UNIVERSITA' DEGLI STUDI DI PADOVA

DIPARTIMENTO DI SCIENZE ECONOMICHE ED AZIENDALI "M. FANNO"

CORSO DI LAUREA IN ECONOMIA E FINANZA

PROVA FINALE

"UNCERTAINTY AND MONETARY POLICY SHOCKS IN THE UNITED STATES"

RELATORE:

CH.MO PROF. CASTELNUOVO EFREM

LAUREANDO: DUÓ FEDERICO

MATRICOLA N. 1164278

ANNO ACCADEMICO 2020 – 2021

Sommario

Con questo lavoro ci si è posti come obiettivo quello di ricercare se ci sia relazione tra gli shock di politica monetaria e l'incertezza, il tutto misurato al massimo in un periodo di un anno dall'intervento. Analizzeremo diversi tipi di incertezza: finanziaria, di politica economica, macroeconomica e reale. I dati utilizzati hanno rilevazione mensile e sono raccolti nel territorio degli Stati Uniti dal gennaio 1985 al dicembre 2007.

Oltre ai dati di incertezza indicati in precedenza abbiamo tenuto in considerazione anche il tasso di disoccupazione, l'indice di produzione industriale e li abbiamo inserirti in un modello stimato, che permetta di capire la relazione tra gli shock di politica monetaria e l'incertezza. Su questo modello poi è stata applicata una analisi VAR, che permetta di stimare i vari coefficienti del modello e ci siamo soffermati in particolare sul coefficiente degli shock di politica monetaria. Ripeteremo poi la regressione anche con ritardi (individuati nel modello stimato dalla variabile "h") che applicheremo all'incertezza per valutare come reagisca la stessa all'aumentare del tempo passato dallo shock. Di conseguenza siamo arrivati a costruire una funzione di risposta di impulso che conterrà i 13 coefficienti stimati per le 13 combinazioni che abbiamo con "h", termine inserito per ottenere il ritardo, compreso tra 0 e 12.

Da questi grafici, inserito anche l'intervallo di confidenza del coefficiente in oggetto, possiamo vedere come si comporta l'incertezza nei vari casi: se il coefficiente degli shock è significativo solo nei primi mesi dopo l'input oppure se, in altri casi, ritorna significativo dopo svariati mesi; se è positivo fa aumentare l'incertezza o al contrario, se è negativo la fa diminuire.

In generale però possiamo definire come l'incertezza, nonostante molte ricerche, resti ancora una variabile poco controllabile con certezza matematica anche se, come vedremo durante la tesi, ci sono alcune indicazioni che possono permettere di limitarla o quantomeno indirizzarla, diminuendo l'impatto negativo che ha sull'economia.

Index

Introduction

Uncertainty can be defined as the inability of economic actors to understand the future dynamics of the economic system, to predict the expectations of agents on the main macroeconomic variables (and on the mechanisms they use to build them) and to understand how these variables will fluctuate in the coming periods.

In particular, the economic sphere collects many variables of uncertainty that are linked to the economic performance of the moment.

The economist Olivier Blanchard recognizes the uncertainty component because of crises and as a cause of the behaviour of economic actors. In situations of high uncertainty or, as the economist himself calls it, of "unknown variables" that make the economic environment so complex that it is almost incomprehensible, the result is extreme prudence, or even paralysis of investors, consumers and businesses.

These behaviours fuel crises. The phenomenon at a macroeconomic level materializes with investors willing to invest in non-risky assets with respect to the baseline scenario, resulting in highly negative macroeconomic consequences.

The research behind this thesis is whether and how there is a relationship between monetary policy shocks and uncertainty, which we will divide into economic policy uncertainty, financial uncertainty, macroeconomic uncertainty and real uncertainty. We will also investigate whether the former can directly and significantly affect the latter over a period, limited in our case to 12 months, following a shock. All data and related analyses are from the USA, which we will use for research purposes.

To determine these data, once the model has been built, we will rely on the analysis of vector autoregression (VAR), a statistical model used to capture the relationship between multiple quantities as they change over time. We will then use the result of the regression to create impulse response functions of the estimated coefficient of monetary policy shocks (MPS), where we will evaluate how the relationship between the various measures of uncertainty and shocks reacts to the passage of time after the input.

A similar research was achieved by Giovanni Pellegrino (2021) who places uncertainty as endogenous in the model. This paper in turn partially takes up a previous one, Castelnuovo and Pellegrino (2018), where the difference in the effectiveness of monetary policies that are more effective in times of relative tranquillity than in periods of high uncertainty is also empirically defined.

Data and Variables

The data is collected monthly and the observations are about the USA as we said before. In the following pages we will analyse each variable that will be used in the model individually. To have a total view of the general trend of each time series in the graph, we take data from January 1985 up to the latest available. Subsequently, due to the series of monetary policy shocks, it will be necessary to limit the analysis in the model to December 2007. Then we will analyse below: Economic Policy Uncertainty, Financial uncertainty, Macroeconomic uncertainty, Real uncertainty, Monetary Policy Shocks, Unemployment Rate and Industrial Production Index.

Economic Policy Uncertainty (EPU)

This measure is explained in "The Quarterly Journal of Economics" of November 2016, where Baker, Bloom and Davis identify this variable of uncertainty, which derives from the first work of the three economist dated 2013. The index is developed and built on three fundamental components all processed in a structured quantitative form:

- The first component quantifies the references to uncertainty present in 10 American press organs, related to economic policy. This is done by carefully searching for articles containing terms such as "uncertainty" or "uncertain", "economy" or "economic", "Federal Reserve", "deficit" and others. The goal is to search for economic policy articles that explicitly refer to uncertainty as a key variable. The research is carried out monthly with relative updating.
- The second component, on the other hand, relates to the future tax revenue flows expected for the coming years and the related maturities. Note that a component of this type is a factor of uncertainty (both for investors and for families) because the CBO (Congressional Budget Office) often decides to extend or not extend temporary tax measures at the last minute.
- The third component, on the other hand, quantifies and evaluates the "discrepancies present in the economic forecasts" regarding "politically relevant variables as a proxy for uncertainty", as specified by Baker, Bloom and Davis (2013). For the United States, the economic forecasts issued by the Federal Reserve Bank of Philadelphia's Survey of Professional Forecasters (SPF) are used, carried out with reference to price dispersion (through the CPI - Consumer price index) and expenditure on state goods and services and of local and federal governments. The variables called into question are the previous

ones since, as argued by Baker, Bloom and Davis (2013), “directly influenced by monetary and fiscal policy decisions”.

Generally, as a quantitative reference to evaluate the results obtained, an EPU index value equal to 100 is taken. For index values greater than 100 it is concluded that the level of uncertainty is above the average level. For index values less than 100 it is concluded, in the opposite way, that the level of uncertainty is below the average level. With reference to the figure (Figure 1), it can also be inferred that the value of the EPU index tends to grow in phases of decline or mild growth of real GDP. It grows steeply before and during recessions, returning to normal values only later. Strangely, however, it is noted that the index assumes very high values even during periods of great expansion, like what happens during recessions. It should be noted that in the last period, that corresponding to the pandemic, levels of uncertainty have been reached that had never been recorded in the previous 30 years to underline the impact and consequences that the pandemic has had on the economy.

