 | 0.757 | 0.451572 |
| A.dl1 | 0.725 | 0.470623 |
| P.dl1 | -5.852 | 1.09e-07 *** |
| D.dl2 | 0.325 | 0.745847 |
| C.dl2 | 0.436 | 0.663788 |
| A.dl2 | -0.933 | 0.353577 |
| P.dl2 | -3.647 | 0.000477 *** |

# Annexe 2 : R Codes

## 1- Stationarity

### Augmented Dickey Fuller Test

```
D=Data[ ,1]
C=Data[ ,2]
A=Data[ ,3]
P= Data[ ,4]
X=cbind(D,C,A,P)
adf.test(D)                - kpss(D)
adf.test(C)                -kpss ( C)
adf.test(A)                -kpss(A)
adf.test(P)                -kpss(P)
adf.test(diff(D))                - kpss(diff(D))
adf.test(diff(C))                -kpss ( diff(C))
adf.test(diff(A))                -kpss(diff(A))
adf.test(diff(P))                -kpss(diff(P))
```

## 2- The choose of the lag order

```
VARselect(M, lag.max = 8, type = "both")
```

## 3- The cointegrations

```
vecm2 <- ca.jo(M, type = "trace",ecdet = "const", K = 3, spec = "transitory")

vecm1 <- ca.jo(M, type = "trace",ecdet = "trend", K = 3, spec = "longrun")

vecm3 <- ca.jo(M, type = "trace",ecdet = "none", K = 3, spec = "transitory")
```

## 4- The Causalities

```
granger.test(M, p=2)
```

## 5- The Structural Vector Error Correction SVEC modelisation

```
vecm2 <- ca.jo(M, type = "trace",ecdet = "constant", K = 3, spec = "transitory")
Vecm2=cajorls(vecm2,r=2)

SR <- diag(4)
diag(SR) <- NA
SR[1,2] <- NA
SR[3,1] <- NA
SR[3,2] <- NA
SR[4,2] <- NA
SR[3,4] <- NA
SR[4,1] <- NA
LR <- matrix(NA, nrow = 4, ncol = 4)
Svec2 <- SVEC(vecm2, LR = LR, SR = SR, r = 2, lrtest = FALSE, boot = TRUE, runs = 100)



Vecm1 <- ca.jo(M, type = "trace",ecdet = "trend", K = 3, spec = "longrun")
Vecm1=cajorls(vecm1,r=1)

SR <- diag(4)
diag(SR) <- NA
SR[1,2] <- NA
SR[3,1] <- NA
SR[3,2] <- NA
SR[4,2] <- NA
SR[3,4] <- NA
SR[4,1] <- NA
LR <- matrix(NA, nrow = 4, ncol = 4)
Svec1 <- SVEC(vecm1, LR = LR, SR = SR, r = 1, lrtest = FALSE, boot = TRUE, runs = 100)
```

## 6- VECM Modelisation comparaison

```
summary(Vecm1$rlm)
summary(Vecm2$rlm)
```

## 7- Structural shocks analysis

```
svec.irf 1<- irf(svec1, response = "A", n.ahead = 13, boot = TRUE)
 plot(svec.irf)

svec.irf 2<- irf(svec2, response = "A", n.ahead = 13, boot = TRUE)
 plot(svec.irf)
```

## 8- The forecast error variance decomposition

```
fevd(svec1, n.ahead=13)
fevd(svec2, n.ahead=13)
```

## 9- Test of no cointegration versus threshold cointegration of Seo 2006

```
TVECM.SeoTest(T, lag=3, beta=1, trim = 0.1, nboot=100, plot = FALSE,hpc = c("none", "foreach"), check = FALSE)
```