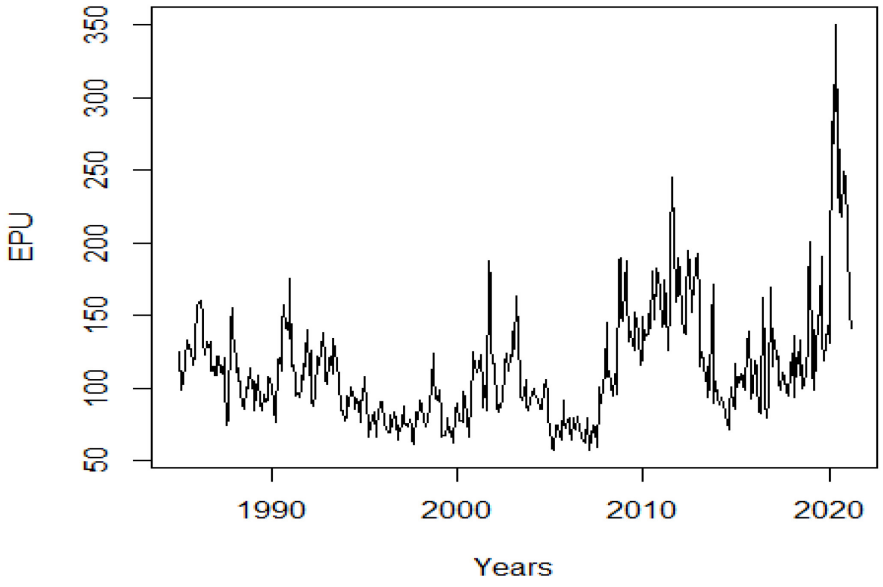

Figure 1, Economic Policy Uncertainty as in Baker, Bloom and Davis (2016)

The graph above shows the peaks of uncertainty due to the Black Monday of October 19, 1987, both the Gulf wars, September 9, 2001, the bankruptcy of Lehman Brothers and the Debt Ceiling Dispute. Also note in this graph what the impact of the epidemic is on the economy and on uncertainty not only in the US, which we have here in the example, but throughout the world.

Financial Uncertainty

When we refer to financial uncertainty it is good to fully understand the crucial difference between risk and uncertainty.

Risk is directly related to return as a higher return is expected to compensate for taking a higher risk. There are many ways to measure both risk and return, but once the expected return is achieved, this can be used to calculate the value of the asset. Furthermore, this process is complicated by the existence of uncertainty. In finance, uncertainty has a very different meaning from risk.

The American economist Frank Knight made the distinction in 1921, in his book *Risk, Uncertainty, and Profit*, when he differentiated risk from uncertainty. Risk is something that can be measured and quantified and from which those who take it can take steps to protect themselves. Uncertainty, on the other hand, does not allow such steps to be taken as no one can exactly predict future events. To use a more recent example, uncertainty means what former US Defence Secretary Donald Rumsfeld famously called "unknown strangers."

In the face of uncertainty, we are simply unable to predict how a future disaster might unfold, although some may have an idea of the triggering conditions, as has happened with a history of market corrections. Furthermore, financial calamities can also be triggered by the intersection of finance with external forces. Geopolitical issues (such as how a sharp drop in oil prices are mobilized to curb Russian military adventurism in Ukraine) or global security issues (such as the threat of terrorism and our ongoing response) continue to affect the resilience of our current economic and political systems.

Some economists have argued that this distinction is exaggerated. In real business, this objection argues, all events are so complex that forecasting is always a matter of addressing "true uncertainty," not risk; however, past data used to predict risk may not reflect current conditions. In this perspective, "risk" would be best applied to a highly controlled environment, such as pure casino gambling, and "uncertainty" would apply to almost everything else. Even so, Knight's distinction between risk and uncertainty can still help us analyse the recent behaviour of, for example, financial firms and other investors. Investment banks who in recent years believed their apparently accurate risk assessments to be reliable may have considered operating under Knightian risk conditions, where they could judge the probabilities of future results. Once the banks recognized that such valuations were inadequate, however, they realized they were operating under Knightian uncertainty and may have held back from trading or providing capital, slowing the economy further as a result.

Ricardo Caballero, chair of MIT's Department of Economics and Ford's International Professor of Economics, Macroeconomics, and International Finance, is among those who have recently invoked Knight's uncertainty to explain investor behaviour in times of financial panic. As Caballero said in a conference at the International Monetary Fund research conference last November: “When investors realize that their risk assumptions are no longer valid and that Knightian uncertainty conditions apply, markets can assist. to "destructive flights to quality" in which participants free their portfolios of everything except the safest investments, such as US Treasury bills”.

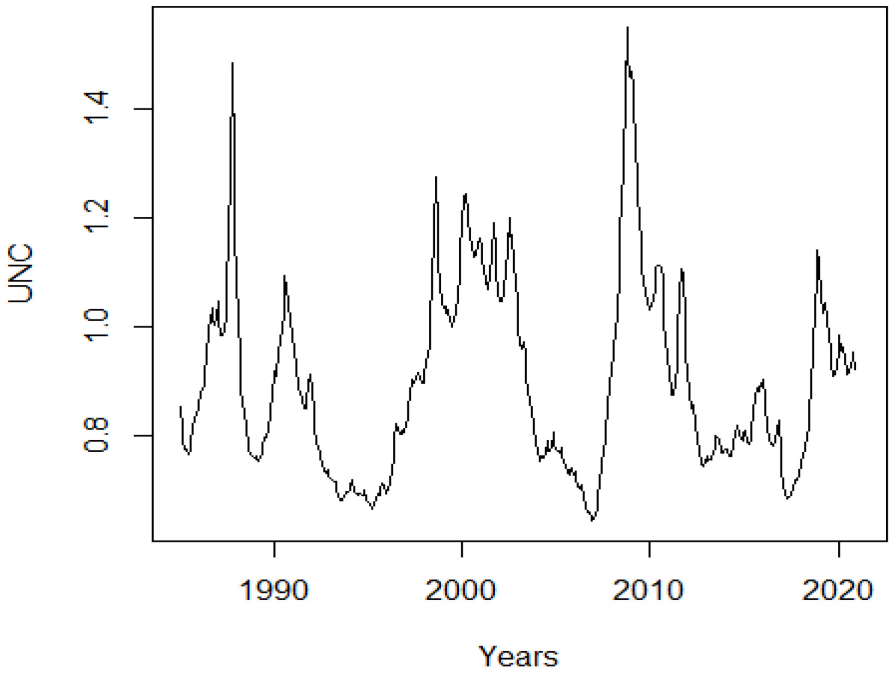

Figure 2, Financial Uncertainty as in Ludvigson (2021)

Financial uncertainty can consequently be linked to the trend of the stock markets and therefore to rates. In particular, in Figure 2 we see great growth in situations of tension on the stock exchange such as the first peak, which is attributable to Black Monday, while close to 2000 the Russian crisis and then the attack on the twin towers, passing through the creation of the euro ensured that financial uncertainty remained high in the US. The peak of this uncertainty occurs in correspondence with the 2007 crisis, which highlights the moment of greatest instability in the period examined in the graph.

Financial uncertainty is not an abstract thing that can be eliminated with some clever calculation. Nor is it that almost omnipresent entity, a power that should convince us that calculation is doomed to misery. Financial uncertainty is a concrete thing, one of the vital components for economic exchanges. It is something malleable whose form, as we understand it empirically, depends on the institutional frameworks that shape the circulation and recording of economic information and on the calculation, processes used for this purpose.

This information, its transformations and its calculations are components of economic activity: they are accounting principles and operations ranging from the creation of double-entry tables to the balancing of a system of equations, or to the construction of a stochastic process. Consequently, scientists must realize that grasping a phenomenon makes sense only in relation to a particular frame of reference, which does not mean - here as in physics - that this phenomenon is inconsistent, far from it. Only by relating it to the various frames of reference and then by comparing the morphologies can it be circumscribed, and its consistency can be highlighted. Here, the rate and index databases provide considerable empirical material, of which we have commented on only two highly aggregated series. Arguably, much remains to be done in economics and economic history. However, there is a strong relativity - in an epistemological sense - of financial uncertainty regarding the implicit frameworks in the recording of economic information. Only by taking this strong relativity as a working basis can it be rigorously characterized and therefore an analysis of the characteristic movements of financial activities and the transformations of the social environment that contribute to this change can be outlined.

Macroeconomic Uncertainty

The macroeconomic uncertainty is mainly derived from the macroeconomic scenario in which we find ourselves. It is defined by the economist Ben Bernanke as that of the "Great Moderation", a period characterized by the decrease in the volatility of both GDP and inflation. This period has started, as described in the article by Blanchard and Simon (2001) since the mid-1980s, since a 50% decline in GDP growth variability is documented, while inflation variability has decreased. by about one third. The reduction of this volatility has multiple benefits including an improvement in the functioning of the markets, greater stability about employment rates and more generally a reduction of the macroeconomic uncertainty itself.

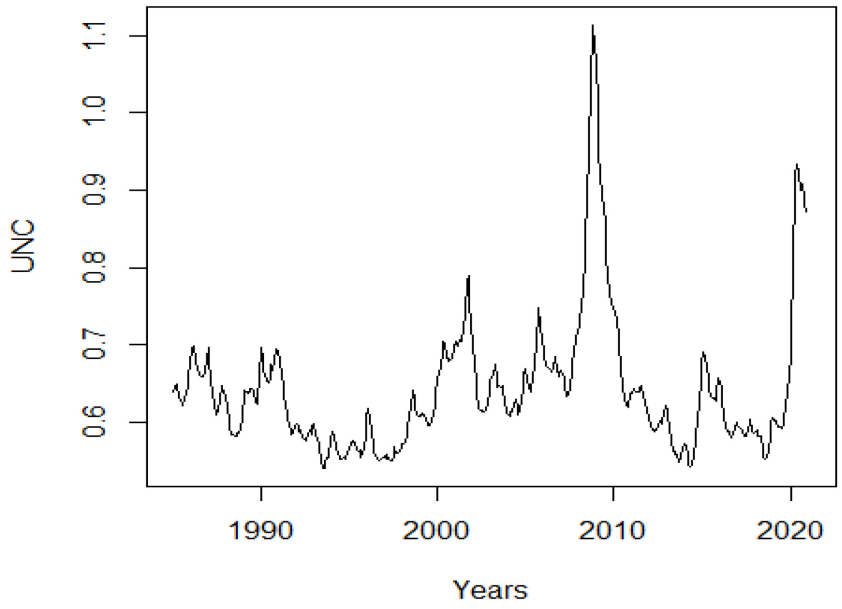

Figure 3, Macroeconomic Uncertainty as in Ludvigson (2021)

As already described above, the graph (Figure 3) remains stationary until the 2007 crisis, except for a small tip relating to the macroeconomic choices derived from 11 September. It should also be noted that the pandemic of the last year has also considerably impacted on macroeconomic uncertainty, both in the US and in the world.

Real Uncertainty

By real uncertainty we mean the uncertainty that is reflected on production and consumption, but also on GDP and unemployment rate. From the graph (Figure 4) it is possible to see how it is generally stable, except for the peaks corresponding to the crisis of 2007 and the pandemic of the last year.

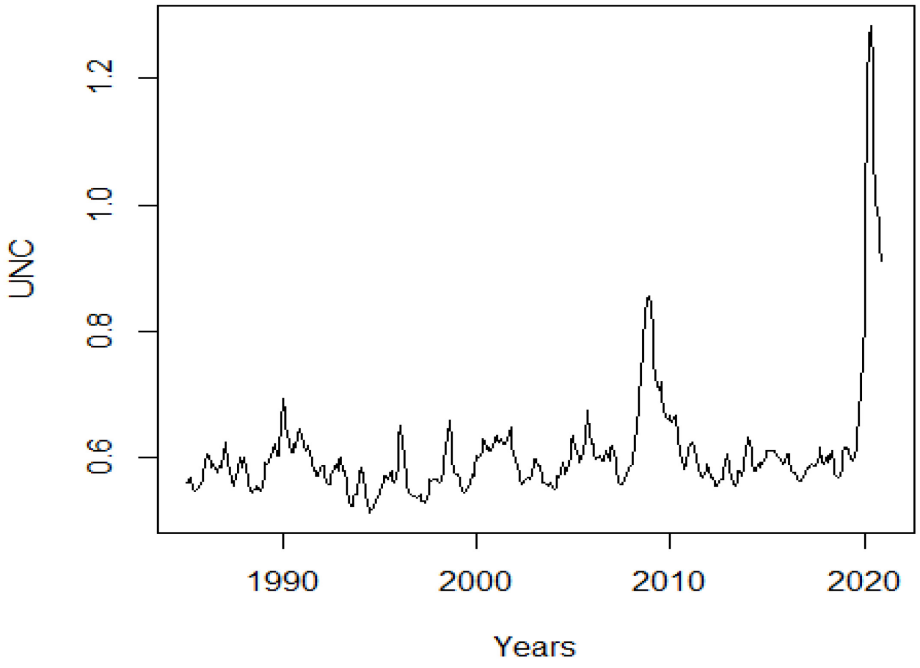

Figure 4, Real Uncertainty *as in Ludvigson (2021)*

Monetary Policy Shocks (MPS)

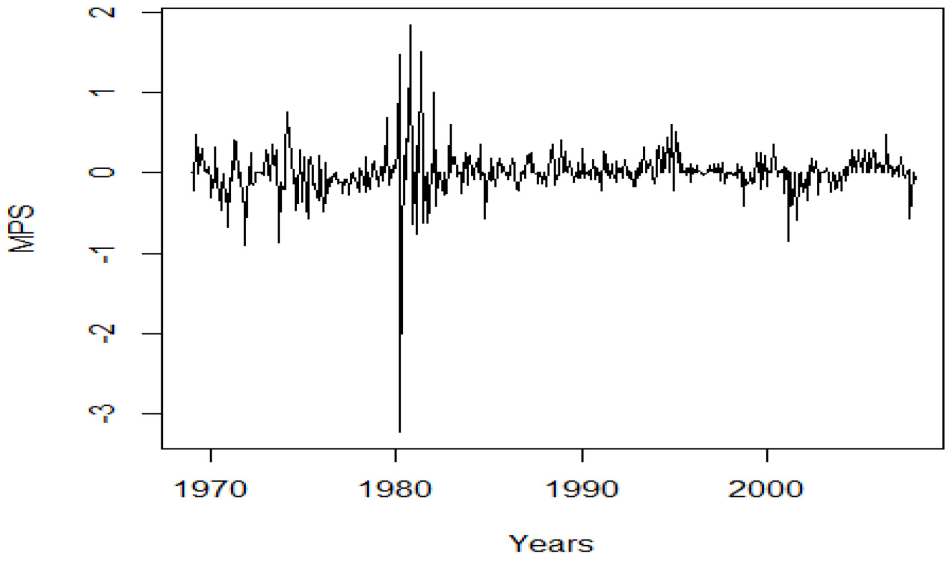

Figure 5, Monetary Policy Shocks as in Agrippino (2007)

By Monetary Policy Shocks (MPS) we mean all those monetary policy decisions that impact the economic environment causing shocks. They can be of two types:

- Expansive when, through the reduction of interest rates, one tries to stimulate private investments and household consumption, pushing the economic cycle.
- Restrictive when with the increase in interest rates the money supply is reduced, making any type of investment and production less convenient.

This is the graph regarding MPS. The graph can be defined as non-periodic and stationary, with a necessary clarification that have to be made on what happens close to the 1980.

The Federal Reserve faced a turbulent year in the economy and in financial markets in 1980 as it sought to dampen inflationary pressures by restraining money and credit growth. The economy was buffeted by several shocks, including sharp hikes in energy prices, heightened tensions in the Middle East, and rapidly shifting inflationary expectations. The special credit restraint program announced on March 14—and its subsequent removal—had a larger than expected impact and combined with other developments to produce dramatic changes in economic activity, interest rates, and financial flows. The economy plunged into a steep recession in the second quarter and then, much to the surprise of almost all analysts, recovered

over the balance of the year—making the recession one of the shortest on record. Interest rates soared to unprecedented levels early in the year, dropped dramatically in the spring, only to rise sharply again, in some cases to new highs, by late autumn. The recession and the Federal Reserve policy stance helped dampen inflationary expectations temporarily, but the quick turnaround in the economy and concern over the prospects for the Federal deficit renewed public anxiety over the price outlook. By the year-end, inflationary psychology still seemed firmly embedded in the economy, although the speculative fever evident earlier in the year in the commodities markets and the sense of rapidly accelerating inflation had not returned.

Unemployment Rate (UN)

The unemployment rate is the unemployed percentage of a country's total workforce.

The trend in unemployment is strongly correlated with the confidence of businesses in the national economy. In an expanding economy, high entrepreneurial activity would increase the confidence of companies and encourage them to reconsider their operations by hiring more staff. On the other hand, if the economy is stagnant or unstable, they would aim to maintain their current operating level and refrain from making new investments in their business. In times of crisis such as devaluation or pandemics, however, the main purpose would be to ensure the survival of the company and job cuts would increase.

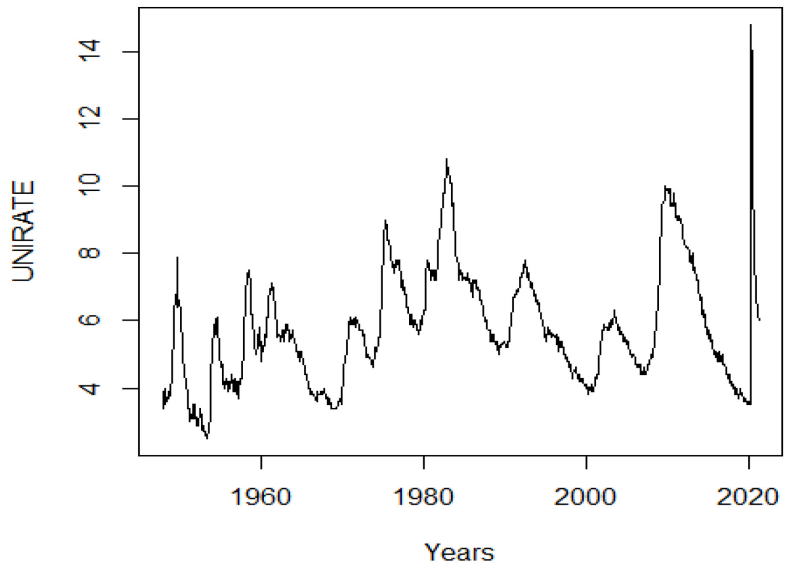

Figure 6, UN Rate as in https://fred.stlouisfed.org/series/UNRATE, sources from U.S. Bureau of Labor Statistics

Here you can see the graph concerning unemployment. The trend that is represented has a non-linear trend, but unquestionably linked to external events as can be seen in particular from the last two unemployment peaks, the first linked to the 2007 crisis and consequent to 2012, while the second to the Covid epidemic- 19 which has increased unemployment to figures never reached in the last 60 years.

Industrial Production Index

The industrial production index - internationally now always referred to as IPI - is a monthly indicator that is disseminated by all major economies worldwide.

This indicator measures the production of industry and manufacturing, of mines and extractive activities, of electricity and energy companies.

Economists use industrial production as a component to determine when the economy is in recession. Other signs of a recession are a steady state of gross domestic product, rising unemployment, retail sales and per capita income. Consequently, even if the manufacturing sector alone represents only a part of economic activity, it is in a scenario where it is under close surveillance of the financial markets.

In the United States, industrial production statistics are released monthly by the Federal Reserve Board of Governors. Revisions to the index may be issued in subsequent releases. This ratio is one of the deciding factors on when an economic downturn begins and when it ends, so that previous assessments can be revised, because even a small change can make all the difference in an economy's history.

The governing body that sets the interest rate policy in a country, such as the Federal Reserve in the United States, will pay special attention to industrial production results. This is because, considering its relationship with the economic environment, it is a measure of capacity utilization, which illustrates in what capacity an economy is functioning. If economic sectors are running at 85 percent capacity or more, this could lead to higher inflation, which in turn affects interest rates.

Investors in financial markets are affected by industrial production in different ways according to the types of financial instruments in which they have invested. An economic boom can be rewarding for investors in the stock market because a high use of industrial production to create value for a single product usually creates an environment for corporate profits to grow. The

same economic environment could be less attractive for investors due to signs of a possible increase in inflation which could be negative for the value of a company with a relatively low industrial production index. We can deepen and underline the substantial difference between this variable and the UN rate. Then in our model we will insert the two variables at the same time and it could be argued that they are similar and sometimes redundant. However, we must consider how the two variables, especially in periods of high uncertainty, behave differently. Let us consider the case that arises in the 2007 crisis. In this case there is an immediate increase in the unemployment index and a drop in the industrial production index. Subsequently, however, industrial production grew immediately, while unemployment took many years to reach the situation before the great recession (Figure 6), reaching a situation of *jobless recover*.

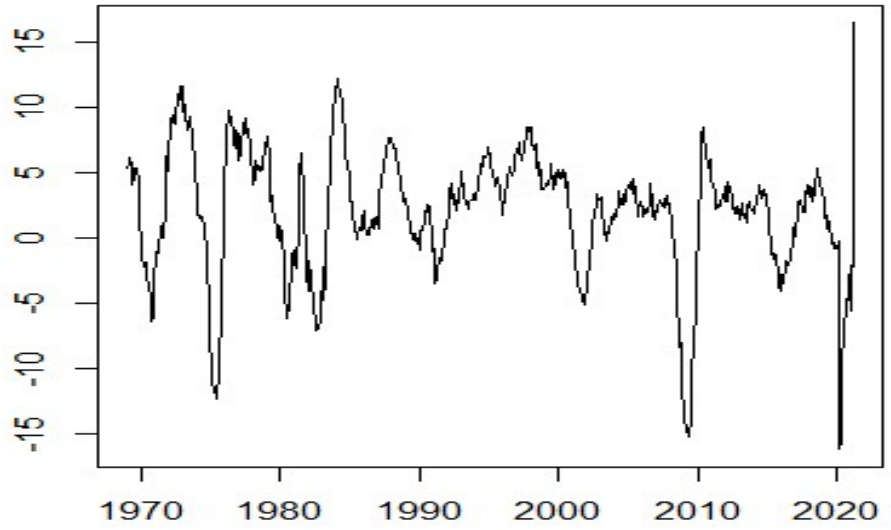

Figure 7, Industrial Production Index as in https://fred.stlouisfed.org, data from Federal Reserve Economic Data

From what we can evaluate from the graph (Figure 7), we can see how it is characterized by a very fluctuating trend, although around the value 0. Recognizable drops in production due to energy crises, sudden and lasting increases in the price of oil, the 2007 crisis and the 2020 pandemic.

VAR

Vector Autoregression Model (VAR)

With two important articles Sims (1980,1982) introduces VAR models as a new approach for large-scale data analysis: starting from a model based on empirical data and statistical theory, to identify the "real" relationships between the variables.

In particular, the VAR models are overall simpler than the structural models, and their performance in terms of forecasting capacity of macroeconomic variables appears better.

Some characteristics: All the variables of the economic system are treated as endogenous, there is no a priori information derived from economic theory. The estimated model is "unrestricted", which turns out to be a pure statistical model. From the unrestricted model, some restrictions allow to give an economic interpretation to the model: Structural VAR (SVAR) when used to model the structure of the economic phenomenon to be investigated.

VAR models are not intended to describe the entire large-scale economy, so we focus on a limited number of economic variables Y (n × 1 vector). VAR models are reduced form models: they consist of systems of equations that relate the current values of a given set of economic variables to the past values of the variables themselves. All the variables therefore assume an endogenous nature, while in the previous model they were considered only exogenous to the system. The emphasis is more on the statistical properties of the model and its ability to grasp the PGD (data generation process). There are more sophisticated techniques, which can easily be extended to multivariate analysis, and more structured in our empirical analysis: we can see more clearly the links between empirical and theoretical macroeconomics. Vector Auto Regressions (VAR) is the dominant research methodology in empirical macroeconomics (time series). Its goal is the dynamic response of various macro-variables to an unexpected exogenous economic political shock.

- Advantages: The flexibility of the autoregressive formulation allows for a statistical description of a wide range of real data sets and provides a unifying framework in which to analyse alternative theories and hypotheses.
- Disadvantages: Such models do not represent the truth in economics, but they are a useful tool for obtaining information on the interactions between different variables. Difficult to interpret the results of estimating an unlimited VAR. It’s difficult to say anything about how the economy reacts to various shocks. Many econometricians view

SVARs as more of an art than a science. One way to assess the robustness of the results is to see if the impulse responses match our economic intuition and the expectations of economic theory.

To perform the regression we use the Ordinary Least Squares method.

The ordinary least squares method (OLS) is an optimization (or regression) technique that allows you to find a function, represented by an optimal curve (or regression curve), that comes as close as possible to a set of data (typically points of the plan). In particular, the function found must be the one that minimizes the sum of the squares of the distances between the observed data and those of the curve that represents the function itself. In this case, we can distinguish the least squares parabola and the least squares line. This method converges only in its limiting case to an interpolation, so in fact the optimal curve is required to contain all the data points.

In statistics, when estimating a parameter, it is often insufficient to identify a single value. It is therefore advisable to accompany the estimate with an interval of plausible values for that parameter, defined as the confidence interval. The confidence level is instead indicated in an arbitrary way by the researcher, in fact in my case a confidence level of 68% was used.

Furthermore, to determine with better precision the standard errors of the coefficients we use a function of the program, the HAC correction, which allows to have robust errors in conditions of heteroskedasticity and autocorrelation. The first to use this method were Newey & West (1987).

At the basis of the model used is the idea that the various shocks have repercussions not only immediately, on the contrary, they have a more significant impact, especially with the passing of the months. Whenever, in fact, the committee delegated to monetary policy decides to undertake a specific move, it must be considered that it takes time for: the policy makers, first of all, to realize that the state of the economy has changed (recognition lag) ; they decide with what kind of political plan to respond (decision lag); the policy is actually implemented (implementation lag). All these delays are part of the so-called "inside lag" of monetary policy, to which must also be added an "outside lag", which expresses the time needed for the implemented policy to have concrete effects on the real economy.

In the model we use the variable h, which together with t defines the time of the variable to which we refer, which determines whether at a distance of a given period, between 0 and 12 months from when the shock was defined, to verify if and when these shocks have had more impact on uncertainty.

Impulse Response Function

It is also important to define the impulse response functions, which will be fundamental for the understanding of the final phenomenon.

An impulse response function of a dynamic system is a function that analyses the output of that system, caused by the input, called impulse. In general, an impulse response refers to the reaction of a dynamic system over time to some external change. In our field, particularly in macroeconomic modelling, the impulse response functions describe how the economy reacts over time to exogenous impulses, called "shocks". They try to understand the reaction of macroeconomic variables such as output gap, inflation, interest rate and other variables at the time of the shock and after it.

Local Projection

The idea behind the model can be found in local projection. This method, used by Ramey and Zubairy, re-takes another, that of Jordà (2005) to estimate impulse responses and multipliers. Auerbach and Gorodnichenko (2013) were the first to use this technique to estimate state-dependent budget models, employing it in their OECD panel data analysis. The Jordà method simply requires estimating a series of regressions for each horizon h for each variable. This method contrasts with the standard method of estimating the parameters of the VAR for the 0 horizon and then using them to scroll forward to construct the impulse response functions.

Our model

Once the uncertainty variables have been defined, we build a model that relates the uncertainty, the value with the values attributed by the Miranda-Agrippino study regarding monetary policy shocks in such a way as to reach an answer to the question underlying this thesis.

This is the model we're going to use:

$$UNC(t+h) = \beta_0 + \beta_1 MPS(t) + \beta_2 UN(t) + \beta_3 UNC(t-1) + eps(t+h)$$

Within it we find various variables that we have already described above:

- UNC measures the uncertainty, which will change depending on the uncertainty used among the 4 identified above;
- MPS (Monetary Policy shocks), excerpts from the work carried out by Miranda-Agrippino, Senior Research Economist in Monetary Analysis at the Bank of England;
- UN measure of unemployment, inserted as a control variable, so as not to give too much weight to the MPS model that otherwise would have given distorted results. The data are available on the FRED website;
- UNC(t-1) the uncertainty of the previous time is entered, which according to the data represents a month earlier, as the uncertainty of a given period will certainly be linked to the uncertainty that was present the previous month;
- Eps as model residuals
- β_0 as the intercept value
- h , between 0 and 12, to determine the relationships as the time from shock increases

By applying a regression with the least squares method to this model, using the R Studio software, it is possible to trace the coefficients of the variables and their confidence intervals.

Analysis

Now we can apply the theory seen above to practice starting from the model

$$UNC(t+h) = \beta_0 + \beta_1 MPS(t) + \beta_2 UN(t) + \beta_3 UNC(t-1) + eps(t+h)$$

And performing the regression through the program, to estimate the coefficients of the model itself. The regression will be repeated with a "for" function in order to see the relationship between the various variables by increasing the delay of the uncertainty measurement, for example verifying if and how MPS affects the uncertainty also by increasing the time from when the shock is carried out. Finally, the process is repeated for all the various types of uncertainty that we have seen above.

The time interval will always be from 01-1985 to 12-2007 for a total of 276 observations for each variable given that we have monthly data series.

Model with EPU

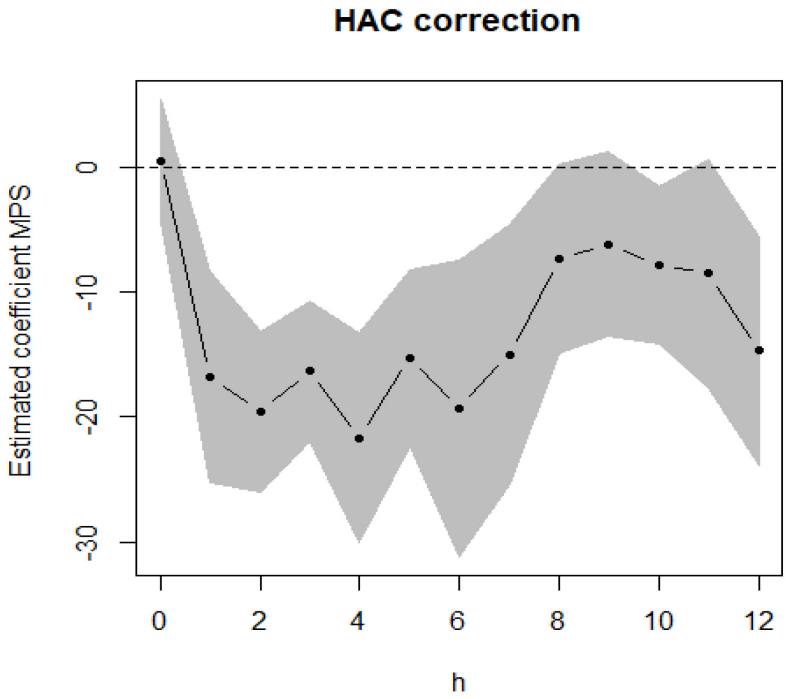

Figure 8, Estimated MPS coefficient; Model with EPU

The graph (Figure 8) shows how the Monetary Policy Shocks (MPS) variable is significant at the same period as the EPU (i.e. with the variable h = 0) but, by increasing the delay, the variable does not impact significantly on the uncertainty itself. However, close to the 8-month delay it becomes significant again and implies an increase in uncertainty itself. We can interpret these data by defining that a monetary policy shock has a significant impact on economic policy uncertainty as soon as a certain monetary policy measure is carried out. Furthermore, we see that the estimated coefficient of MPS returns to be significant in the 8 to 10 months following the shock, probably because, due to the very nature of EPU, after that period of time we find real effects of the shocks carried out months before. However, it can be concluded that in general the uncertainty of economic policy decreases in the light of a monetary policy shock in a very short time.

Model with Financial Uncertainty

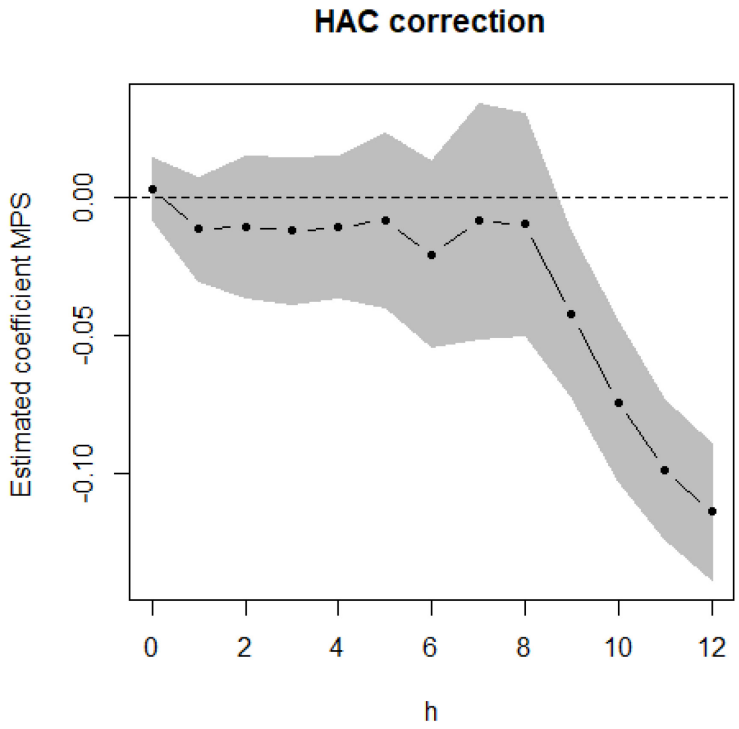

Figure 9, Estimated MPS coefficient, Model with Financial Uncertainty

As regards the relationship of MPS with financial uncertainty, we can see from Figure 9 how the estimated coefficient of MPS moves in a very limited range close to 0 and with a negative sign. The coefficient is significant and has a positive impact on uncertainty. In fact, a negative coefficient leads to less financial uncertainty.

Expansive monetary policies can be considered fundamental to reduce uncertainty. Considering that financial uncertainty is also directly linked to the volatility of interest rates, an expansive policy, which seeks to control interest rates and to reduce them, is decisive and effective in reducing this type of uncertainty.

Model with Macroeconomic Uncertainty

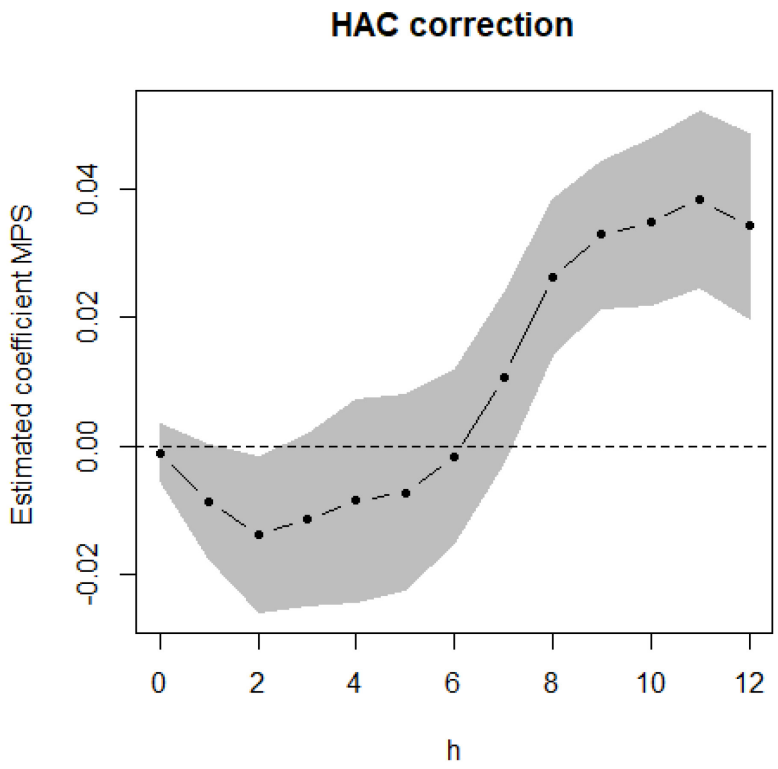

Figure 10, Estimated MPS coefficient, Model with Macroeconomic Uncertainty

By inserting the macroeconomic uncertainty in the model we use for our research, we obtain this graph. MPS remains significant for macroeconomic uncertainty until the seventh month after the shock, where it becomes insignificant and takes on a positive sign. This movement may suggest a periodic situation due to the trend of some cyclical trend, which would lead to having to pay further attention to this result. In fact, if it were really the result of a cyclic macroeconomic trend, the model would have to be reconsidered, presumably by inserting an additional control variable that does not allow the economic cycle to impact so strongly on our research. Starting from this request, I inserted the variable rate of growth of industrial production into the model. At first glance the graphs look very similar and this may involve two further thoughts:

- The economic cycle is very relevant and cannot be excluded from the model;
- The answer given by the graph is correct and tells how macroeconomic uncertainty needs almost half-yearly stimuli to ensure that it remains low.

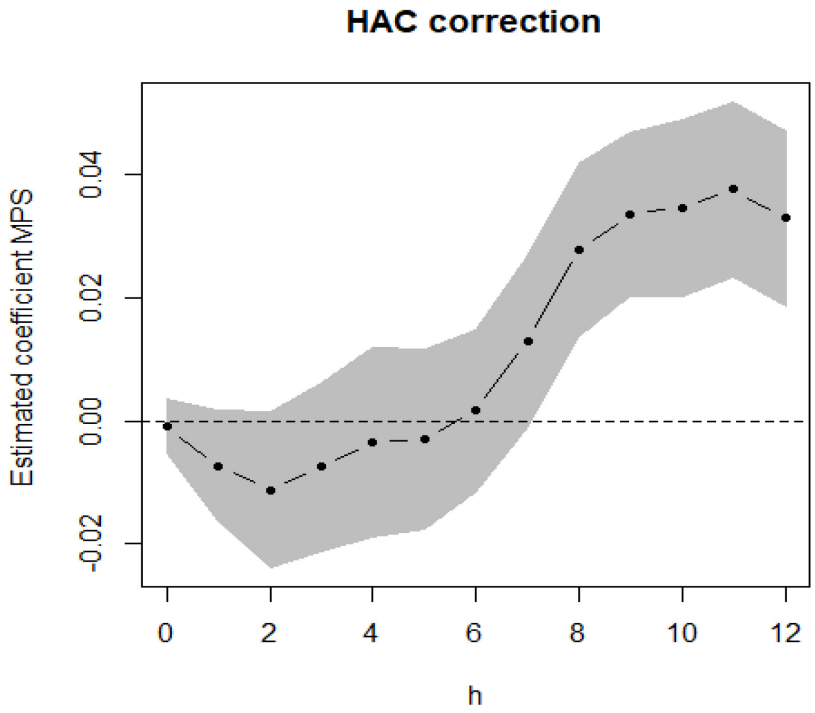

Figure 11, Estimated MPS coefficient, Model with Macroeconomic Uncertainty and IPI

In any case, from the graph (Figure 11) it can be deduced that a monetary policy shock can have beneficial effects on uncertainty, reducing it, but after the first 6-month period it loses its effectiveness, leading the uncertainty to increase significantly. In the macroeconomic context, it can therefore be considered that a monetary policy shock must be followed by other actions in a short time to allow the macroeconomic uncertainty to be kept low.

It is also interesting to analyse the regression results also considering the estimated coefficients relative to the other variables. We can see how the coefficient of the UNC variable (t-1) is very high compared to the coefficients of the other variables, which implies an important relationship between the uncertainty in each period and the uncertainty of the previous month.

Model with Real Uncertainty

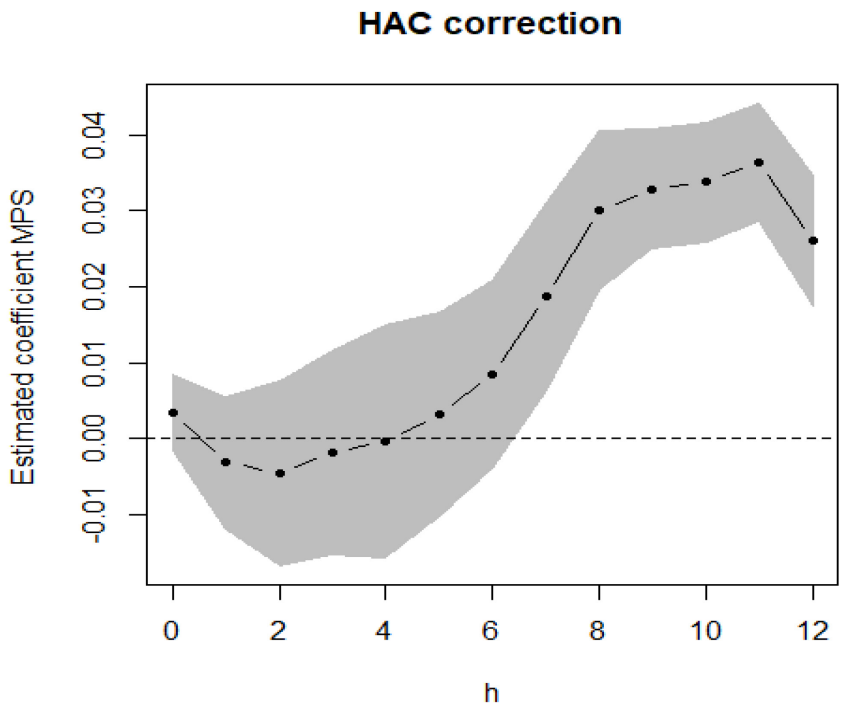

Figure 12, Estimated MPS coefficient, Model with Real Uncertainty

It is evident that the Figure 12 of the real uncertainty coefficient is very similar to that of the Macroeconomic uncertainty seen above. And the same considerations are to be made regarding the shape of the graph and its tendency which can lead it to be considered as very influenced by the economic cycle. In the same way, I also added the variable production growth index to the model, obtaining this result.

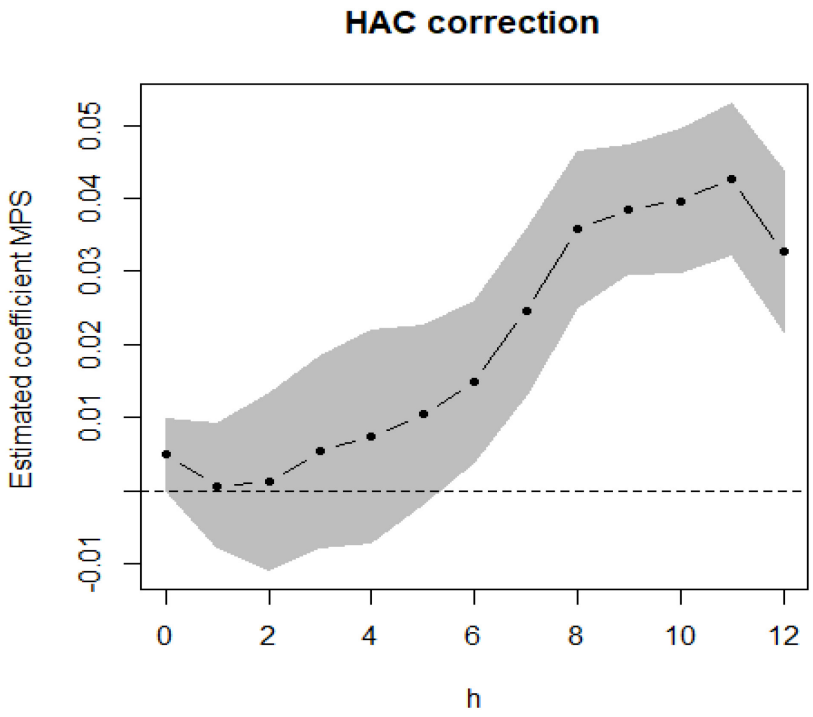

Figure 13, Estimated MPS coefficient, Model with Real Uncertainty and IPI

From what we observe the shape does not change much, as in the case of the macroeconomic uncertainty, but the situation is different about the first part of the graph. The coefficient of MPS is always positive (Figure 13), and consequently, in this case, a monetary policy shock does not reduce uncertainty, but causes it to increase slightly within the first few months of the input, until it increases significantly after 6 months. from the shock.

Residual Analysis

To account for this margin of imprecision, an error term is added in the regression models, which is indicated by the Greek letter Epsilon (ε). The response variable (y) in the regression equation is therefore determined by the values of the explanatory variables (le x) plus an error term (ε).

For the regression model to have good predictive power, this error must be an unpredictable change in the response variable. To see if this is the case, when you build a regression model you need to do some testing on how the residuals are distributed.

The residual values in a regression analysis precisely represented the part of the prediction error of the regression model. The residuals, also called offsets, represent the differences between the values observed in the dataset and the estimated values calculated with the regression equation. In other words, the residuals indicate the variability of the data around the regression line. Remember that the residuals of a regression model constructed with the least squares (OLS) method always have zero mean. The residual plots of the various models are shown below considering the different uncertainty that is inserted in the model.

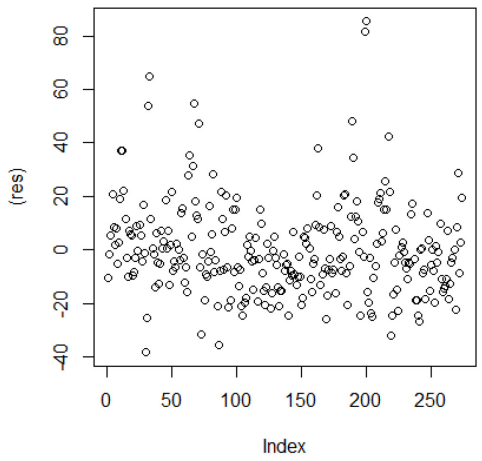

Figure 14, *Model with EPU*

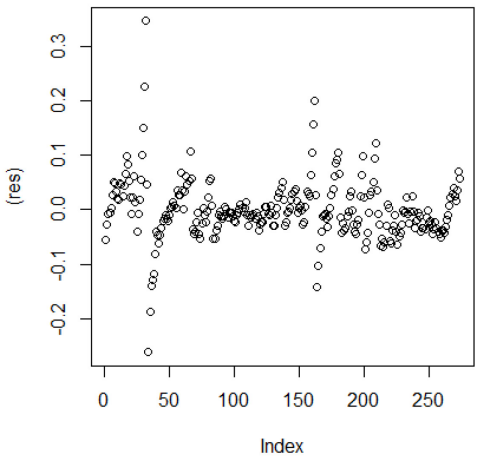

Figure 15, Model with Financial Uncertainty

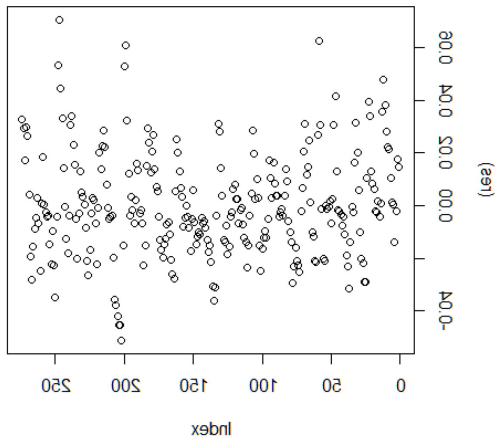

Figure 156 Model with Macroeconomic Uncertainty

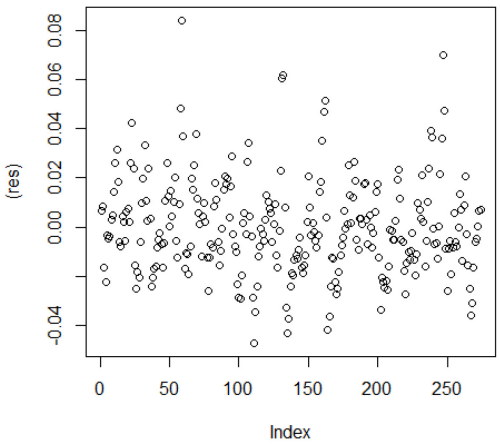

Figure 167 Model with Real Uncertainty

As can be seen from the graphs, the residuals are distributed quite randomly along the 272 observations, but still, as per definitions, collected close to the mean 0.

Conclusions

From the thesis we can draw some answers to the question we asked ourselves, that is, whether monetary policy shocks directly affect uncertainty, how and if there was the possibility of controlling uncertainty through such shocks.

First, when we talk about uncertainty and the related areas of use, it is good to define what kind of uncertainty we are talking about. As we have seen, in fact, there is a substantial difference between the various measures and the term uncertainty is not precise enough to define what area we are talking about, or rather, it is not appropriate from an economic point of view to speak of uncertainty without determining its type.

We can consider another view from the data we have processed. For example, how and when the estimated coefficient of MPS goes to 0, that is, when the monetary policy shock value does not affect the uncertainty. In the case of EPU this situation occurs with h = 0, that is when the shock has just occurred. The same happens with the Financial Uncertainty, with the MPS measurement that does not affect the uncertainty in a limited time in the first month after the shock.

Otherwise we can observe how in the models containing the macroeconomic uncertainty they show that the MPS coefficient goes to 0 in a period between the fifth and sixth month after the shock in the case of the basic model we have used, while between the sixth and seventh month in the case of the model with adding the industrial production index. In the case of real uncertainty, the estimated coefficient reaches 0 in the fourth month after the shock, while in the model also containing the industrial production index the coefficient never reaches 0.

Consequently, we can say that in the first two cases the impact of MPS on uncertainty is zero within the first month of the arrival of the shock, and then have a positive impact in which both the EPU and financial graphs have negative values, the which implies a reduction in uncertainty within the period we determined after the shock. As for the models with the other two uncertainty measures, as already explained above, we have the estimated coefficient that reaches 0 after being a negative period, and subsequently will be positive. It can therefore be assumed that a monetary policy shock has a more lasting beneficial effect on uncertainty as regards the first two uncertainty measures (even if the coefficient is not significant for the whole graph), while for the latter two measures of uncertainty, it seems that they need more frequent monetary policy stimuli, around a maximum of six months for macroeconomic uncertainty and four months for real uncertainty.

Focusing once again on the graphs concerning the individual models and observing the model containing the financial uncertainty, we can deduce how statistically significant results are returned for a longer period than the outputs with the other uncertainty measures and this could be due to the fact that this measure is more correct in relation to the model we have adopted.

We can consider that expansive monetary policy shocks can reduce the various measures of uncertainty, not always significantly and generally not with extreme precision, both due to the various nature of uncertainty (which are difficult to quantify in themselves) and to the difficulty in precisely quantifying the extent of monetary policy shocks (MPS).

The fact of not having total significance of the data is one of the most critical points of the entire research. This criticality is to be found in the model used, which although precise and more likely from a logical point of view, instead empirically and mathematically will always remain a theoretical approximation of the real world.

In fact, the lack of an effective model is the greatest difficulty encountered in delving into these areas because it is clearly impossible to create a model that collects all the components that can influence uncertainty. However, what partially succeeded in this work was to find the correlation, albeit approximate, between the monetary policy shocks and the various measures of uncertainty, how the impact of the shock on uncertainty changes according to the time passed and to understand how to control, even if partially the uncertainty.

References

- Bank of England. “Uncertainty and Central Banking”, *Bank Workshop on Role of Uncertainty in Central Bank Policy. Research and Documents.*
- Baker, S. R., Bloom, N., & Davis, S. J. (2012). Measuring economic policy uncertainty. *www.policyuncertainy.com*.
- Baker, S. R., Bloom, N., & Davis, S. J. (2015). *The Quarterly Journal of Economics* at Oxford University
- Bernanke, B. S. (1983). Irreversibility, uncertainty, and cyclical investment. *The Quarterly Journal of Economics*, 98(1), 85-106
- Bernanke, B. S., Boivin, J., & Eliasz, P. (2005). Measuring the effects of monetary policy: a factor-augmented vector autoregressive (FAVAR) approach. *The Quarterly Journal of Economics*, 120(1), 387-422
- Blanchard O. (2009). (Nearly) nothing to fear but fear itself. *The Economist*
- Blanchard O., Simon J. (April 2001) The Long and Large Decline in U.S. Output Volatility.
- Castelnuovo E., Pellegrino G. (2018). "Uncertainty-dependent Effects of Monetary Policy Shocks: A New Keynesian Interpretation," *"Marco Fanno" Working Papers 0219,* Dipartimento di Scienze Economiche "Marco Fanno"
- Federal Reserve Economic Data about Industrial Production Index in *https://fred.stlouisfed.org,*
- Ludvigson, Ma, Ng (2020) Uncertainty and Business Cycles: Exogenous Impulse or Endogenous Response?
- New York FED, Monetary Policy and Open Market Operations in 1980
- Newey WK & West KD (1987). “A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix.” Econometrica, **55**, 703–708.
- Pellegrino, G. (2021) Uncertainty and monetary policy in the United States: A journey into nonlinear territory. *Economic Inquiry*, 1–23.
- Ramey, Zubairy (2018). Government Spending Multipliers in Good Times and in Bad: Evidence from US Historical Data. Journal of Political Economy
- U.S. Bureau of Labor Statistics, data about Unemployment rate in *https://fred.stlouisfed.org/series/UNRATE*
- *www.huffpost.com*. Financial Risk vs Financial Uncertainty.
- *www.sec.gov.* US Securities and exchange commission. Measurement Uncertainty in Financial Reporting